EHS Introduction

Foreword

- The document describes the various safety accidents caused by misoperation and lack of relevant safety knowledge in practice and introduces corresponding ways to avoid them, with a view to ensuring a safe environment.

Objectives

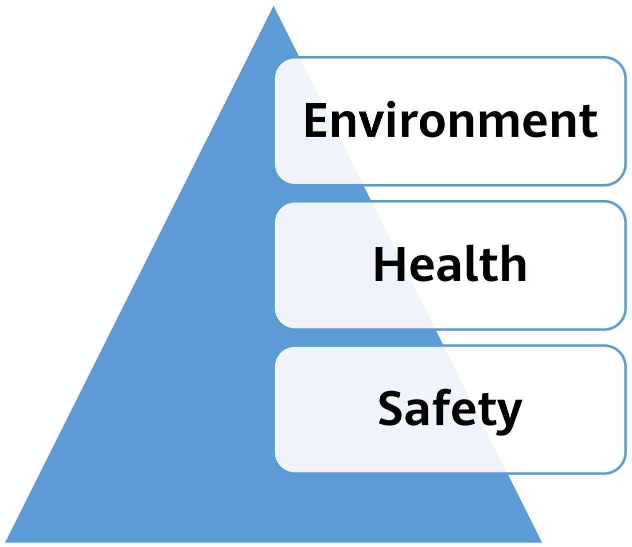
Upon completion of this course, you will be able to:

- Understand the importance of safety training;
- Understand causes of accidents in work;
- Understand ways to avoid accidents;
- Understand how to implement protection.

Contents

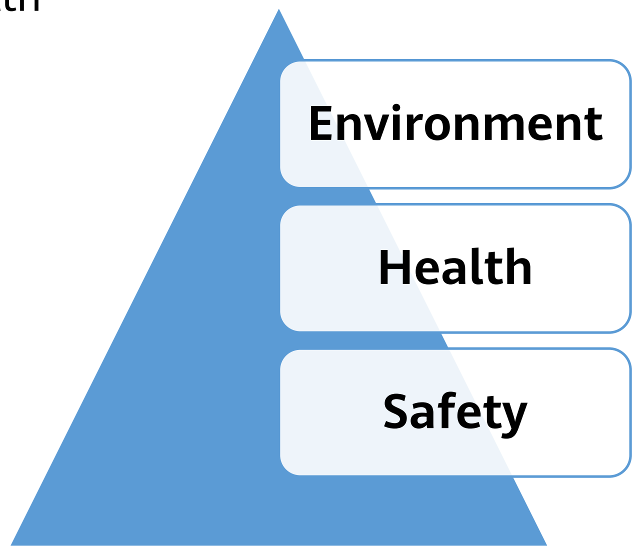
Introduction to EHS (1)

- Concept
  - EHS is short for environment, health, and safety.
  - The EHS management system establishes a systematic prevention and management mechanism to minimize various accidents, environmental hazards, and occupational diseases. It improves the safety, environment, and health performance of enterprises.



Introduction to EHS (2)

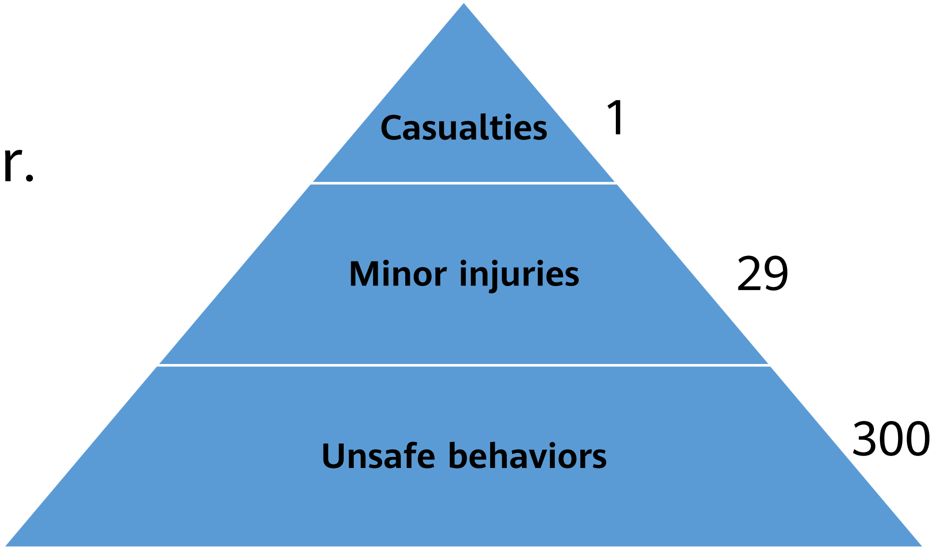
- Functions
  - Helps enterprises meet the laws and regulations on environment, health, and safety.
  - Helps protect the environment and meet the requirements of the strategy for sustainable development.
  - Helps maintain the reputation of enterprises and enhance their competitiveness.
  - Helps reduce enterprise costs and save energy and resources.
  - Helps reduce the occurrence of various accidents and ensure the health and safety of employees.
  - Helps meet public expectations and maintain favorable public and social relationships.
  - Helps enterprises effectively combine economic benefits, social benefits, and environmental benefits.



Contents

Heinrich's Law

- A famous U.S. safety engineer Heinrich induced Heinrich's Law in 1931. He counted 550,000 mechanical accidents, including non-injury accidents, 1666 fatalities and serious injuries, and 48,334 minor injuries. Later, he came to an important conclusion: the proportion of casualties (serious injuries and deaths), minor injuries, and unsafe behaviors in mechanical accidents was **1:29:300**. This law of accidents is internationally recognized.
- No accident does not mean no accident will occur.



Staff's Mental Status Affects the Probability of Accidents

- Four states
  - Rush
  - Complacent
  - Fatigued
  - Frustrated
- Four possible results
  - Eyes away
  - Absent-minded
  - Dangerous areas
  - Imbalanced/dragged/clipped
- These errors increase the injury risk

Sufficient Preparations to Reduce Fatal Errors

- Electricians must have good health and be free of diseases or physiological defects that affect their work, such as mental disease, heart attack, faint, and color blindness.
- Operators must be well rested before performing an important operation. Working under fatigue is not allowed.
- Huawei equipment can be installed, operated, and maintained only by personnel who have received a thorough training, understand all necessary safety precautions, and are able to correctly perform all operations.
- Only trained and qualified personnel are allowed to install, operate, and maintain the equipment.
- Only personnel certified or authorized by Huawei are allowed to replace or change the equipment or components (including software).
- When operating the equipment, comply with local laws and regulations. The safety instructions in the document are only supplements to the local laws and regulations.

Contents

PPE Protection (1)

- Definition
  - The production process is filled with dangerous and harmful factors, which harm workers' bodies and health and even endanger their lives. Personal protective equipment (PPE) refers to articles workers wear during production to avoid or reduce accidents and occupational hazards.
- Functions
  - Protects our bodies against harms incurred by equipment or facilities during production, namely, to prevent work-related injuries.
  - Effectively ensures our health and prevents us from occupational diseases.
  - Though all production processes are filled with dangerous and harmful factors, correctly using and wearing PPE is an effective measure to ensure work safety.

PPE Protection (2)

<table>
<tr><th>No.</th><th colspan="2">Operation</th><th>Mandatory PPE</th><th>Recommended PPE</th></tr>
<tr><td>1</td><td colspan="2">Operations involving objects falling and colliding</td><td>1. Safety helmet; 2. Protective shoes</td><td>Safety net</td></tr>
<tr><td>2</td><td colspan="2">Operations with flying scraps</td><td>Shock-proof goggles</td><td></td></tr>
<tr><td>3</td><td colspan="2">Operations involving sharp instruments</td><td>Anti-mechanical harm gloves (cut resistant gloves)</td><td></td></tr>
<tr><td>4</td><td colspan="2">Low-voltage (below 1 kV) electric operations</td><td>1. Insulation gloves; 2. Insulation shoes</td><td>Insulation protective clothing</td></tr>
<tr><td>5</td><td rowspan="2">High-voltage electric operations</td><td>1–10 kV</td><td>1. Insulation gloves; 2. Insulation shoes;
3. Insulation protective clothing</td><td></td></tr>
<tr><td>6</td><td>10–500 kV</td><td>Electricity shielding clothing</td><td></td></tr>
<tr><td>7</td><td colspan="2">Operations involving high temperature substances</td><td>High-temperature resistant gloves</td><td></td></tr>
<tr><td>8</td><td colspan="2">Operations involving low temperature substances</td><td>Low-temperature resistant gloves</td><td>Low-temperature resistant clothing</td></tr>
<tr><td>9</td><td colspan="2">Operations at heights</td><td>1. Safety helmet; 2. Safety belt</td><td>Safety net</td></tr>
<tr><td>11</td><td colspan="2">Operations involving toxic substances</td><td>1. Chemical resistant gloves; 2. Gas mask</td><td></td></tr>
<tr><td>12</td><td colspan="2">Operations with corrosive substances</td><td>1. Anti-corrosion goggles; 2. Acid and alkali resistant gloves; 3. Acid (alkali) resistant clothing</td><td>Chemical resistant shoes</td></tr>
<tr><td>13</td><td colspan="2">Operations with pollution risks</td><td>1. Acid and alkali resistant gloves; 2. Chemical resistant clothing</td><td></td></tr>
</table>

PPE - Head Protection

- Head Protection
  - Safety helmet: special protective equipment
    - Three certificates: production license, product qualification certificate, safety sign/safety authentication certificate).
  - Common head protection equipment : safety helmet and ESD cap.

ESD cap

Safety helmet

PPE - Facial Protection

- Facial Protection
  - Facial protection refers to wearing protective articles to protect your eyes and face from smoke, dust, metal sparks, flying scraps, heat, electromagnetic radiation, laser, and chemical splashes.
  - Common facial protection equipment: laser safety glasses, goggles, and protective masks.

Protective masks

Welding mask

PPE - Hand Protection

- Hand Protection
  - Gloves worn by workers during production to protect their hands and arms are called “hand protection equipment”.
  - Common hand protection equipment: rubber protective gloves (to prevent corrosion against acid, alkali, and other dangerous and chemical substances), finger cots, heat- and cold-resistant gloves, cut resistant gloves, and cotton gloves.

Finger cots

Cut resistant gloves

Cold-resistant gloves

Rubber protective gloves

PPE - Foot Protection

- Foot Protection
  - Protective wears used to protect the workers' feet against hazardous substances and energy.
  - Common foot protection equipment: ESD shoes, puncture-proof shoes, high-temperature resistant shoes, insulation protective shoes, and acid and alkali resistant shoes.

ESD shoes

Insulation protective shoes

Puncture-proof shoes

PPE - Falling Protection

- Falling Protection
  - Working at heights refers to operating at a height of 2 m or more with the possibility of falling down, such as installing high towers or cleaning walls of high buildings.
  - Securing workers operating at heights to a fixed object using a rope or belt to avoid falling from heights or making a net under the working region to protect those workers who accidentally fall from the heights.

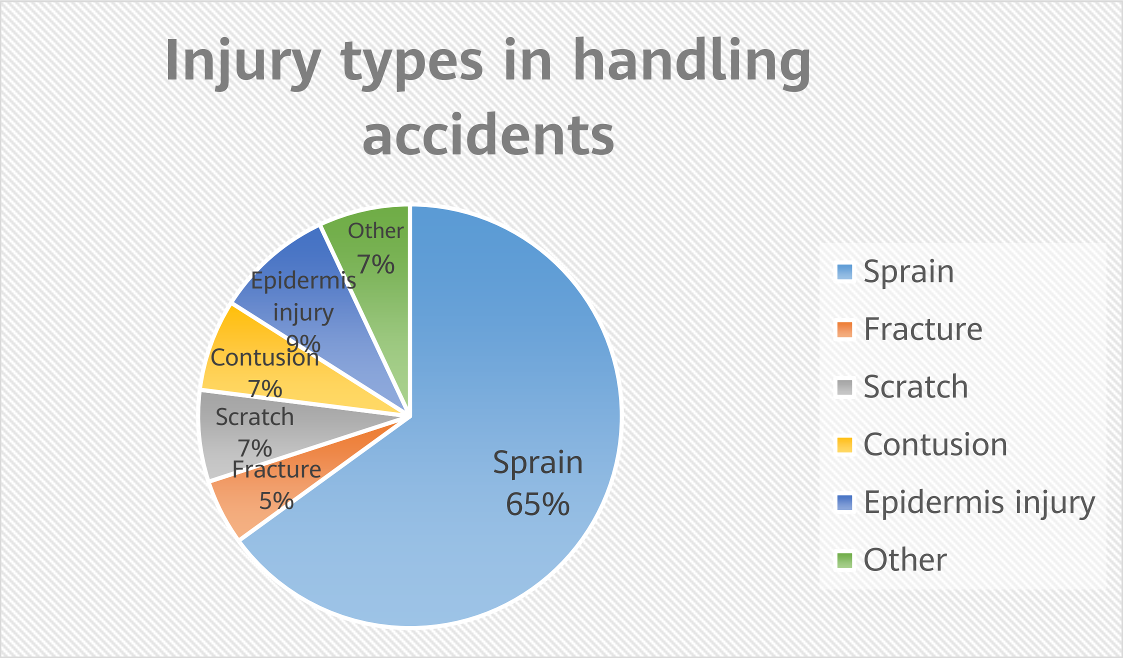
Contents

General Safety

- Personal safety
  - Do not operate the equipment or cables during thunderstorms.
  - Wear electrostatic discharge (ESD) clothing, ESD gloves, and an ESD wrist strap before operating equipment such as an uninterruptible power system (UPS) and air conditioner. Remove conductive objects such as jewelry and watches to avoid electric shocks or burns.
  - In the outbreak of fire, evacuate the building or equipment area and press the fire alarm bell or make a fire call. Do not enter the burning building again in any case.
- Grounding requirements (for the equipment that need to be grounded)
  - Ground the equipment before installing it. When removing the equipment, remove the ground cable at last.
  - Do not damage the ground conductor.
  - Do not operate the equipment when the ground conductor is not installed. Before operating the equipment, check its electrical connection to ensure it is reliably grounded.
- Regulatory requirements
  - Comply with local laws and regulations when operating the equipment. The safety considerations in the product manual are only supplements to the local safety regulations.
  - Only qualified and trained personnel are allowed to install, operate, and maintain the equipment.

Handling (Loading) Safety (1)

- Manual handling safety
  - A quarter of accidents are related to handling.
  - Handling accidents account for 6% of serious accidents.
  - Most handling accidents cause a loss of more than three workdays.
  - Most handling accidents cause back muscle strains or sprains.
  - Muscle sprains or strains are mostly caused by improper force and (or) prolonged force. Incorrect posture and excessive repetitive movements are the main causes of muscle sprains or strains.
  - Muscle strains and sprains are hard to fully recover.



Handling Safety (2)

- Preventive measures (1)
  - Improve the layout and logistics and storage location of loads.
  - Improve the carrying efficiency.
  - Try to keep the load you push in the direction consistent with that your eyes see and pull the load instead of carrying it.
  - Control the carrying frequency to reduce fatigue.
  - Have flexible rest time.
  - Ensure adequate space when carrying loads in partnership. Hold the load firm and carry it in a coordinated manner.
  - Wear PPE accessories that do not bring safety risks.
  - The auxiliary transporting equipment should be in good condition.

Handling Safety (3)

- Preventive measures (2)
  - Reduce workload.
  - Reduce load volume.
  - Facilitate the control of load.
  - Keep the surface of the package clean and free from dirt, oil stains, and corrosive products.
  - Ensure that the package is free from sharp edges, unfilled corners, and rough surface.
  - Avoid scalding or frostbite by using auxiliary equipment and PPE.

Handling Safety (4)

- Preventive measures (3)
  - Reduce space obstacles.
  - Ensure that the ground or work surface is in good condition.
  - Do not carry load on a steep slope.
  - When carrying objects on the ground of great height difference, use stairs or slopes as transition to facilitate the load carrying.
  - Avoid strong wind interference.
  - Lighting.

Mechanical Safety

- Drilling holes
  - Remove cables inside a cabinet before drilling holes on the cabinet.
  - Wear a pair of goggles when drilling holes to protect your eyes from metal scraps.
  - Wear protective gloves when drilling holes.
  - Prevent metal scraps from falling into the cabinet. Clean up metal scraps in time after drilling.
- Fans
  - Place the component, screws and tools in a safe place when replacing a component. If any of them fall into an operating fan, the fan and relevant equipment will be damaged.
  - Do not insert your fingers and boards into the operating fan until the fan is switched off and stops running when replacing a component near a fan; otherwise, you may get hurt or damage the equipment.

Fan

Electrical Safety (1)

- Personal safety refers to the safety of personnel in electrical operations. The following lists the two main causes.
- Lack of electrical safety knowledge.
- Non-compliant acts.
- Equipment safety refers to the safety of electrical equipment and auxiliary devices.

Electrical Safety (2)

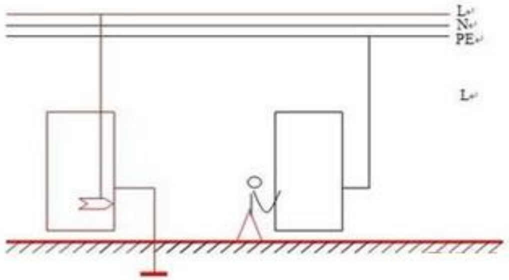
- Electric Current Effects to the Human Body
  - Ventricular fibrillation: When the heart quivers instead of pumps due to disorganized electrical activity in the ventricles. It results in cardiac arrest with loss of consciousness and no pulse.
  - Suffocation: When the current flows through the respiratory center in brain, it inhibits the breathing; when excessive current flows through the chest in a certain time, it leads to abnormal contraction of chest muscles, resulting in respiratory arrest.
  - Electric shocks also bring intense spasm, causing secondary accidents, such as tumble and falling.

Electrical Safety (3)

- Current intensity: The higher the current, the greater the harms to human bodies.
- Energized duration: The longer the energized duration, the lower the body impedance, and the greater the harms of electric shock.
- International Electrotechnical Commission (IEC) stipulated that the contact voltage threshold (equivalent to the safe voltage) is 50 V, and that no preventive measures against electric shocks are needed for 25 V or lower voltages.

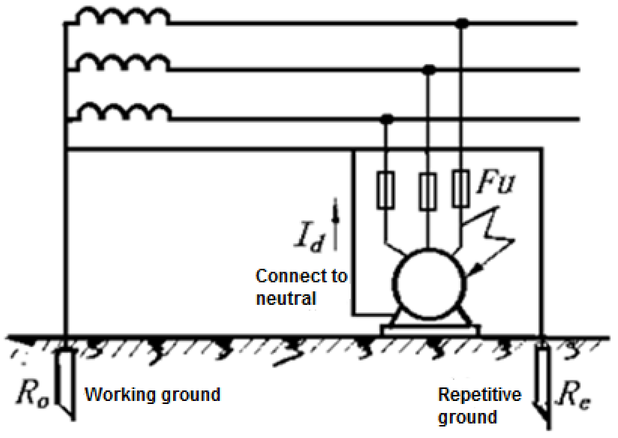
Electrical Safety (4)

- Protective Grounding and Protective Connecting to Neutral
  - Protective grounding means that a certain point of electrical devices or energized circuits is directly connected to the ground, or a certain point of the de-energized part is manually connected to the ground.
    - Working grounding refers the connection to the ground with a view to ensuring the normal operation of the power system, for instance, the neutral point grounding in the three-phase and four-wire low-voltage power distribution system.
    - Safe grounding refers to the connection to the ground with a view to ensuring personal and equipment safety, including protective grounding (against electric shocks), surge protection grounding, ESD grounding, and shield grounding.



Electrical Safety (5)

- Protective Grounding and Protective Connecting to Neutral
  - Protective connecting to neutral: refers to connecting the non-energized part of electrical devices in normal circumstances to the neutral wire of the power grid. It is worth noting that in the three-phase and four-wire power system, metal shells of the electrical devices are both grounded and connected to the neutral wire. This measure is called "repetitive grounding protection."



Electrical Safety (6)

- Surge Protection Measures
  - SPD types: Lightning rod, lightning wire, lightning net, lightning belt, and surge protector.
- Tips for individual lightning protection
  - Do not stay in open areas, mountain tops, ridges, or rooftops.
  - Do not stay near iron gates, metal clotheslines, and railway tracks.
  - Do not stay in the swimming pool, lakes, or seaside or under isolated trees.
  - Close doors and windows to avoid flank-striking lightning or lightning balls.

Electrical Safety (7)

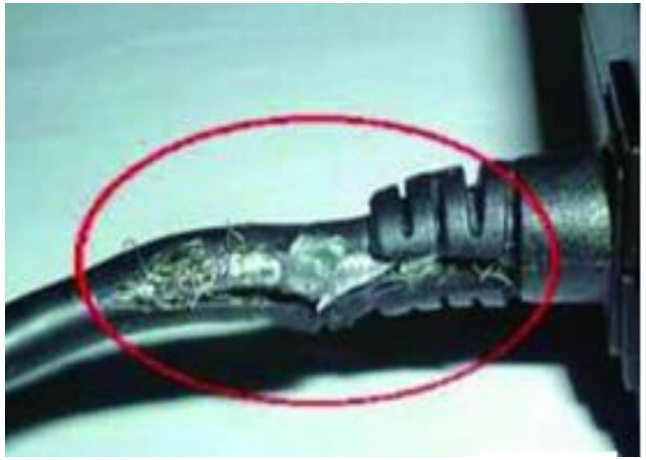
- Measures against body ESD accidents
  - Use ESD floor/shoes/socks (static electricity conducted to the ground from feet).Put on ESD footgear and stand on the ESD floor, mats, and carpets to form a combined grounding.
  - Wear an ESD wrist strap and ground it (static electricity conducted to the ground from hands).Discharge the static electricity on the body from hands. The ESD wrist strap is composed of an ESD elastic, snap, spring, resistor, and plug/clip. The inner layer of the elastic is braided with ESD yarns and the outer layer is braided with common yarns.

Electrical Safety (8)

- Establish comprehensive safety regulations and rules, and enhance the related education and trainings.
- Electrical operations must be performed by qualified personnel. Personnel without related certificates must not maintain or repair electrical devices or perform unauthorized operations.
- Electrical device safety
  - The electrical devices should be protected from corrosion and moisture.
  - The metal shells of electrical devices must be grounded (or connected to the neutral wire).
  - Do not use electrical devices over their rated values.

Electrical Safety (9)

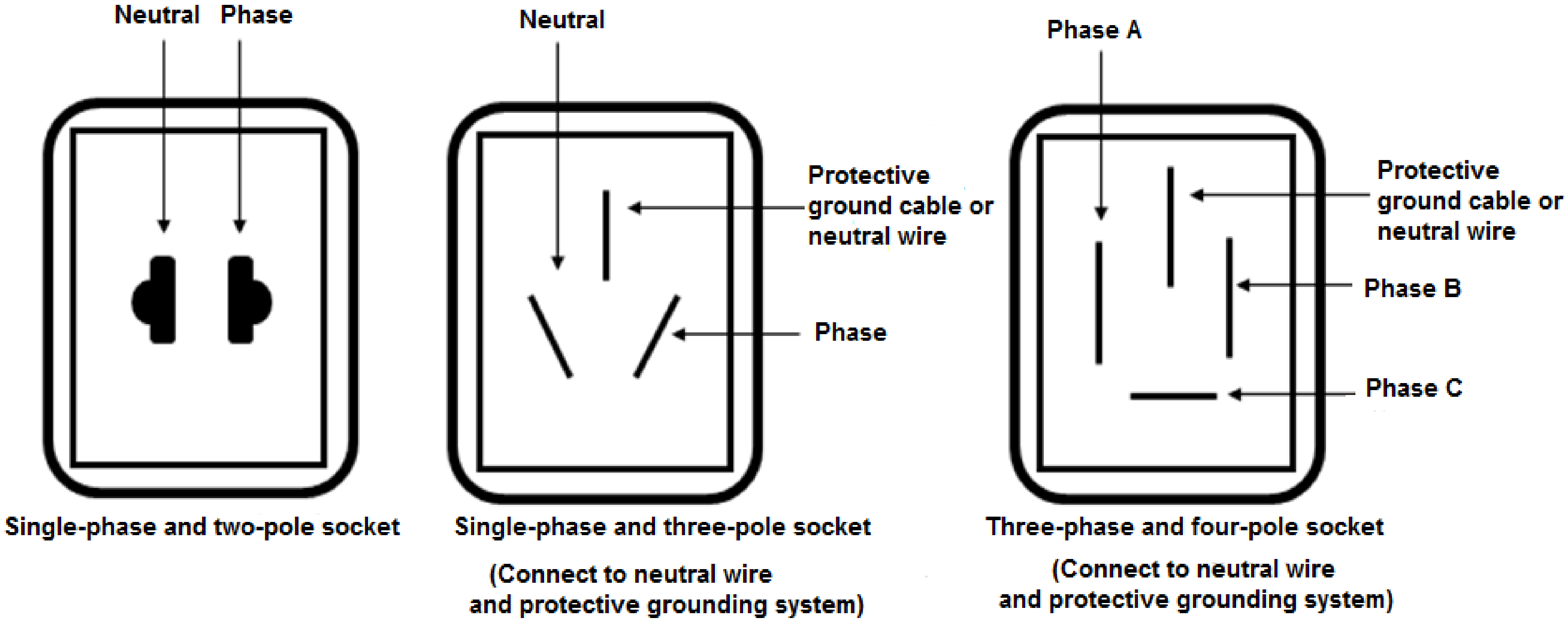
- Check the following items of instruments before working.
  - Insulation condition.
  - Validity period.
  - Voltage level.
- Implement the work ticket system when checking, maintaining, or cleaning the power-off electrical devices.
- To check, maintain, or clean the power-off electrical devices, the following safety measures must be taken.
  - Power off.
  - Check the power.
  - Install the ground cable.
  - Hang a sign and set a shelter.



Electrical Safety (10)

- Precautions Against Ground Cable Installation
  - All ground cables and the energized parts should be kept a proper distance required by regulations.
  - After checking that the device under maintenance is non-energized, promptly ground the device and perform a three-phase short circuit.
  - The ground resistance must meet requirements.
- Precautions Against Power Check
  - Put "Do not switch on." signs on handles that can power on the device.
  - Do not move or remove the shelter, ground, or other signs without permission during the construction.
- Operations performed after power-off must be carried out under supervision.
- Disconnect the power supply before you carry or move electrical devices.

Electrical Safety (11)



Welding Safety (1)

- Welder shells must be grounded or connected to the neutral wire. Only electricians are allowed to install or uninstall the welder power system. The insulation resistance between the winding and iron core as well as between the winding, lead, and shell should not be less than 0.5 mΩ in the primary and secondary winding self-check of the welder.
- The welder should be put in a rainproof place with good ventilation. Do not put combustible or explosive articles at the welding site. Wear protective equipment as required before welding.
- Welding tongs and cables must be well insulated and securely connected. Wear gloves before changing welding rods. When working in a damp environment, stand on the insulation rubber or wooden floors.
- Do not weld pressurized containers or pipes. Power off the electrical devices before welding them.
- Disconnect the power supply first before moving the welding cables as the working sites change. Do not climb a ladder holding welding cables.
- Clear the welding slag using the electric arc and wear protective glasses in the process to protect yourself.

Welding Safety (2)

- Outdoor welding operations are not allowed in thunderstorm days.
- Obtain a permit from relevant departments before welding in combustible and explosive gas and liquid diffusion areas.
- After the welding, disconnect the power supply from the welder, and check the site. Ensure that there is no fire hazard at the site before leaving.
- If combustible or explosive articles are stacked near the welding site, do not weld until they are completely removed or effective safety measures are taken.
- If a welding machine is on fire, disconnect the power supply from it first.
- Extinguish the fire using CO_2 or 1211 fire extinguishers. Do not use the foam fire extinguisher.
- Apply for the fire operation approval and surveillance measures in accordance with the site firefighting system before welding.

Battery Safety

- Basic protective measures (before battery installation and maintenance)
  - Use dedicated insulated tools.
  - Wear protective goggles and take other necessary protective measures.
  - Wear rubber gloves and a protective coat to guard against electrolyte overflow.
- Battery short circuit
  - To avoid battery short circuit, do not maintain batteries with power on.
- Hazardous gas
  - Lead-acid batteries in use emit flammable gas. Take ventilation and fireproofing measures at the sites where lead-acid batteries are used.
- Electrolyte leakage
  - Protect your skin and eyes from electrolyte leakage. If your body meets electrolyte leakage, wash with clean water immediately and visit a doctor.

A battery accident in an equipment room

Air Conditioner Safety (1)

- High temperature and high pressure
  - Misoperation may cause high system pressure, which leads to the refrigerant system to crack or explode.
  - Pay attention to high-temperature components, such as the compressor, refrigerant pipe and electric heater.
  - Pay attention to high-pressure components, such as the compressor and refrigerant pipe.
- Refrigerant frostbite
  - Refrigerant leakage may cause frostbite. Take protective measures (such as wearing goggles and antifreeze gloves) when handling refrigerant.
  - Pay attention to low-temperature components, such as the evaporator.
- High-speed operation
  - Pay attention to high-speed rotational components, such as fans.

Precision air conditioner

Air Conditioner Safety (2)

- Temperature of the R410a refrigerant can be as low as –52° C the second it ejects from the cylinder, which can instantly frostbite human skins and underlying muscles, and the frostbitten skins become necrotic. In addition, if humans inhale too much refrigerant in a short time, they are likely to be suffocated to death. Therefore, having a general knowledge of refrigerant leak types in operating air conditioners and familiarizing with the related countermeasures are crucial in ensuring the safety of operators.
- Minor leaks: If minor leaks occur in the pipe connection points or welding positions during the system running, tighten the connection ports, or re-weld the faulty positions after the system refrigerant is released. Minor leaks bring no personal injuries.

Air Conditioner Safety (3)

- Before welding the connection point of the indoor and outdoor units, completely exhaust nitrogen from the units, and ensure that related parts are in good condition.
- Wear protective goggles and antifreeze gloves when refrigerant is involved in the operation.

Goggles

Antifreeze gloves

- A nitrogen reducing valve must be equipped when operating the nitrogen cylinder.

Nitrogen reducing valve

Air Conditioner Safety (4)

- Pipe break or needle valve plug damage: When the air conditioning pipes break or the needle valve plug is damaged, there will be major refrigerant leaks. The following lists the correct way to solve this problem.
- Promptly open the doors of the air conditioner cabinets in a safe place.
- Evacuate all persons in the air conditioner room.
- Open all doors and windows that can be opened.
- After refrigerant in the air conditioning system leaks out completely and the air inside the air conditioner room is safe to breathe (no obvious smell), you are allowed to continue the next operation.
- Note: In the event of major refrigerant leaks, do not try to stop the leak.

Air Conditioner Safety (5)

- Refrigerant cylinder damage: When the upper body of the refrigerant cylinder breaks or the safety port bursts, there will be major refrigerant leaks. The following lists the correct way to solve this problem.
- Promptly open the doors of the air conditioner cabinets in a safe place.
- Evacuate all persons in the air conditioner room.
- Open all doors and windows that can be opened.
- After refrigerant in the cylinder leaks out completely and the air inside the air conditioner room is safe to breathe (no obvious smell), you are allowed to continue the next operation.
- Note: In the event of major refrigerant leaks, do not try to stop the leak.

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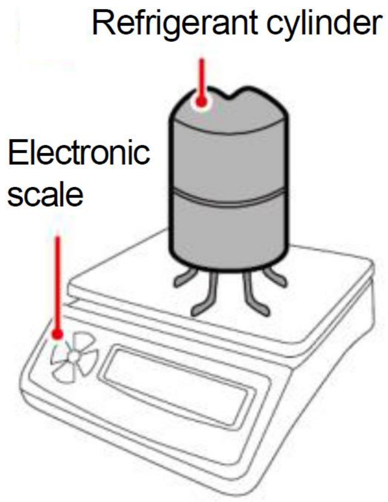
Air Conditioner Safety (6)

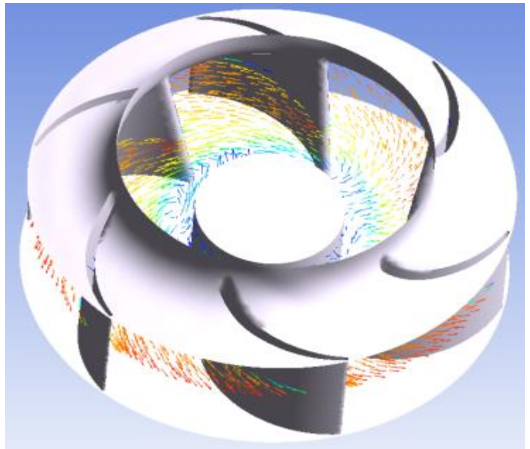
- Connection pipe damage during refrigerant charging: If leaks occur due to breaks or damage of the connection pipe during the refrigerant charging, promptly close the valves on both sides, and replace the connection pipe. If there is only one valve, (for example, the pipe is connected to the needle valve), promptly close the valve, disconnect the pipe from the other end, and then replace the connection pipe.



- Note: If one end of the connection pipe is disconnected due to leaks at that end, promptly place a heavy object on the pipe so that the high-pressure gas ejection will do no personal harms. Then, proceed following preceding instructions.

Air Conditioner Safety (7)

- Internal and external fans are high-speed rotational components, pay attention to the following instructions when maintaining them.
  - When maintaining the fans, motors, or adjacent components (such as fan guards), disconnect their power supply, and lock the power supply hangtag.
  - When operating such as maintaining adjacent the fans, prevent dropping tools or other articles in the rotating fans, because broken fans or other pieces flying out might hurt someone.
  - Do not wear hangers, such as necklace, employee ID card, and bracelet, when operating rotational components.



Quiz

1. (Multiple)Which of the following measures can reduce risks during transportation?
   A. Control transportation frequency and reduce fatigue
   B. Proper use of personal protective equipment
   C. Avoid strong wind interference.
   D. Good lighting conditions

Summary

- Introduction to EHS
- Accident Probability and Personnel Qualification
- PPE Protection Overview
- Engineering Construction Safety

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise：http://support.huawei.com/enterprise/
  - Online Learning：http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Data Center Facility Knowledge

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Foreword

- This slides describe the development, key components, common standards, and common energy consumption indicators of the data center infrastructure.

Objectives

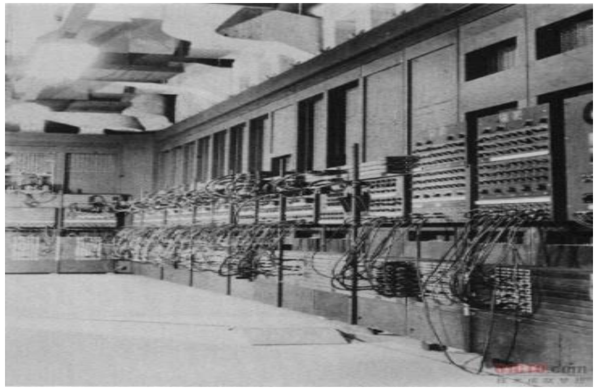
Upon completion of this course, you will:

- Know the history of data center development;
- Know the common standards of data centers;
- Know the composition and energy consumption indicators of data centers;
- Know the Huawei data center products.

Contents

Development History of Global Data Centers

- In 1942, the first electronic digital universal computer was born.
- Before 1990, data centers were mainly used for government and scientific research applications, but seldom for commercial applications. Data centers were large yet few.
- From 1991 to 2000, Internet companies emerged, so did commercial data centers. These data centers were small, but they increased gradually.
- From 2001 to 2011, the data volume from governments, the Internet, and financial transactions soared. Governmental and commercial data centers began to develop rapidly.
- Since 2012, cloud data centers have become a new trend around the globe thanks to the increase of data center technologies and applications.



Data Center Infrastructure Development Trend - Modular Data Center

- Small and medium data centers are constructed to be simple, easy to use, reliable, and controllable in operation and maintenance (O&M). Compared with traditional data centers, modular data centers have unparalleled advantages in the four aspects.
  - Integrated modular data centers are constructed quickly and have low requirements on the deployment environment.
  - Modular products can be pre-integrated and pre-commissioned in the factory in advance. They also provide the intelligent management function.
- For large data centers, the power density of information IT equipment is increasing. Modular data centers adopt in-row closely coupled cooling, which greatly improves the cooling efficiency. This adapts to the development trend of high power density.

Data Center Infrastructure Development Trend - Cloud Data Center

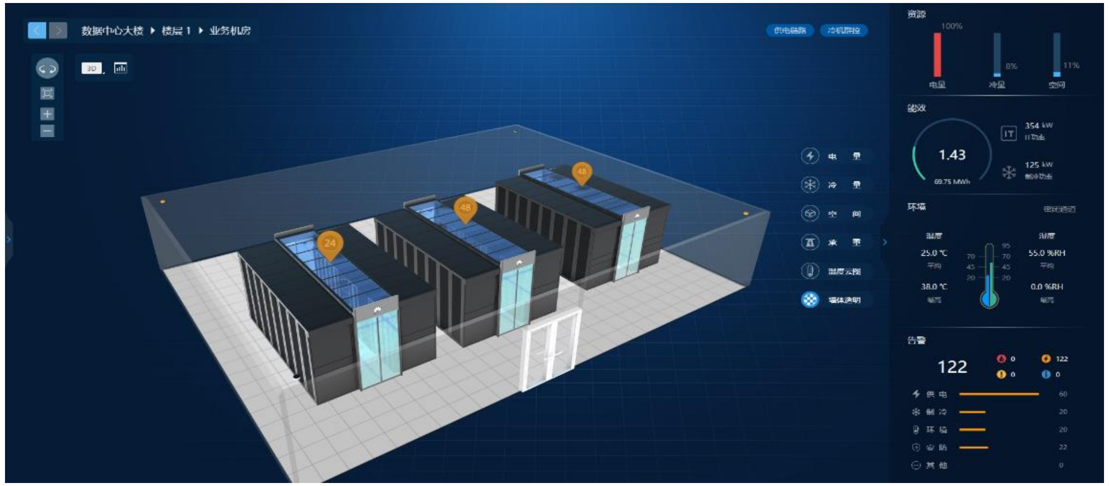
- The application and deepening of cloud computing promote the transformation of data center construction, operations management, and service modes.
  - Data traffic explosion, shared infrastructure, and improved resource utilization drive large-scale data centers.
  - Cloud computing enables flexible expansion, dynamic allocation, and centralized management and control of data centers.
  - The construction of cloud data centers creates new growth points and promote industry adjustment, transformation, and upgrade.
  - As the power consumption of data centers increases, a more efficient and energy-saving cooling system is required.

Data Center Infrastructure Development Trend - Environmental Protection

- With the rapid development in informatization, the construction of global data centers is accelerated. Their power consumption accounts for 1.1% to 1.5% of the global total.
- Clean energy, such as wind and solar energy, is increasingly used in data centers.
- There is a call for saving energy and reducing consumption to reduce power usage effectiveness (PUE) of data centers.

Data Center Infrastructure Development Trend - Intelligent Management

- Inefficient data centers lead to high costs, and data center infrastructure management (DCIM) is of vital importance.
  - Manage and monitor IT equipment, facility equipment, and IT processes in a unified manner.
  - Support resource management and asset management.
  - Support technologies such as real-time information, simulation, and remote monitoring.



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Introduction to Data Center Lifecycle

Planning

Design

Construction

Operation & Maintenance

Evaluation

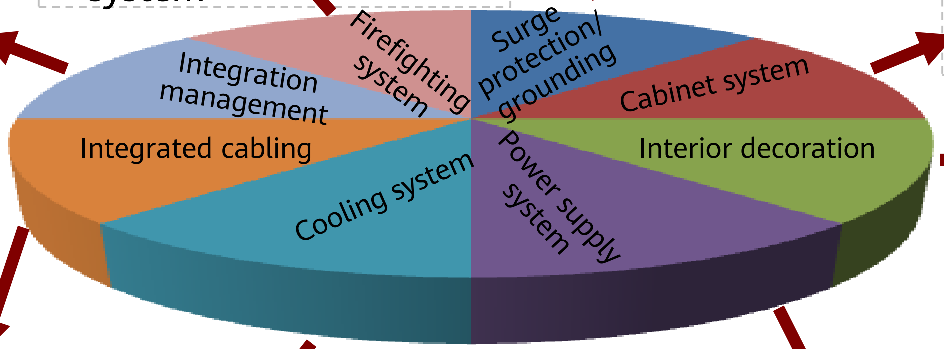
Contents

Composition of the Data Center Facility

- Fire detection system
- Smoke detection system
- Fire extinguishing system

- Transient surge voltage suppression device
- Ground protection system

- Integration management
- Access control
- CCTV
- Power and environment monitoring



- Precision air supply cabinet
- IT device cabinet

- Floor plan
- Doors & windows
- Walls & ceilings
- Raised floor
- Lighting

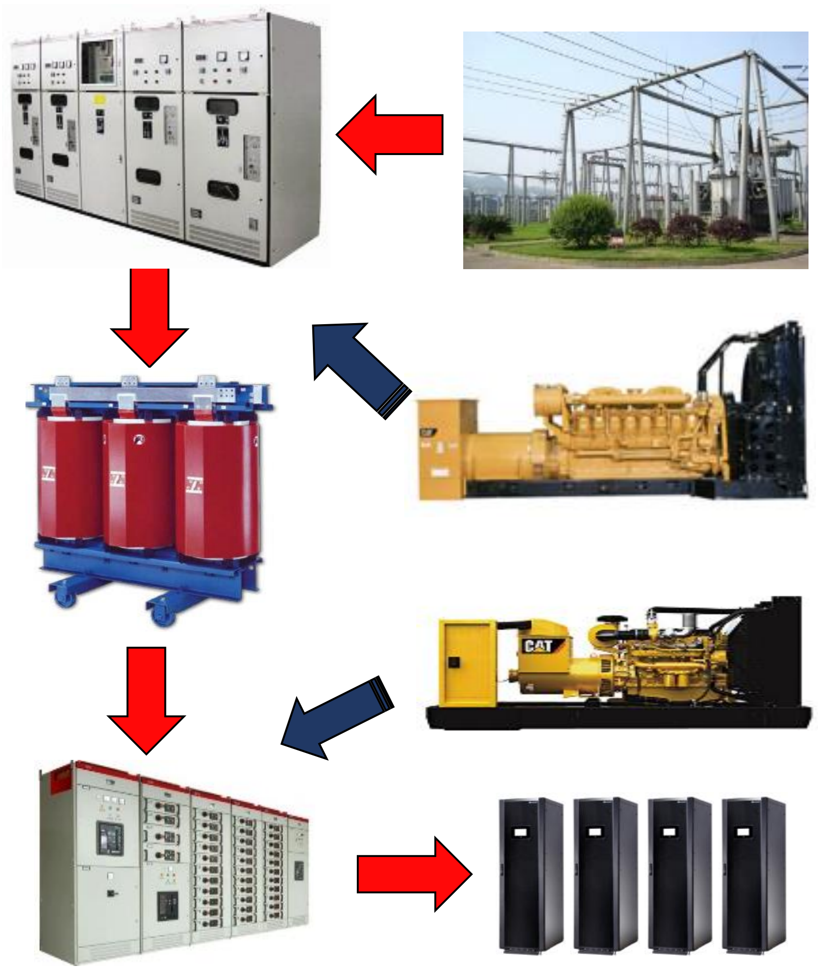
- Cable tray
- Optical distribution frame
- Cables & fibers
- Route label
- Cabling rack

- Precision air conditioner
- Comfort air conditioner
- Ventilation system

- DG & ATS
- UPS
- DC power cabinet
- AC power cabinet
- Static transfer switch
- Battery and battery rack
- Power cable

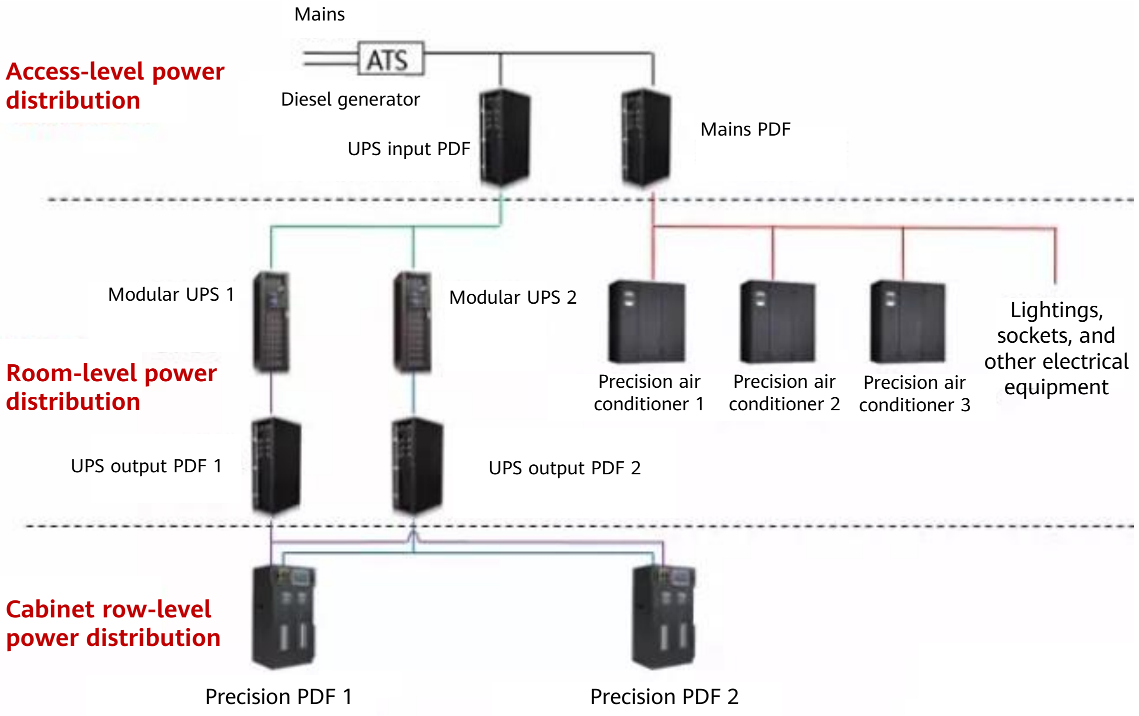
Power Supply System (1)

- High-voltage power transformation and distribution system: Converts the 6 kV/10 kV/35 kV three-phase mains to 380 V/400 V three-phase mains and distributes power for downstream low-voltage devices.
- DG system: As the backup power source, the DG system instantly supplies power to downstream devices once the mains power fails. There are low-voltage and medium-voltage DGs.
- Automatic transfer switch (ATS) system: Automatically switches between one mains and the other and between the mains and the DG.



Power Supply System (2)

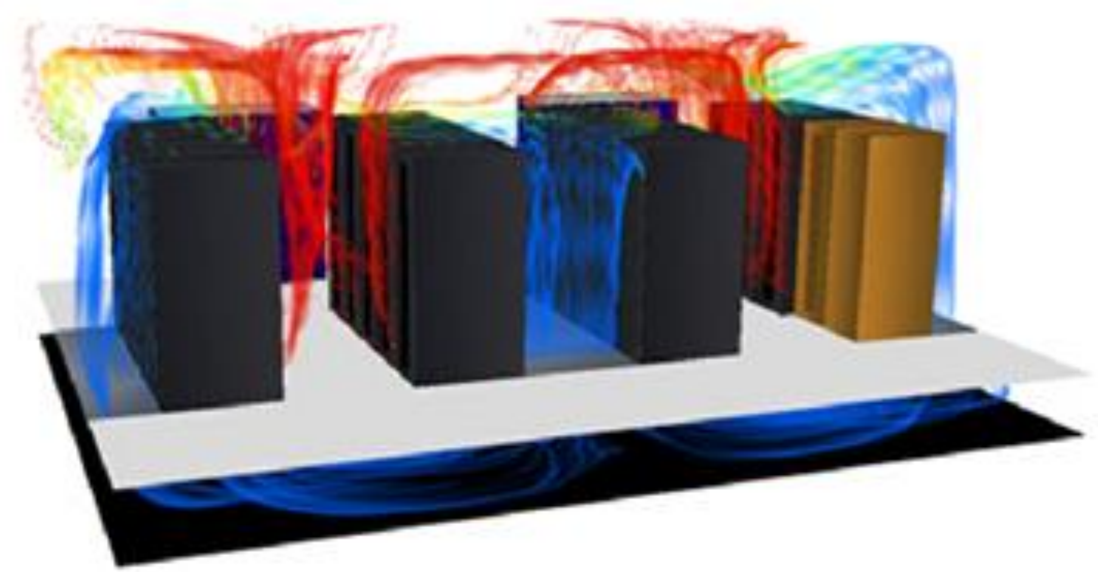
- Low-voltage distribution system: distributes the upstream electric energy to various electrical equipment, such as the uninterruptible power system (UPS), air conditioner, and lighting equipment, based on requirements, standards, and specifications.
- UPS system: purifies and backs up electric energy, and provides pure and reliable power protection for IT loads.
- UPS output power distribution system: distributes the UPS output electric energy to various IT equipment based on requirements and standards.
- Rack power distribution system: distributes the electric energy inside the racks.
- –48 V DC power supply: provides safe and reliable power supply for communication equipment.



Common power distribution architecture of data centers

Cooling System (1)

- With the development of the society and the application of new technologies, the power consumption and power density of the data center increase significantly. The cooling system ensures that the equipment in a data center work in a proper environment.



- Large sensible heat
- Low latent heat
- Large air volume and small enthalpy difference
- Non-stop operation and perennial cooling
- Multiple air flow modes
- Plenum chamber air supply
- Strict requirements for temperature, humidity, and cleanliness

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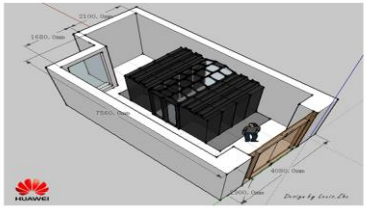
Cooling System (2)

- Based on the scale and total capacity of data centers, there are now two prevalent solutions: air cooled cooling system and chilled water cooling system. In general, the chilled water solution is primarily used in extra large and large-sized data centers, and the air cooled solution is usually used in small- and medium-sized data centers.

Independent room



Functional zoning for each floor

Building equipment room

Warehouse equipment room

Air cooled

500 m^2

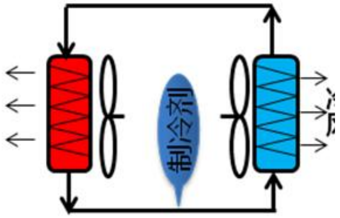
Air cooled or chilled water

1000 m^2

(2 MW)

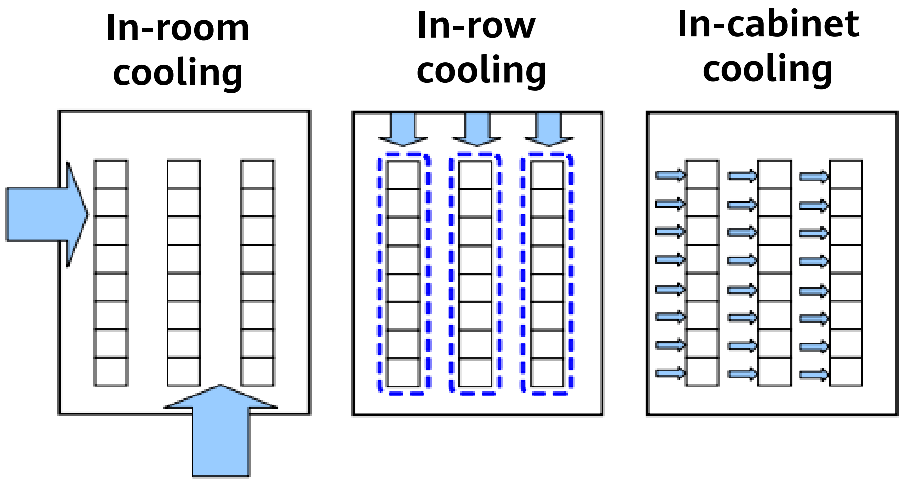
Chilled water

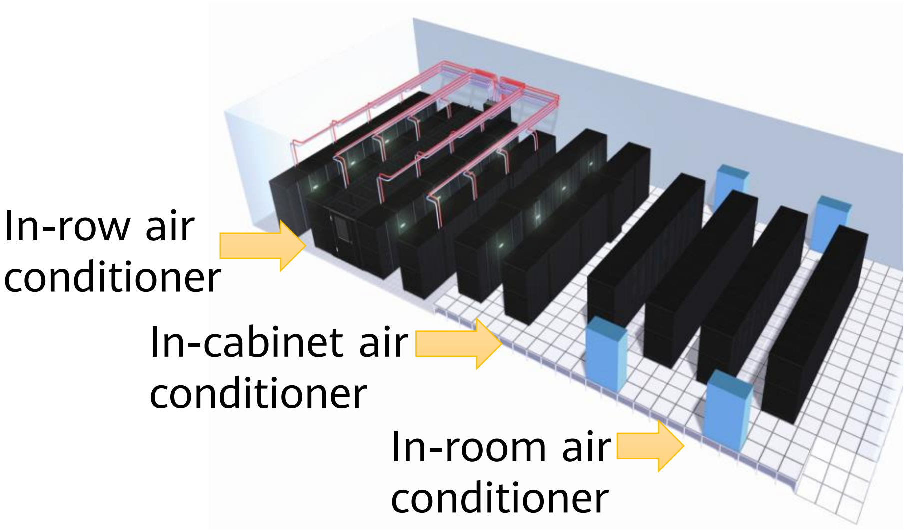
Equipment room scale



Cooling System (3)

- Three cooling configurations: equipment room cooling, in-row cooling, and cabinet cooling.

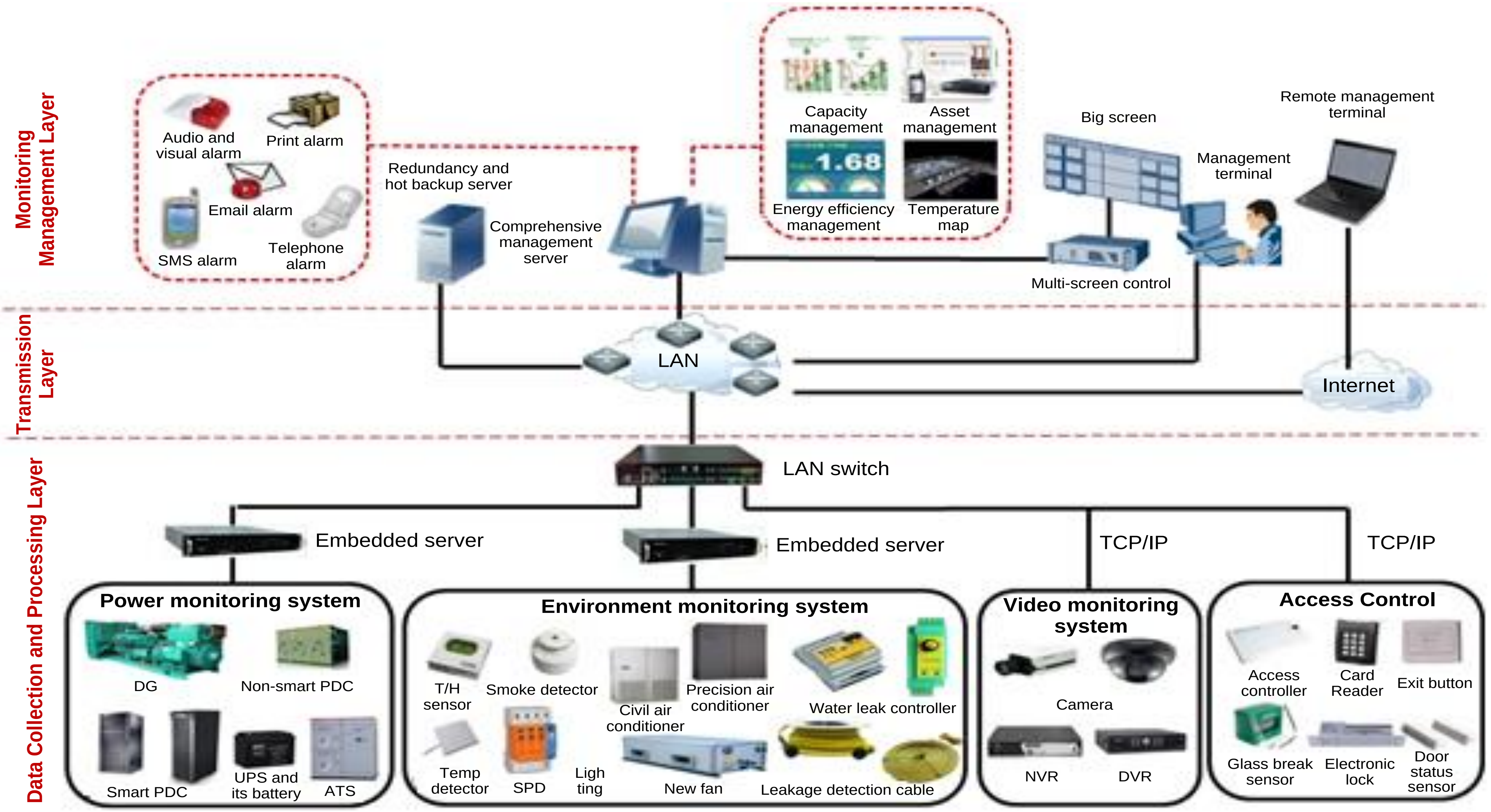




Data Center Integrated Management (1)

- Concept: The monitoring system in the equipment room implements central monitoring and maintenance management over the power and environment in the equipment room to improve the reliability of the data center and security of data devices, facilitate O&M, and increase management efficiency.
- Objects: The power system, environment system, firefighting system, and security system are the primary objects to be monitored.
- Functions: Based on the integrated network cabling system, the monitoring system in the equipment room adopts distributed monitoring, with the host placed in the monitoring room to run the software, to monitor all subsystems in a centralized manner using a uniform LCD. The monitoring system can monitor the operating status and parameters of all devices in real time, promptly generate alarms in forms of multimedia, voice, calls, and SMS when some components or parameters are abnormal, record historical data and alarms, and intelligently provide expert diagnosis, remote monitoring management, and web browsing.

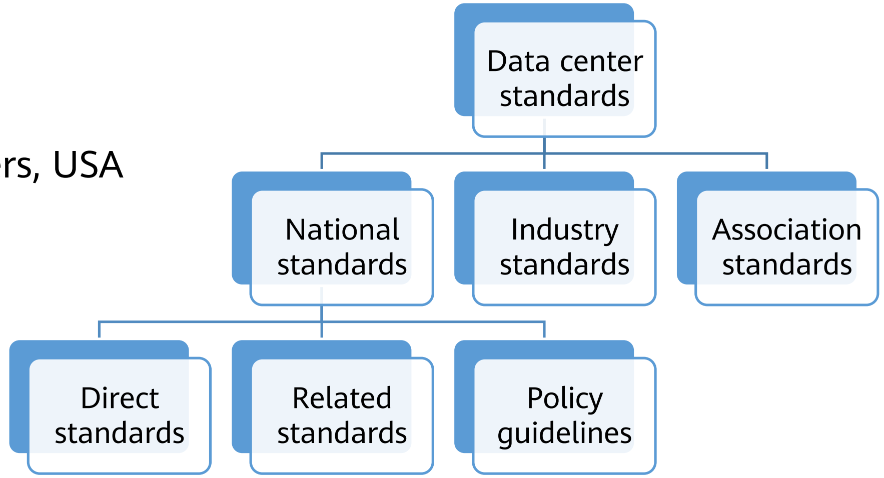
Data Center Integrated Management (2)



Contents

Overview of Data Center Standards

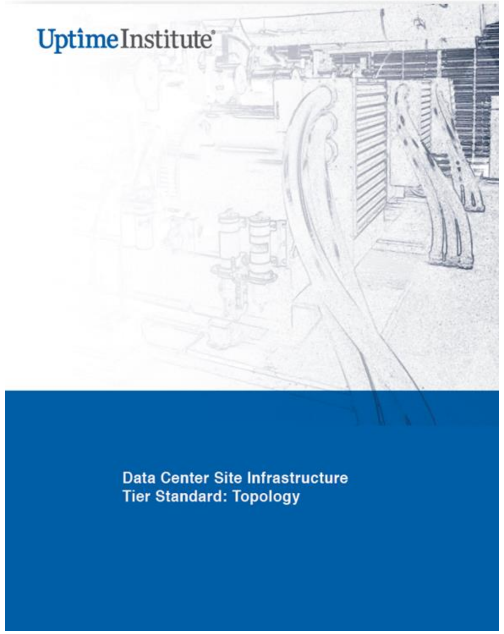
- Standards are a way to unify the language and reduce communication costs. They are designed to make things simpler.
- General standards
  - Code for Design of Data Centers (GB 50174-2017)
  - Data Center Site Infrastructure Tier Standard – Operational Sustainability
  - Data Center Site Infrastructure Tier Standard – Topology
  - TIA-942-B-2017, Telecommunication Infrastructure Standard for Data Centers, USA



Introduction to Uptime Tier Standards

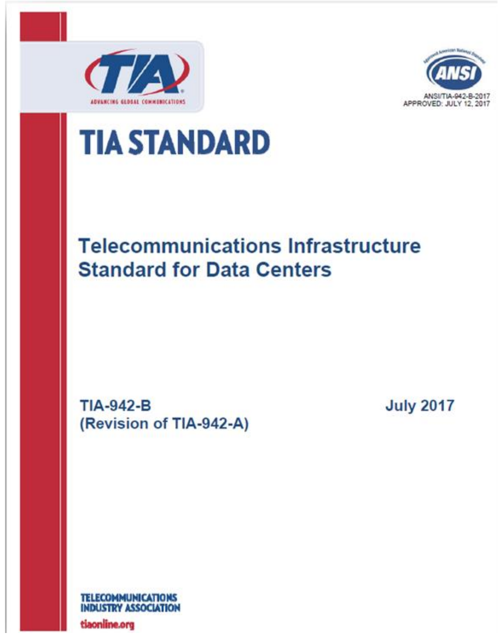
- The Uptime Institute is a well-known data center standards organization and an independent certifier. Uptime Tier certification consists of three parts: Tier Certification of Design Documents, Tier Certification of Constructed Facility, and Tier Certification of Operational Sustainability.

- According to the Uptime Tier standards, data center infrastructure is classified into four levels:
  - Tier I: Basic Data Center Site Infrastructure
  - Tier II: Redundant Site Infrastructure Capacity Components
  - Tier III: Concurrently Maintainable Site Infrastructure
  - Tier IV: Fault Tolerant Site Infrastructure



Introduction to TIA-942 Standard

- TIA-942-B-2017 is *Telecommunications Infrastructure Standard for Data Centers* released by the USA. It classifies data centers into four classes based on the usefulness and security of infrastructure. Its appendix describes the technical requirements of the four classes for telecommunications, architectural infrastructure, electrical, and mechanical infrastructure.
  - I Data Center: Basic
  - II Data Center: Redundant Component
  - III Data Center: Concurrently Maintainable
  - IV Data Center: Fault Tolerant



Introduction to Other Standards (1)

- ISO/IEC 30134 series standards, including five volumes
  - Overview and general requirements - 2016
  - Power usage effectiveness (PUE) - 2016
  - Renewable energy factor (REF) - 2016
  - IT equipment energy efficiency for servers (ITEE) - 2017
  - IT equipment utilization for servers (ITEU_SV) - 2017

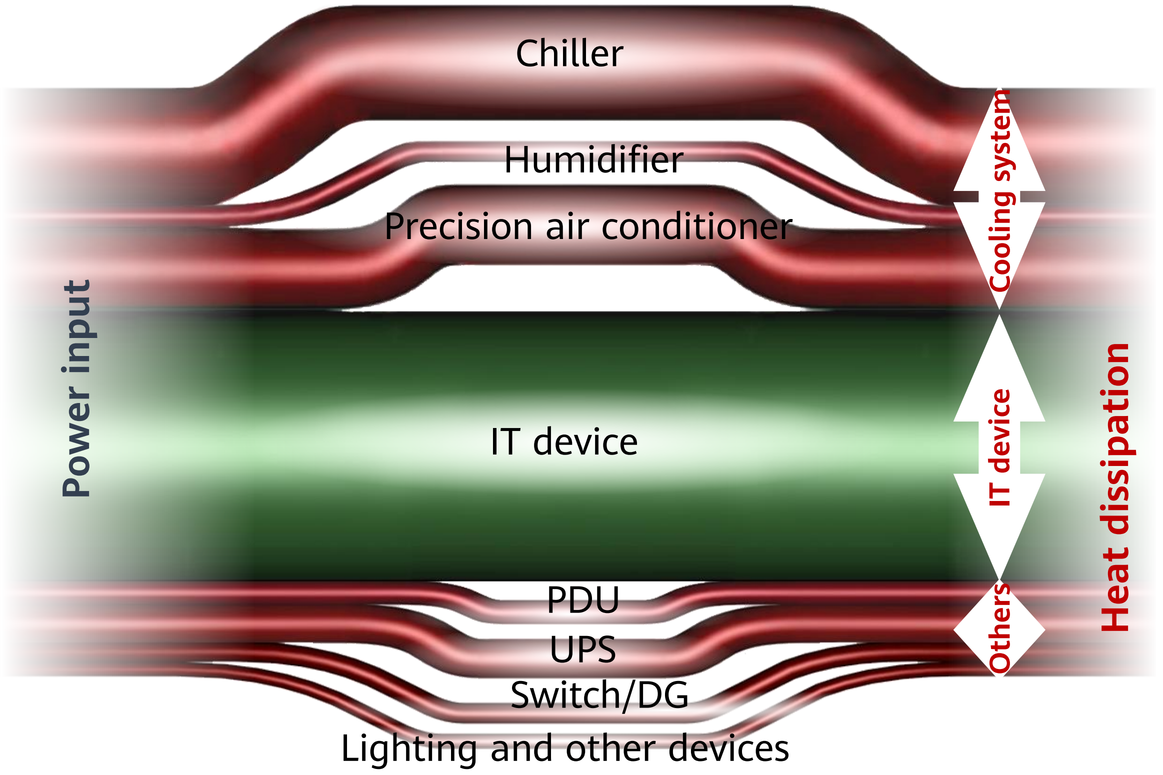
Introduction to Other Standards (2)

- EU EN 50600 series standards
  - By 2017, the European Committee for Electrotechnical Standardization (CENELEC) of the European Union (EU) has released the EN 50600 series standards, which include four parts in 10 standard texts. The EN 50600 series standards specify three levels of systems for availability, physical security, and energy efficiency implementation. It also provides requirements and suggestions on data center operation, processes and management.
- Japan JDCC FS-001 standard
  - Based on the TIA-942 standard, the JDCC FS-001 standard classifies data centers into four levels. It is also supplemented and modified based on the actual situation of Japan. The JDCC FS-001 standard incorporates the unique elements of Japan, including earthquake risk and assessment, reliability of commercial electric power, and products of high efficiency, and reliability.

Contents

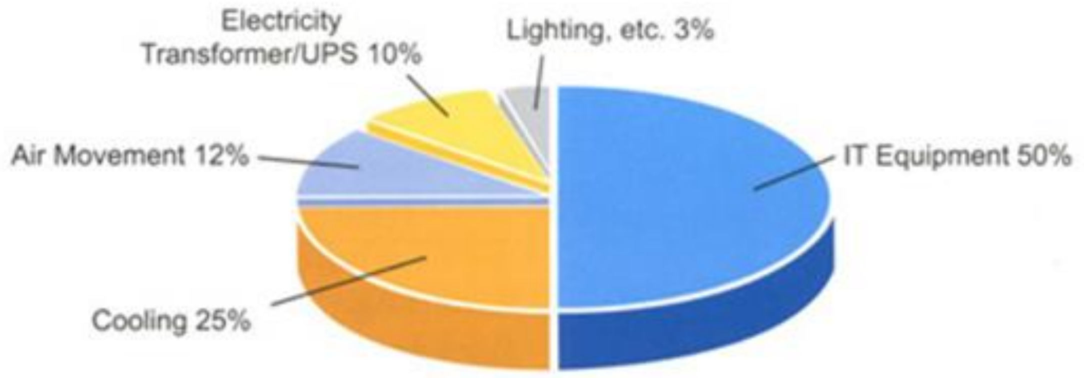
Data Center Power Consumption (1)

- Power consumption of data centers includes the IT device loads, cooling device loads, lighting loads, and device power losses.
- Because the power consumption of IT devices is difficult to reduce and that of the cooling system is the lion's share, lowering the power consumption of the cooling system is the key to improve the energy efficiency of the data center.



Data Center Power Consumption (2)

- Main sources of the data center energy consumption include the IT devices, lighting system, air conditioner, and power and distribution system. A lot of enterprises and scholars across the world made significant research in the data center energy consumption. Though the results differ in the exact proportion of each factor, the factors that constitute the energy consumption and the order of these factors by importance are largely the same.



Energy consumption distribution of data centers (source: Lawrence Berkeley National Laboratory)

Power Consumption Index - PUE

- Power usage effectiveness (PUE) is a widely-used comprehensive indicator inside and outside China that measures the data center infrastructure efficiency (DCiE). The formula is: PUE = P_{Total}/P_{IT}, where P_{Total} indicates the total power consumption of the data center and P_{IT} indicates the power consumption of the IT devices.

PUE= P_{Total}/P_{IT}

DCiE = P_{IT}/P_{Total}

PUE	DCiE	Energy Efficiency Level
3.0	33%	Extremely poor
2.5	40%	Poor
2.0	50%	Average
1.5	67%	Good
1.2	83%	Excellent

Power Consumption Index - pPUE

- Partial PUE (pPUE) is an extension to the PUE concept and used to evaluate and analyze the energy efficiency of part of the data center or devices.
- Before the pPUE is performed, the data center should be divided into different zones. The zone can be an equipment room in a multi-story data center building or a container module in a container data center.
- pPUE is used to represent the energy efficiency of some zones or devices, and can be greater or less than the PUE. Generally, to improve the overall efficiency, we must first ameliorate the efficiency of devices or zones with greater pPUE values in the data center. pPUE is applicable to the partial energy efficiency evaluation of modular data centers built based on containers or other modular units, or large-sized data centers composed of many buildings and equipment rooms.

Power Consumption Index - CLF/PLF

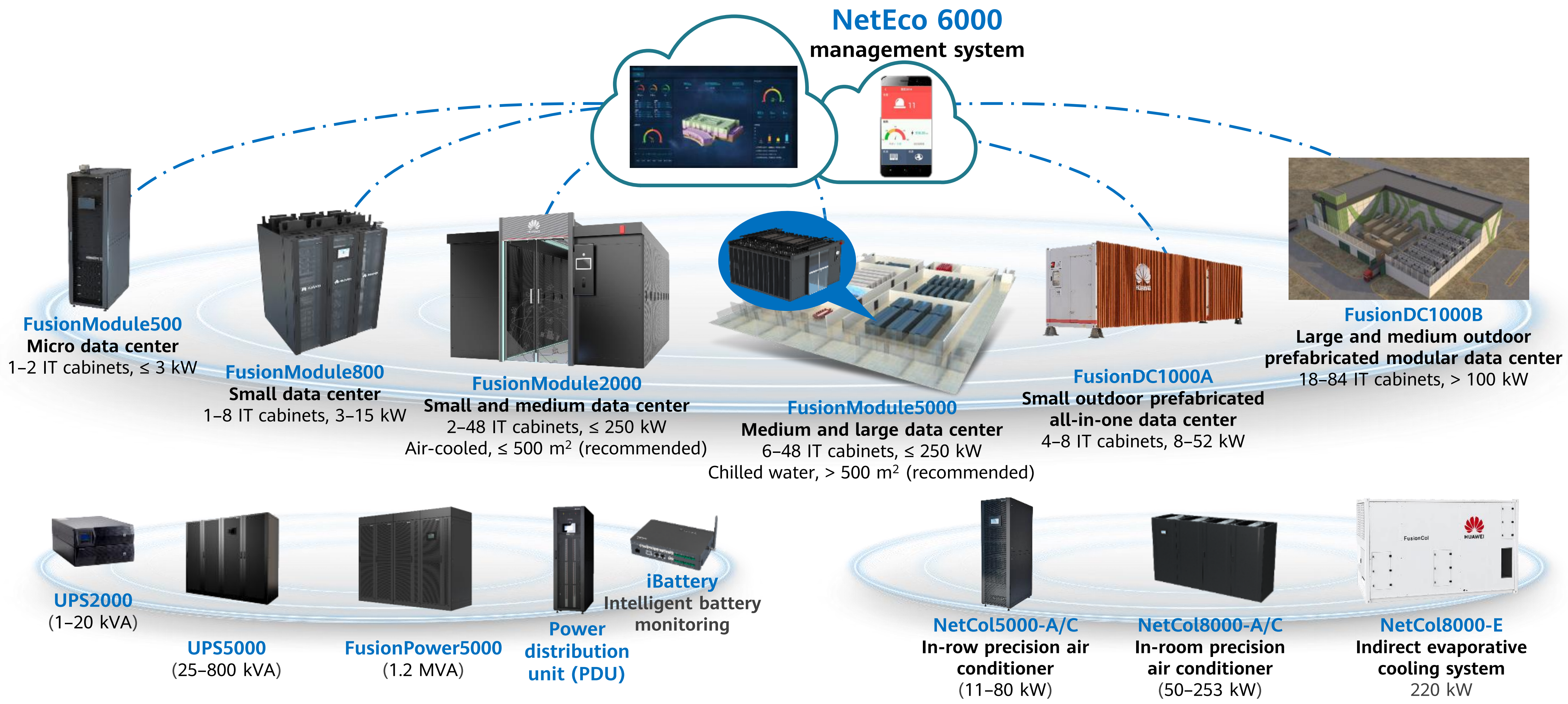
- CLF is short for cooling load factor and PLF power load factor. CLF is used to represent the ratio between the power consumption of the cooling devices and that of the IT devices. PLF is used to represent the ratio between the power consumption of the power and distribution system and that of the IT devices.
- CLF and PLF are supplements and extensions to PUE. Calculating CLF and PLF can help you analyze in a detailed manner the respective energy efficiency of the cooling system and power and distribution system.

Power Consumption Index - RER

- Renewable energy ratio (RER) is used to measure the utilization of renewable sources to renew the solar energy, wind energy, and hydro energy, and promote the use of carbon-free or low-carbon sources. In general, renewable energy indicates recyclable energy sources in nature, such as the solar energy, wind energy, hydro energy, biomass energy, geothermal energy, and ocean energy. Renewable energy sources are environment-friendly in use, widely distributed, and can be exploited locally. Fossil fuels, such as coal, oil, and gas, and nuclear energy constitute the counterpart of renewable energy.
- In particular, RER is a new indicator proposed at the China Cloud Computing Promotion and Policy Forum in light of the fast growth of renewable energy sources in China. Now, RER is submitted to The Green Grid (TGG), an internationally-renowned organization that commits itself to improving the IT efficiency, for discussion.

Contents

Panorama of Huawei Data Center Solutions



Quiz

1. (Single)Which of the following belong to the power supply system?

   A. UPS

   B. CCTV

   C. Access control system

   D. Cable tray

2. (Single)Which of the following is not an energy consumption indicator of a data center?

   A. PUE

   B. pPUE

   C. RER

   D. PFC

Summary

- Introduction to Data Center Development
- Composition of Data Center Infrastructure
- Introduction to Data Center Standards
- Common Energy Consumption Indicators
- Panorama of Huawei Data Center Solutions

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise： http://support.huawei.com/enterprise/
  - Online Learning： http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Basic Knowledge of Power Distribution

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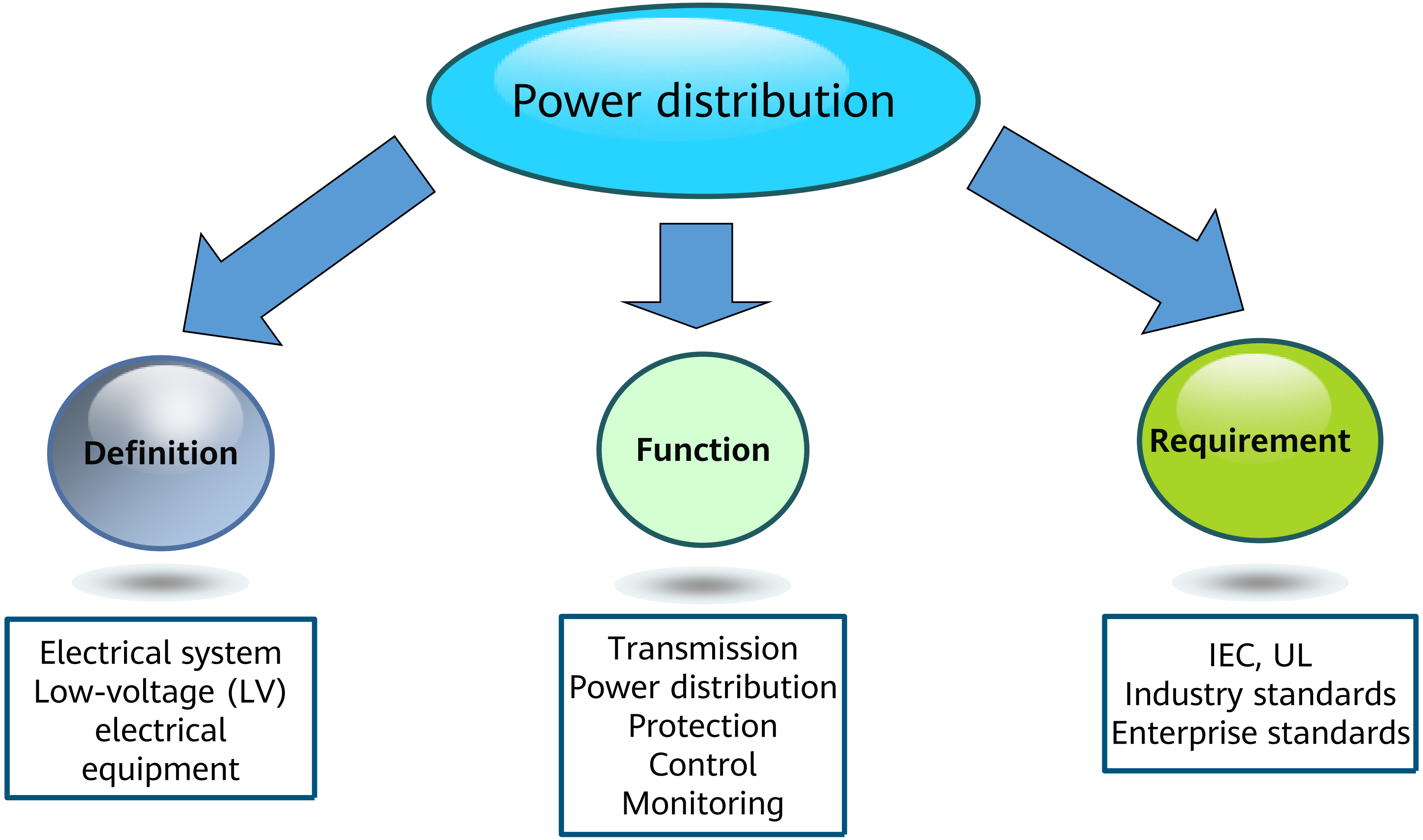
Objectives

After learning this course, you will be able to:

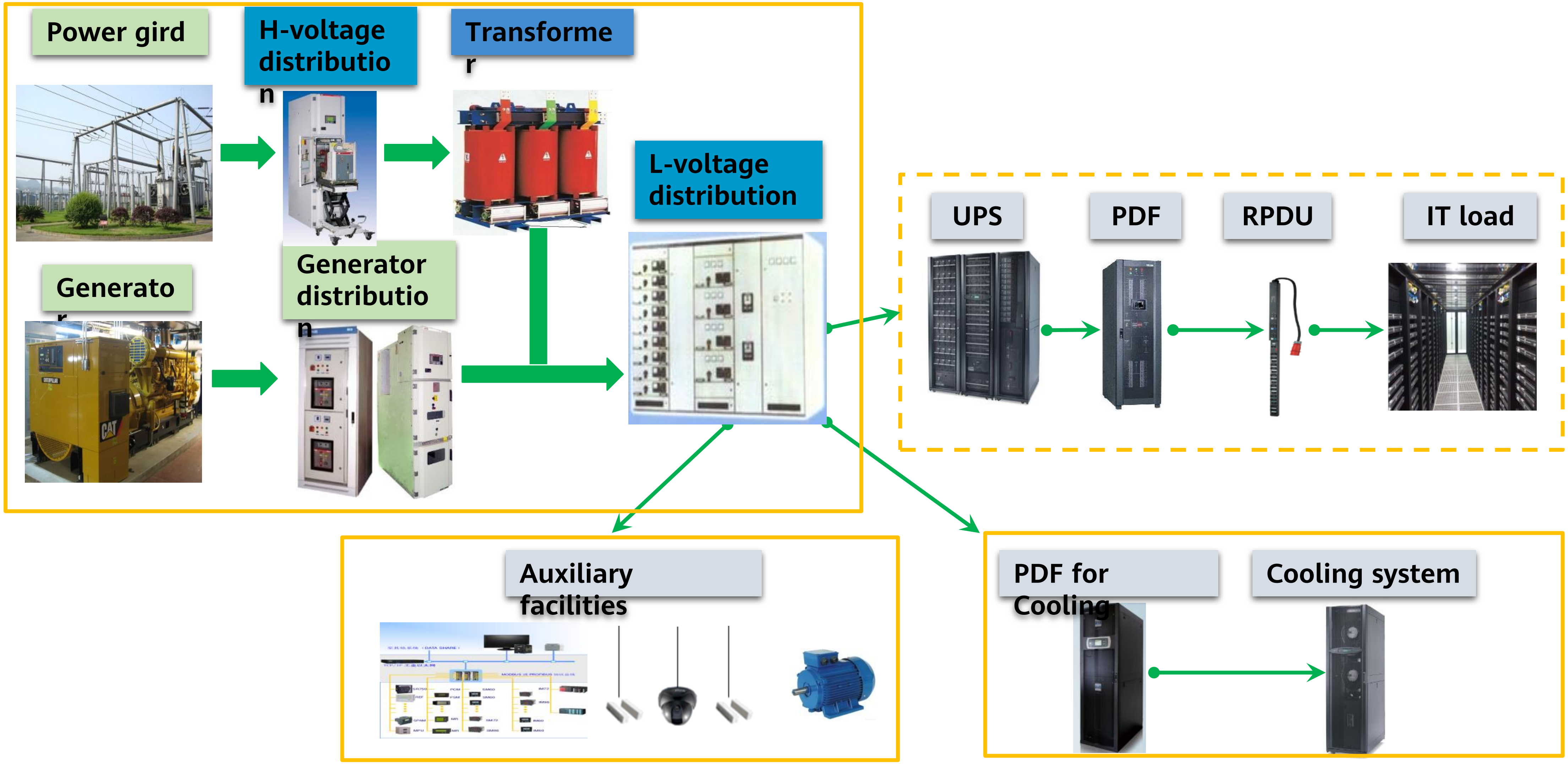
- Understand the basic concepts of power distribution
- Know the grounding system
- Know the common power distribution products

Contents

What Is Power Distribution?



Data Center Distribution System



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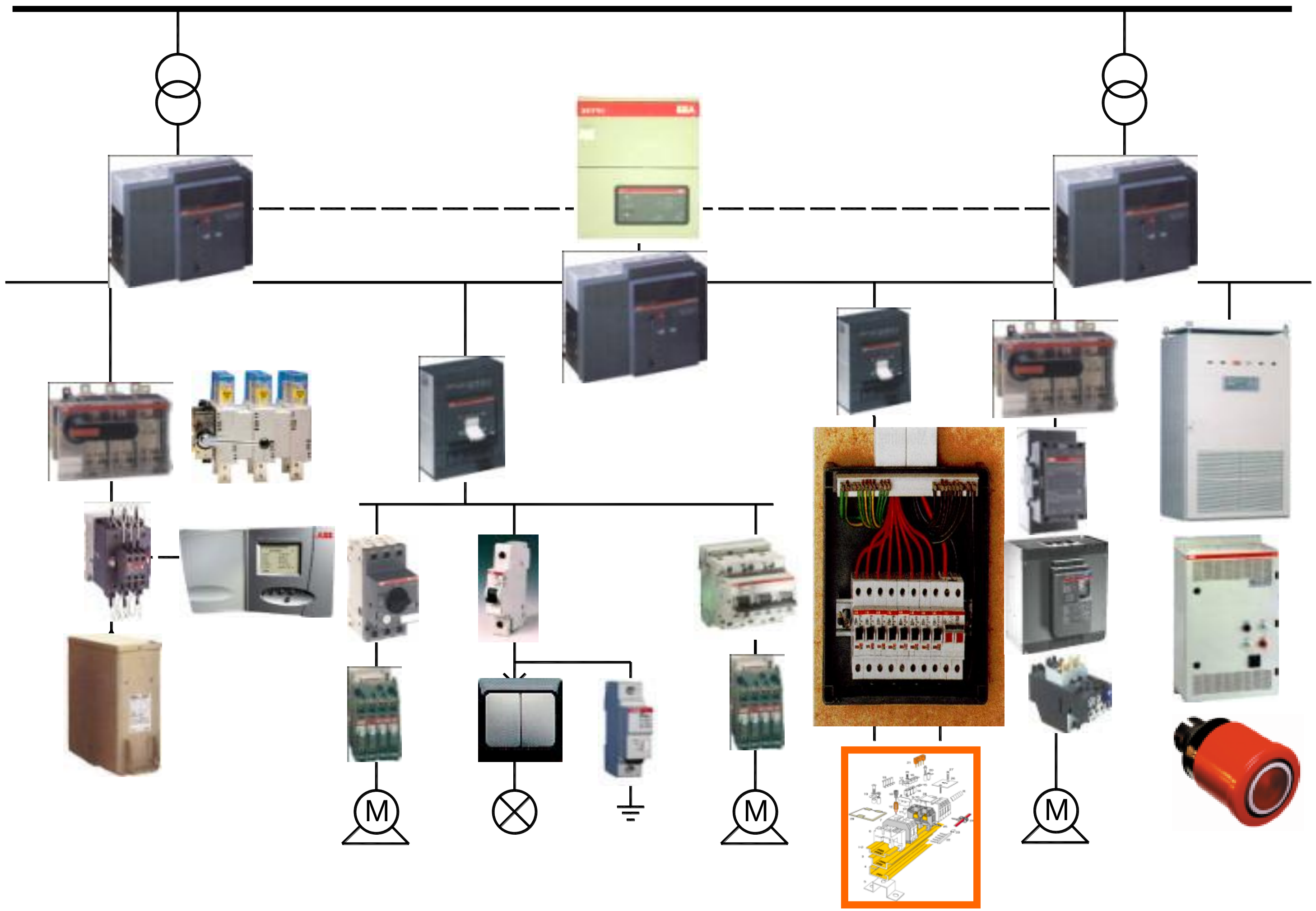
Low-Voltage Electrical Devices

Level.A：
ACB

Level.B ：
MCCB

Level.C ：
MCB

IT load



Contents

Power Supply

- Dual power supplies: A load has two power supplies, which are considered independent of each other for safety.
- Emergency power supply system: To ensure personal safety, the emergency power supply system protects the environment and other equipment from being damaged.
- Emergency power supply (power supply for safety facilities): It serves as a part of the emergency power supply system.
  - In data centers, it means power supply for emergency lights, fire pumps, and other safety equipment.
- Standby power supply: When the normal power supply is powered off, the standby power supply is used to maintain the power supply required by the equipment for non-safety reasons.
  - The standby power supply can be a generator set or a dedicated feed loop independent of the normal power supply.

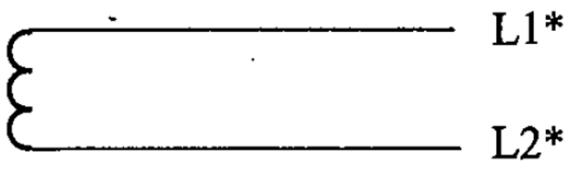
Power Supply Requirements

- Uptime Institute Uptime specifies the power supply reliability requirements of data centers of different levels.

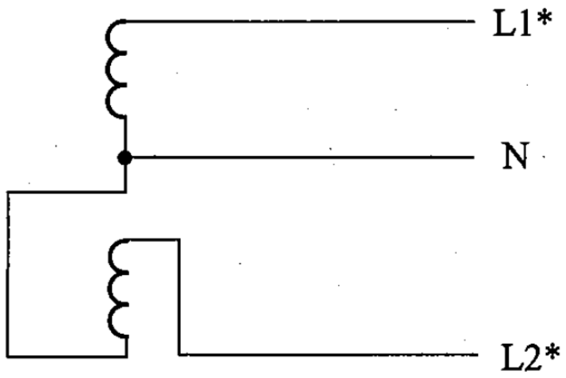
Data Center Tier	Tier IV	Tier III	Tier II	Tier I
Overall function requirement	Fault tolerance (one fault), active-active power supply and distribution routes	Planned online maintenance, active-standby power supply and distribution routes	One power supply and distribution route	One power supply and distribution route
Mains input requirement	/	/	/	/
DG requirement	2N is recommended, but N+1 can also be used.	N+1	N+1	N
UPS requirement	2N	N+1	N+1	N
Backup time requirement	Meeting DG startup requirements	Meeting DG startup requirements	Meeting DG startup requirements	Meeting DG startup requirements
DG fuel storage requirement	12 hours	12 hours	12 hours	No specific requirements

Voltage

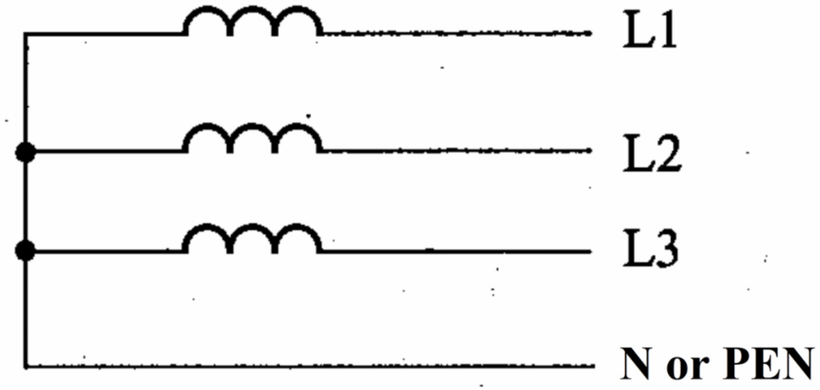
- The power grid transmits 110 kV, 35 kV, 20 kV, and 10 kV power to enterprises. Then the transformer decreases the voltage to 380 V, and the LV power distribution system transmits the power to the power-consuming equipment in data centers.
- When 220 V/380 V single-phase power-consuming equipment is connected to a three-phase system, it is recommended that the three phases be balanced.
- For the 220 V load supplied by the LV power grid, if the line current is less than or equal to 60 A, the 220 V single-phase power supply can be used. When the line current is greater than 60 A, the 380 V three-phase four-wire power supply is recommended.



Single-phase, two-wire



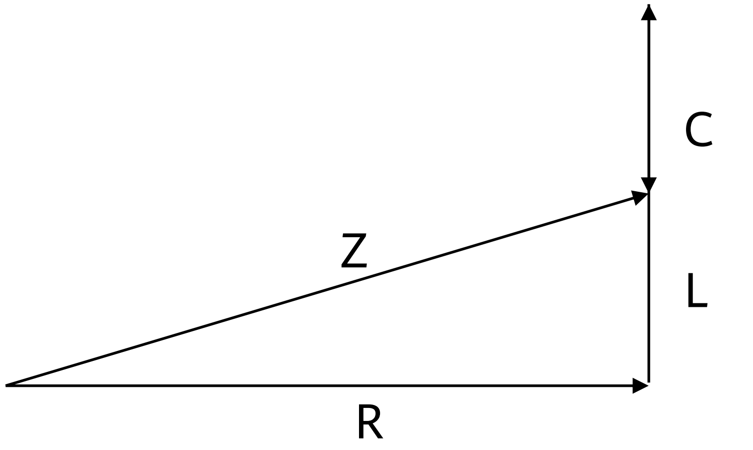
Single-phase, three-wire



Three-phase, four-wire

Load Characteristics: Resistor, Capacitor, and Inductor

- Resistors have the function of blocking current and can be used as electric heating parts to convert electric energy into internal energy. It is marked as R or r, and the unit is ohm.
- Capacitors are two unconnected plates used to store and discharge electric charges, converting electrical energy into electric field energy. It is marked as C, and the unit is F.
- Inductors are spiral coils, in which a changing magnetic field is generated by changing a current, and the magnetic field is prevented from converting electric energy into magnetic energy by changing a magnetic flux. It is marked as L, and the unit is H.



Impedance vector diagram

R: Resistor

L: Inductor

C: Capacitor

Z: Impedance

Power

- There are three kinds of power supplied to the load by the power supply: active power, reactive power, and apparent power.
  - Active power (P): the power that can convert electric energy into other forms of energy and can be directly consumed

  The formula for calculating the power of a three-phase circuit is as follows: $P = \sqrt{3}UI\cos\phi$

  - Reactive power (Q): When the load contains inductors or capacitors, the equipment generates reactive power. Equipment such as transformers and motors require the magnetic field generated by reactive power to work. Therefore, reactive power is not useless.

  The formula for calculating the power of a three-phase circuit is as follows: $Q = \sqrt{3}UI\sin\phi$

  - Apparent power (S): the sum of active power P and reactive power Q

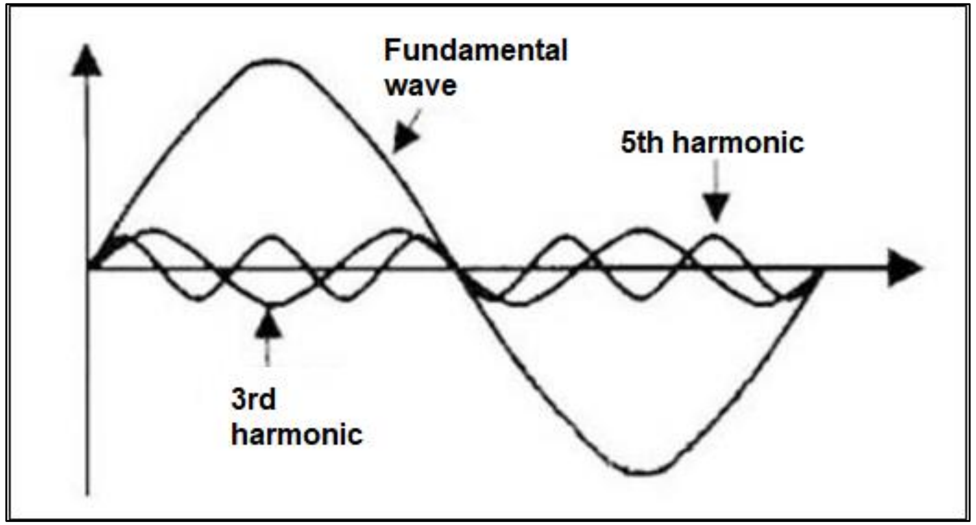
  The formula for calculating the power of a three-phase circuit is as follows: $S^2 = Q^2 + P^2 = \sqrt{3}UI$

Power Quality and Harmonic

- Power quality: refers to the voltage quality, that is, the quality of the voltage amplitude, frequency, and waveform. The main technical specifications include harmonic, voltage deviation, power supply interruption, three-phase voltage imbalance, and voltage fluctuation and flicker. The ideal power quality means the sinusoidal voltage with constant power and constant amplitude, as well as continuous power supply.
- Power quality issues may cause great loss to data centers. Common power quality issues of data centers include harmonic, voltage deviation, and power supply interruption.
- We will focus on these three issues this time.

Power Quality and Harmonic

- Harmonic: In the AC power grid, the voltage and current waveforms of much non-linear electrical equipment are not complete sine waveforms. The part that is the same as the industrial frequency (50 Hz) is the fundamental wave. The wave whose frequency is a multiple of the fundamental wave frequency (greater than 1) is the harmonic wave.



Harmonic diagram

Voltage Deviation

- The voltage deviation is the relative deviation of the operating voltage to the nominal voltage of the power supply and distribution system under normal operating conditions. The value is expressed in percentage:

$$\Delta u = \frac{U - U_n}{U_n} \times 100\%.$$

Δu : voltage deviation percentage, 100%

U : operating voltage (V)

U_n : nominal voltage of the system (V)

Power Supply Reliability

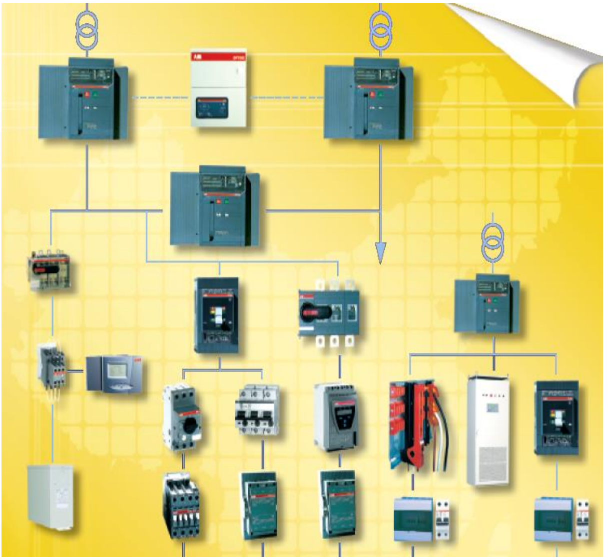
- Power supply reliability: refers to the continuous power supply capability of a power supply system.
- The electric energy of a data center is mainly from the power grid. The power supply reliability of the power grid directly affects the power supply system architecture (power supply configuration and battery configuration) of the data center. The mains power supply reliability is classified into the following types.

Type	Power Outage Times (Times/Year)	Power Outage Duration (Hours/Times)
Class 1 power supply	≤ 12	≤ 0.5
Class 2 power supply	≤ 42	≤ 6
Class 3 power supply	≤ 54	≤ 8
Class 4 power supply	Seasonal long-time power outage occurs or no mains is available.	

Contents

LV Power Distribution Equipment

- Definition
  - Based on the usage requirements and control signals, the LV power distribution equipment can connect and disconnect the circuits with the rated voltage of 1000 V AC or 1500 V DC or below using one or more components manually or automatically to control, adjust, convert, detect, and protect the controlled objects in the circuit.
- Common equipment
  - Conversion equipment: transformer and diesel generator (DG)
  - Control equipment: power distribution frame (PDF), circuit breaker, and fuse
  - Auxiliary materials: cables

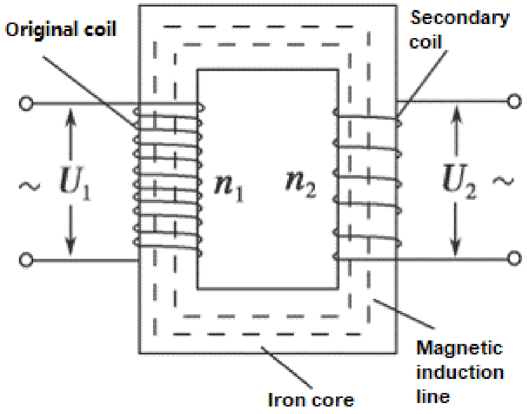


Contents

Transformer

- A transformer consists of an iron core and two or more coils (windings) with different numbers of turns wound around the iron core.
- In a data center, the transformer converts the 10 kV/20 kV voltage on the power grid side into 400 V voltage for equipment.
- Common transformer types:
  - Common oil-immersed transformer: applies to substations in normal environments.
  - Dry-type transformer: applies to places with high fireproof requirements or substations in damp and dusty environments.

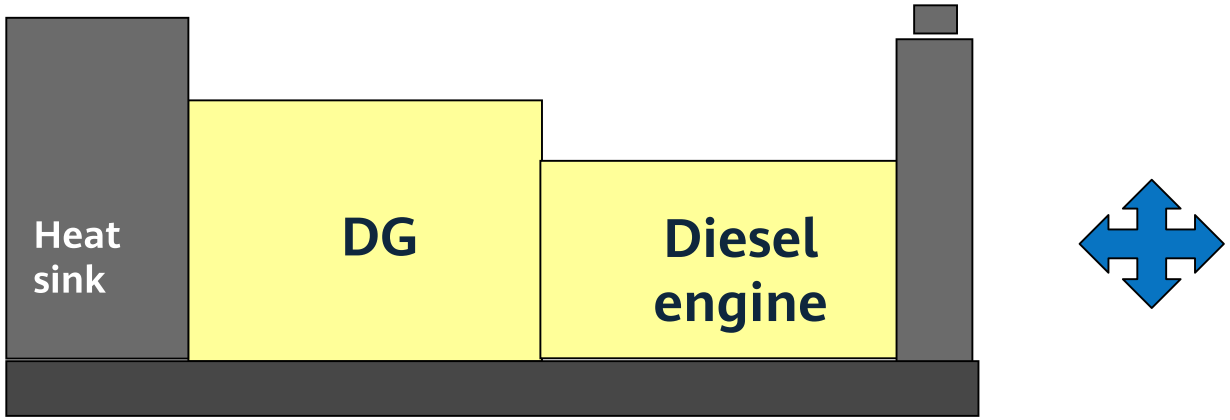
Transformer



Transformer structure

DG

- A DG is a combination of a diesel engine and a generator (usually an AC generator) to generate power in cases of a mains outage
- The DG starts and burns diesel fuel to convert chemical energy into power, ensuring normal operation of the data center.
- The whole set is generally composed of a diesel engine, generator, control box, fuel tank, battery for starting and controlling, protection equipment, emergency cabinet, and so on.



Control box

Contents

LV PDF

- The rated current of the LV PDF is 50 Hz AC. The power distribution system with a rated voltage of 380 V is used as the driving force for power conversion and control for lighting and power distribution.
- The LV PDF should adapt to the rated circuit value and installation conditions. The basic features are as follows:
  - Rated operating voltage
  - Rated frequency
  - Rated operating current
  - Indoor and outdoor types, Ingress protection (IP) rating
  - Fixed type or drawer type

IP Rating

- IP rating refers to the protection level of protecting electrical equipment against intrusion of foreign objects. IP rating consists of two digits. The first digit indicates the level of protection against dust and foreign object intrusion. The second digit indicates the level of protection against moisture and water intrusion. The larger the value, the higher the protection level.

IPXX

Waterproof

Dustproof

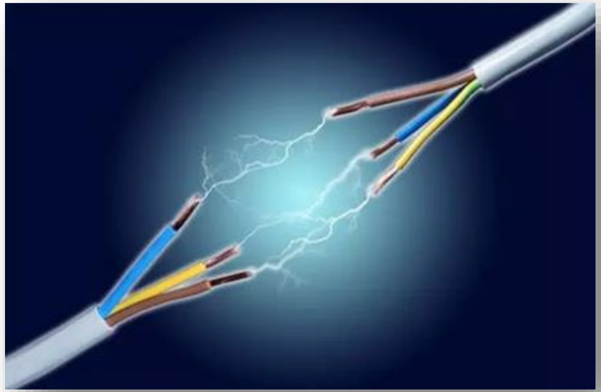
Digit	Dustproof Range	Description
0	No protection	There is no special protection against people or objects outside.
1	Prevents intrusion of solid objects with a diameter of greater than 50 mm.	Prevents human bodies (such as palms) from contacting internal electrical parts due to accidents and prevents large foreign objects (with a diameter greater than 50 mm) from intrusion.
2	Prevents intrusion of solid objects with a diameter of greater than 12.5 mm.	Prevents fingers from contacting internal electrical parts and prevents medium-sized foreign objects (with a diameter greater than 12.5 mm) from intrusion.
3	Prevents intrusion of solid objects with a diameter of greater than 2.5 mm.	Prevents tools, wires, and similar small objects whose diameter or thickness is greater than 2.5 mm from contacting internal electrical parts.
4	Prevents intrusion of solid objects with a diameter of greater than 1.0 mm.	Prevents tools, wires, and similar small objects whose diameter or thickness is greater than 1.0 mm from contacting internal electrical parts.
5	Prevents foreign objects and dust.	Prevents foreign objects from intrusion. Although dust cannot be completely prevented, the dust does not affect the normal operation of electrical equipment.
6	Prevents foreign objects and dust.	Prevents foreign objects and dust from intrusion.

IP Rating

Digit	Waterproof Range	Description
0	No protection	There is no special protection against water or moisture.
1	Prevents droplets from intrusion.	Vertical droplets (such as condensed water) do not cause damage to electrical equipment.
2	When the equipment is tilted by 15 degrees, droplets can still be prevented.	When the electrical equipment is tilted by 15 degrees, droplets do not damage the equipment.
3	Prevents sprayed water from intrusion.	Prevents rain or damage caused by water sprayed in the direction less than 60 degrees from the vertical angle.
4	Prevents splashing water from intrusion.	Prevents splashing water in all directions from intruding into electrical equipment and causing damage.
5	Prevents water jets.	Prevents water jets from all directions from the nozzle from intruding into the electrical equipment and causing damage.
6	Prevents large waves from intrusion.	Prevents damage caused by the invasion of large waves for electrical equipment installed on the deck.
7	Prevents water intrusion during immersion.	Ensures that the electrical equipment is not damaged due to water immersion when electrical equipment is immersed in water for a certain period of time or the water pressure is below a certain standard.
8	Prevents water intrusion during sinking.	Ensure that no damage is caused by water immersion when the electrical equipment sinks indefinitely under specified water pressure.

Low-Voltage Circuit Breakers

- Function:
  - Switch
  - Overload protection
  - Short circuit protection (instant /short delay)
- Classification:
  - ACB (Air Circuit Breaker)
  - MCCB (Mould Case Circuit Breaker)
  - MCB (Miniature Circuit Breaker)
  - HY-MAG (Hydraulic-pressure Magnetic Circuit Breaker)
  - RCD (Residual Current Device)



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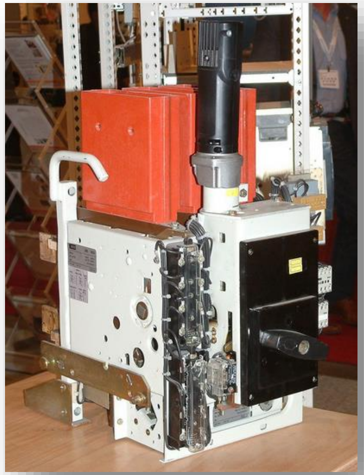
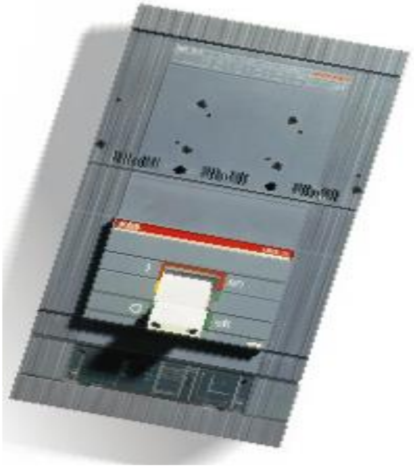
Low-Voltage Circuit Breakers - ACB

- Definition:
  - The type of circuit breaker, which operates in air (where air-blast as an arc quenching medium) at atmospheric pressure, is known to be an Air Circuit Breaker.
- Application and Uses:
  - Used for main power distribution in large industrial plant.
  - Used for protection of transformers, capacitors and generators.
  - Carry heavy current (thousands of amperes).
  - Intelligent monitoring functions: remote control, alarms and data transmission.



Low-Voltage Circuit Breakers - MCCB

- Definition:
  - MCCB is a type of electrical protection device that is commonly used when load currents exceed the capabilities of miniature circuit breakers.
- Features:
  - Used in industrial areas widely.
  - carry medium current (hundreds of amperes).
  - High breaking capability (Icu Ics).
  - operated rapidly.
  - The tripping devices are interchangeable and adjustable.
  - Intelligent monitoring functions: catenation, remote control,
  - alarms and data transmission.



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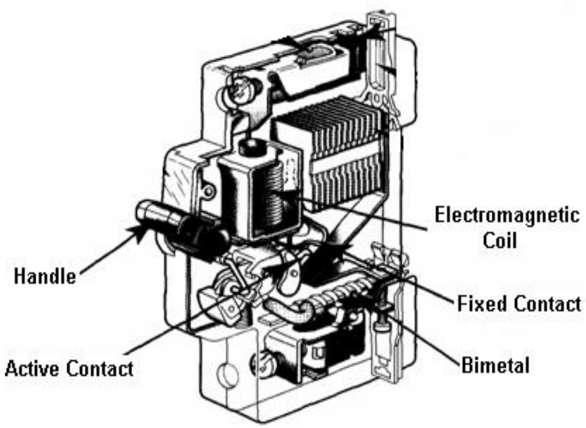
Low-Voltage Circuit Breakers - MCB (1)

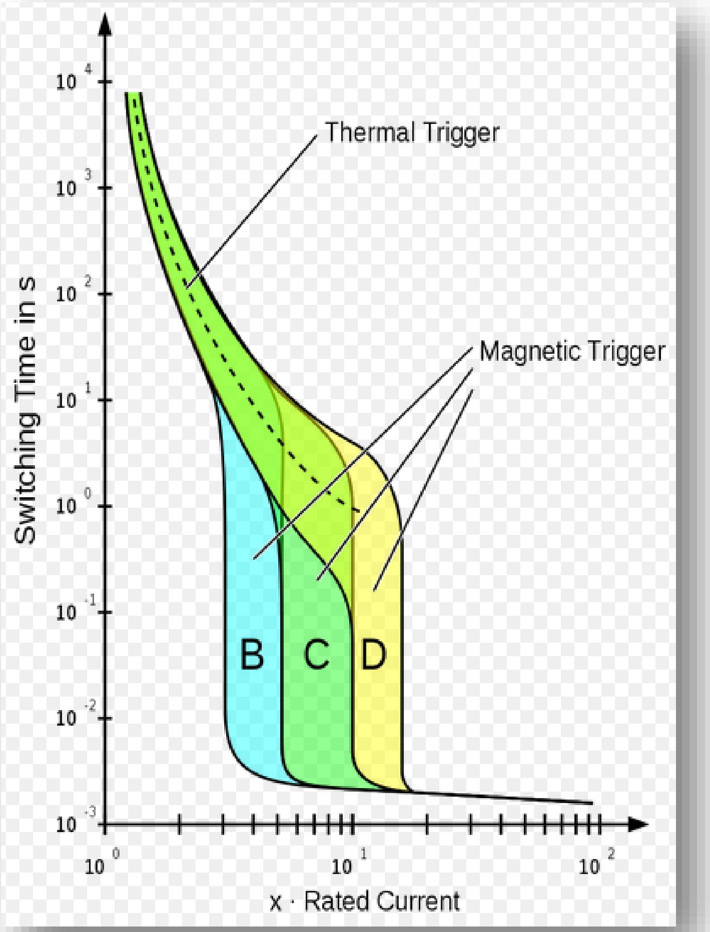
- Definition:
  - An MCB or miniature circuit breaker is an electromagnetic device that embodies complete enclosure in a molded insulating material.
- Main parameters:
  - Carry miniature current (from 1 A to 100 A usually)
  - Nearest to the loads
  - Rated voltage Un：230V/400Vac, 60Vdc
  - Rated breaking current Icu：4.5kA，6kA，10kA…
  - Characteristic: B, C or D
  - Tripping principle: Thermal-Magnetic tripping（TM）



Low-Voltage Circuit Breakers - MCB (2)

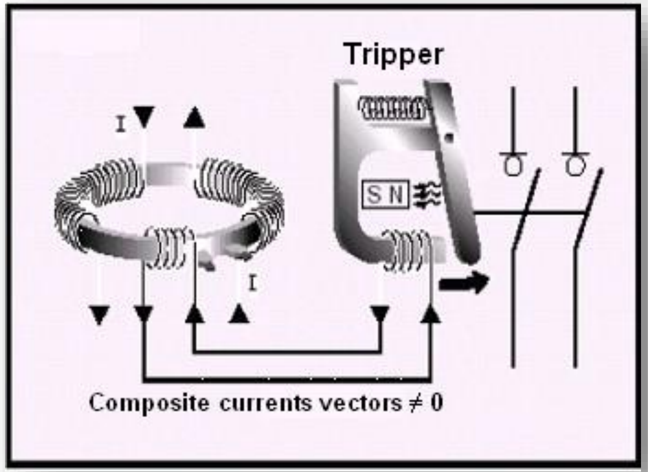
- Tripping Characteristics
  - Definition:
    - B, C, D according to IEC 60898
    - Z, K according to IEC 60947-2
  - Application:
    - Characteristics Z (2-3) In
    - Characteristics B (3-5)In
    - Characteristics C (5-10) In
    - Characteristics D (10-20)In
    - Characteristics K (8 –15)In

Characteristic C is suggested for the MCB in the ICT loads scenario.

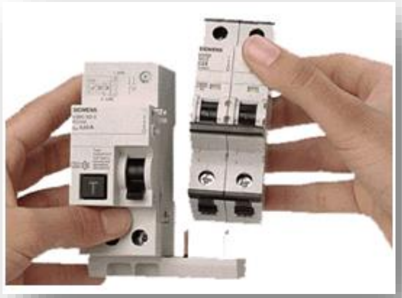


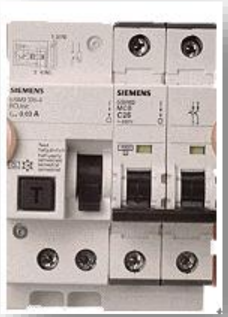
Low-Voltage Circuit Breakers - RCD

- Principle:
  - Kirchoffs Law: ∑I=0
  - Earth leakage current protector
- Classification:
  - By Principle:
    - Electromagnetic type
    - Electronic type
  - By over current protection:
    - Residual Current Circuit Breaker (RCCB)
    - Residual current Circuit Breaker with Over-current protection (RCBO)
  - By relay time: instant type, selected type



Magnetic type RCD

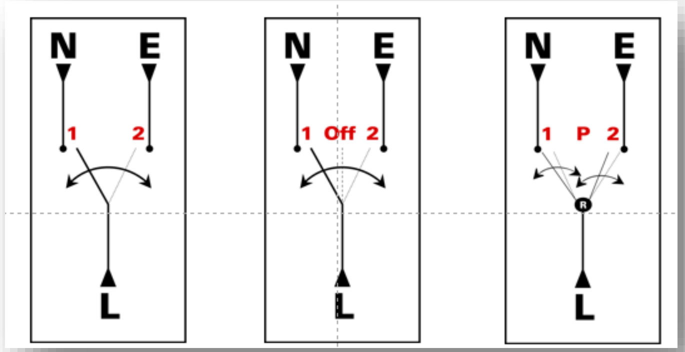




RCCB

Transfer Switch

- Definition:
  - A transfer switch is an electrical switch that switches a load between two sources.
- Classification:
  - ATS: Automatic Transfer Switch（Mechanical action）
  - STS: Static Transfer Switch（ SCR）
- Types
  - Open transition
  - Closed transition
  - Soft loading



Fuse

- Definition:
  - Widely applied in low voltage distribution and control systems
  - One key short-circuit protection device for a single electrical equipment.
- Classification:
  - Based on the breaking range: g (for full range breaking) and a (for partial breaking)
  - Based on the classification: G (common fuse) and M (for motor circuits)
- Feature parameters:
  - Rated voltage
  - Rated current
  - Rated breaking capability
  - Time-Current feature

Fuses

Holders

Pullers

Disconnector

- Definition
  - It is mainly used to isolate the power supply, transfer switching, and connect and cut off the small-current circuit. It has no arc extinguishing function.
- Feature
  - During electrical equipment maintenance, the disconnector can provide an electrical interval, which is a visible disconnection point.
  - The disconnector cannot be operated with load. It can be operated only when the circuit breaker is disconnected.
- Classification by structure
  - Knife switch
  - Fuse-type knife switch
- Classification by operation mode
  - Manual disconnector
  - Automatic disconnector

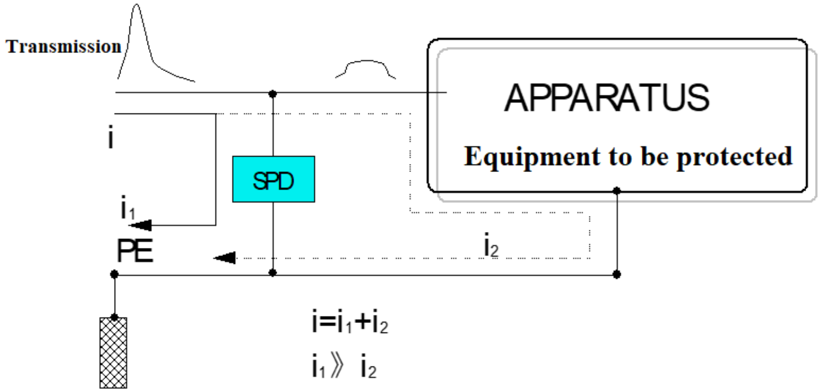
Knife switch

Fuse-type knife switch

Automatic disconnector

SPD (1)

- Definition
  - SPD is installed at the front end of equipment to protect the equipment from being damaged by overvoltage or overcurrent caused by external cables.
- Feature
  - Protection level: level I, II, and III, or class B, C, and D
  - Maximum discharge current Imax: maximum single shot current the SPD can handle without getting damaged
  - Nominal discharge current In: through-current capability that enables the SPD to endure surge
  - Rated impulse voltage value U_w: resistance capability that enables the SPD to prevent overvoltage
  - Residual voltage: peak voltage between SPD terminals when the discharge current passes through



SPD (2)

Impulse current and nominal current of the SPD

Lightning Protection Level	General Power Distribution Box (PDB)		Branch PDB	Equipment Room PDB
	Class 1 test	Class 2 test	Class 2 test	Class 2 test
	I_{imp} (kA)	I_n (kA)	I_n (kA)	I_n (kA)
B	≥ 15	≥ 60	≥ 30	≥ 5
C	≥ 12.5	≥ 50	≥ 20	≥ 3
D	≥ 12.5	≥ 50	≥ 10	≥ 3

Contents

Introduction to Power Cables

- The basic structure of a power cable consists of the core (conductor), insulation layer, shield layer, and protection layer.
- Copper, aluminum, and aluminum alloy are usually used as cable conductors. Copper conductors are recommended for data center cables.
- Cables can be classified into DC cables and AC cables based on the power system.
- Basic cable features:
  - Cable type
  - Rated operating voltage
  - Insulating material
  - Conductor type
  - Cross-sectional area

Naming Rules for Power Cables

ZRC L – YJV 22 -3×120mm^2+ 1×70mm^2

1 2 3 4 5 6 7 6 7

No.	Meaning	Value
1	Type code	ZRC: class C flame retardant
2	Conductor	L: aluminum; T: copper
3	Insulation layer code	YJ: crosslinked polyethylene; V: PVC sheath
4	Protection layer code	V: PVC sheath
5	Armored layer code	0: none; 2: double steel belt; 3: thin steel wire
6	Number of cable cores	3: three-core cable
7	Cross-sectional area	120: 120 mm^2

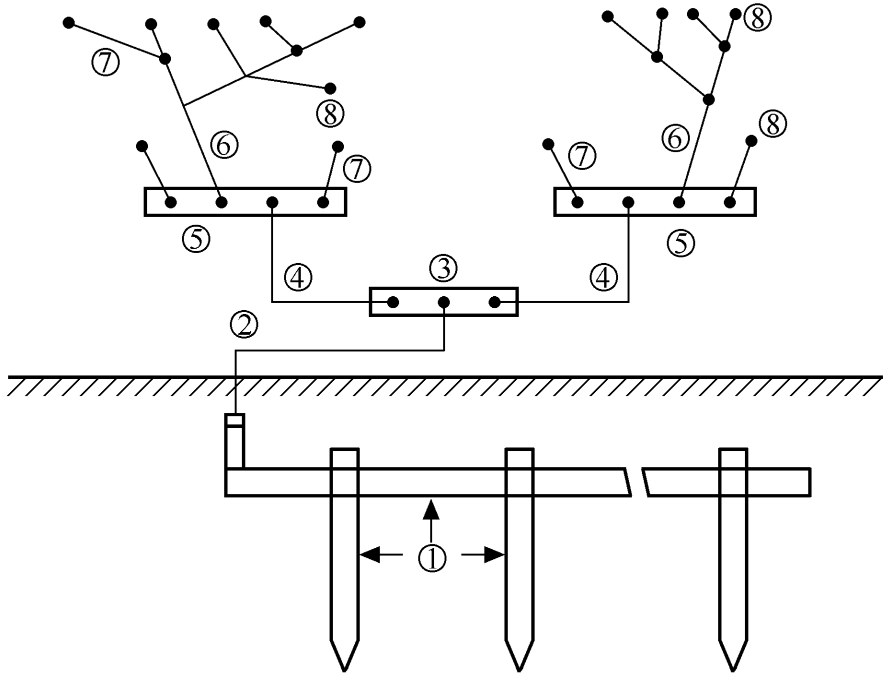
Contents

Grounding System Overview

- Concept
  - Grounding is to connect the grounding terminals of electrical equipment or communication equipment to the ground through grounding devices and inject the electric charges of the grounding terminals into the ground for the purpose of working or protection. In this way, the dangerous voltage is reduced and electromagnetic interference is prevented.
- Components of the grounding system
- Types and functions of grounding

Components of the Grounding System

- The grounding device consists of all grounding bodies and grounding leads. The grounding system is formed by connecting the grounding devices to the grounding terminals of the electrical equipment through the ground cable.



① Ground conductor

② Ground lead

③ Ground bar

④ Ground cable

⑤ Ground bar of the power distribution panel

⑥ Busbar to the communications equipment room

⑦ Ground branch cable

⑧ Ground terminal of the equipment

Grounding Types

- **Function**
  - **Protective ground**
    For safety purposes, ground the system or equipment at one or more points.
    - ➢ Protective grounding of electrical equipment: The exposed conductive parts of electrical equipment are grounded, for example, the shells of the UPS and PDF are grounded.
    - ➢ Operating grounding: ground the live parts that have been powered off.
    - ➢ Lightning protection and grounding: SPD (such as lightning rod and overvoltage protector)
    - ➢ ESD grounding: ground the static electricity, such as the grounding of flammable and explosive pipes and electronic components.
  - **Functional grounding**
    Grounding for purposes other than electrical safety
    - ➢ Grounding of the power system: ground the power system according to the operation requirements of the system. For example, ground the neutral point of the AC power system and the positive pole of the DC power system.
    - ➢ Signal circuit grounding: ensures that signals have stable reference potentials.
  - **Functional and protective grounding**
    - ➢ Grounding that improves the electromagnetic compatibility of equipment, including functional grounding (anti-interference) and protective grounding (anti-damage)
- **Load**
  - AC system grounding
  - DC system grounding

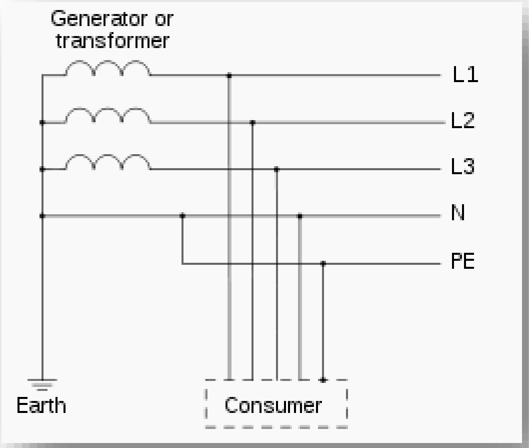
Earthing system Introduction

- Definition：
  - To connect the metallic (conductive) Parts of an Electric appliance or installations to the earth (ground) is called Earthing. IEC 60364 distinguishes three families of earthing arrangements, using the two-letter codes TN, TT, and IT.
- The first letter indicates the connection between earth and the power-supply equipment (generator or transformer):
  - "T" — Direct connection of a point with earth (Latin: terra)
  - "I" — No point is connected with earth (isolation), except perhaps via a high impedance.
- The second letter indicates the connection between earth and the electrical device being supplied:
  - "T" — Earth connection is by a local direct connection to earth (Latin: terra), usually via a ground rod.
  - "N" — Earth connection is supplied by the electricity supply Network, either as a separate protective earth (PE) conductor or combined with the neutral conductor.
- Classification: TN(TN-C, TN-S,TN-C-S,) 、IT、TT.

Earthing system Introduction - TN (1)

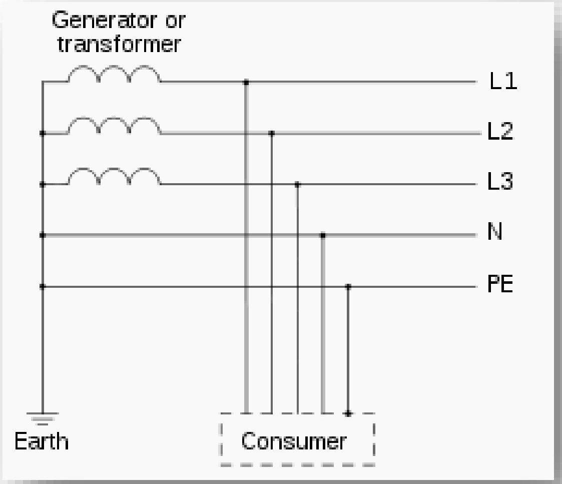
- Definition：
  - In a TN earthing system, one of the points in the generator or transformer is connected with earth, usually the star point in a three-phase system. The body of the electrical device is connected with earth via this earth connection at the transformer.
- Classification：
  - TN–S： PE and N are separate conductors that are connected together only near the power source. This arrangement is a current standard for most residential and industrial electric systems particularly in Europe.
  - TN–C： combined PEN conductor fulfills the functions of both a PE and an N conductor.
  - TN–C–S： combined PEN conductor from transformer to building distribution point, but separate PE and N conductors in fixed indoor wiring and flexible power cords.

Earthing system Introduction - TN (2)

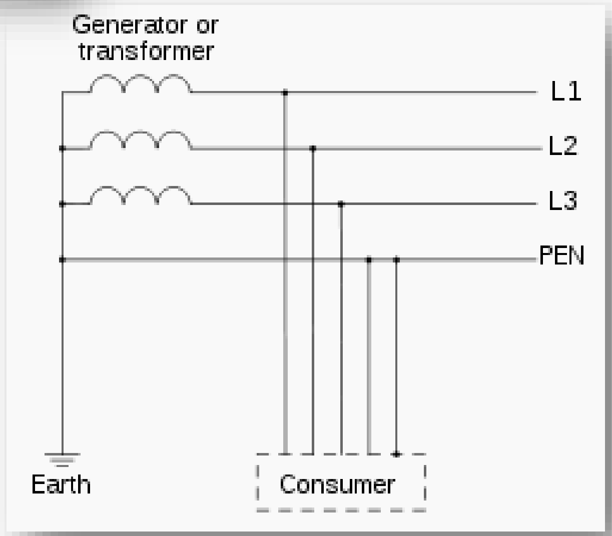


TN-C-S

TN-S

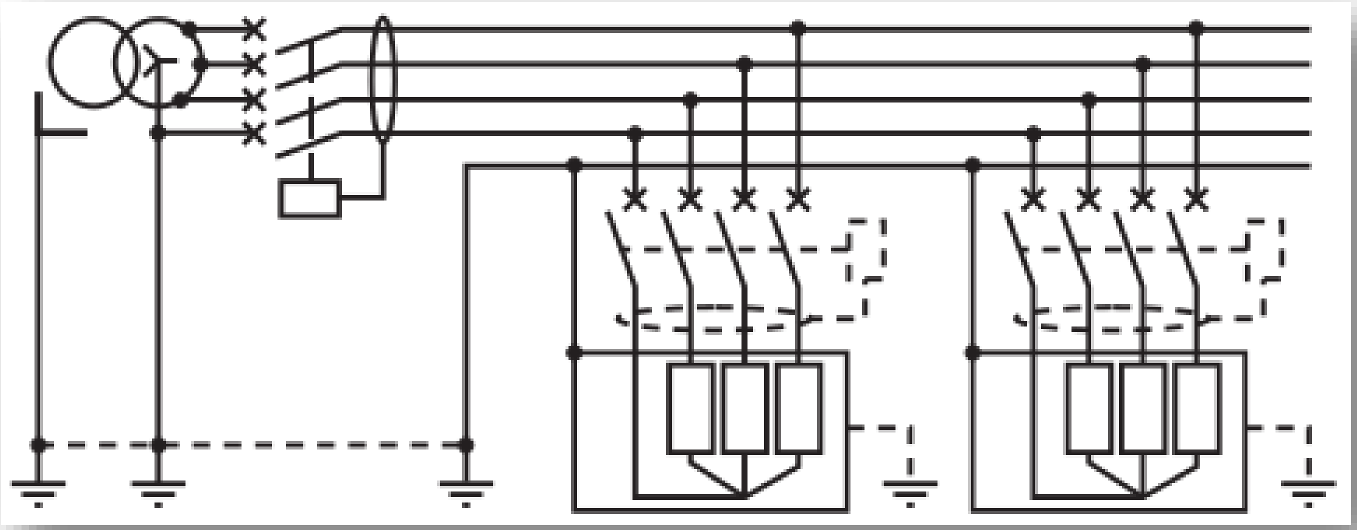


TN-C



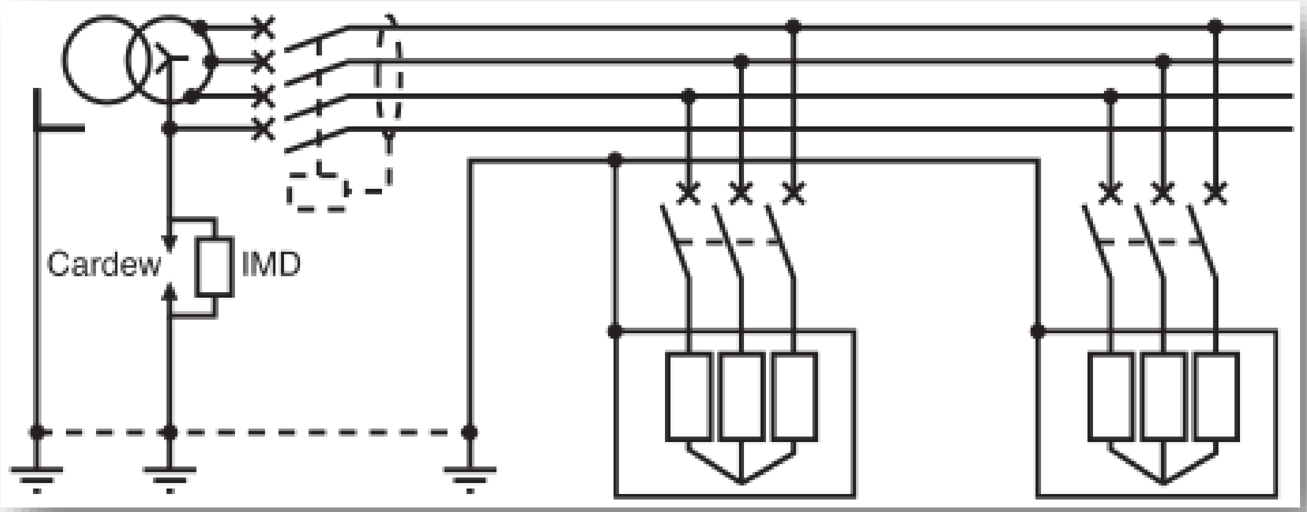
Earthing system Introduction - TT

- Definition：
  - The TT system : Technique for the protection of persons: the exposed conductive parts are earthed and residual current devices (RCDs) are used.
  - Operating technique: interruption for the first insulation fault.



Earthing system Introduction - IT

- Definition：
  - In an IT network, the electrical distribution system has no connection to earth at all, or it has only a high impedance connection.



Quiz

1. Which of the following is the most common grounding system in a data center?

   A. TN-S

   B. TN-C

   C. TN-C-S

   D. TT

   E. IT

Summary

- Data Center Power Distribution Overview
- Basic Concepts of the Power Distribution System
- Common LV Electrical Equipment
- Common Grounding Systems
- Introduction to Data Center Digital Power Products

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise：http://support.huawei.com/enterprise/
  - Online Learning：http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Popular Tools

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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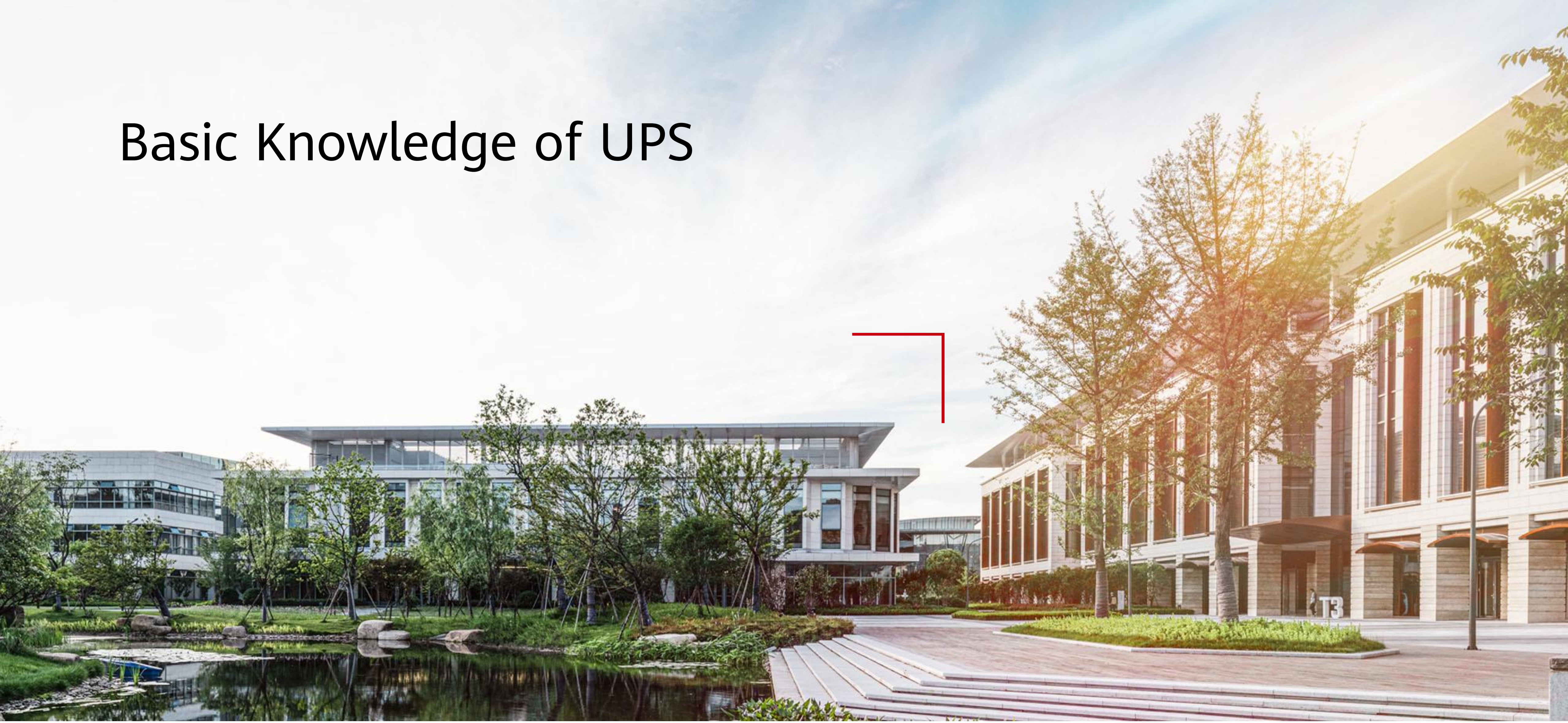
Basic Knowledge of UPS



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Foreword

- The chapter describes UPS basic knowledge, including the function and work principle of UPS and the common configuration solution.

Objectives

On completion of this course, you will be able to:

- Know the basic function of UPS;
- Know the basic working mode of UPS;
- Know the common configuration solution of UPS.

Contents

UPS Development History

Fourth generation:
Full-digital high-efficiency modularized UPS Since 2007

Third generation:
IGBT rectification-supported Transformer UPS 2000–2006

Second generation:
Analog control transformer-based UPS 1985–2000

First generation:
Dynamic storage UPS Before 1985

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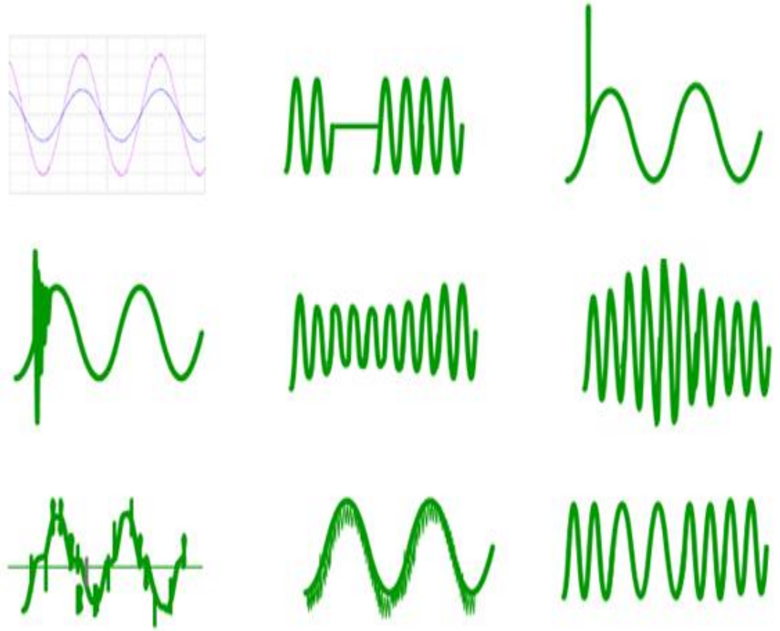
Why Is the UPS Required?

- Power grid pollution affects network and device security.
  - Power interruption, voltage fluctuation, transient peak currents, voltage surges, and high-voltage pulses which damage servers, routers, and disk arrays.
  - Harmonic distortion, high-frequency interruption, and frequency drifts which substantially increase the bit error rate (BER) and decrease the data transmission rate.



Nine power grid faults

UPS Functions

Uninterruptible power supply

- **Solving the problem of mains outage**
  - When the mains fails, batteries in the UPS supply power to loads.

Power purification

- **Solving the problem of power grid pollution**
  - Increases the input power factor, decreases harmonic pollution to the power grid, and supplies pure power to loads.

Stable AC outputs

- **Solving the problem of mains voltage fluctuation**
  - The UPS supports a wide input voltage range, which ensures stable outputs for loads when the mains voltage fluctuates.

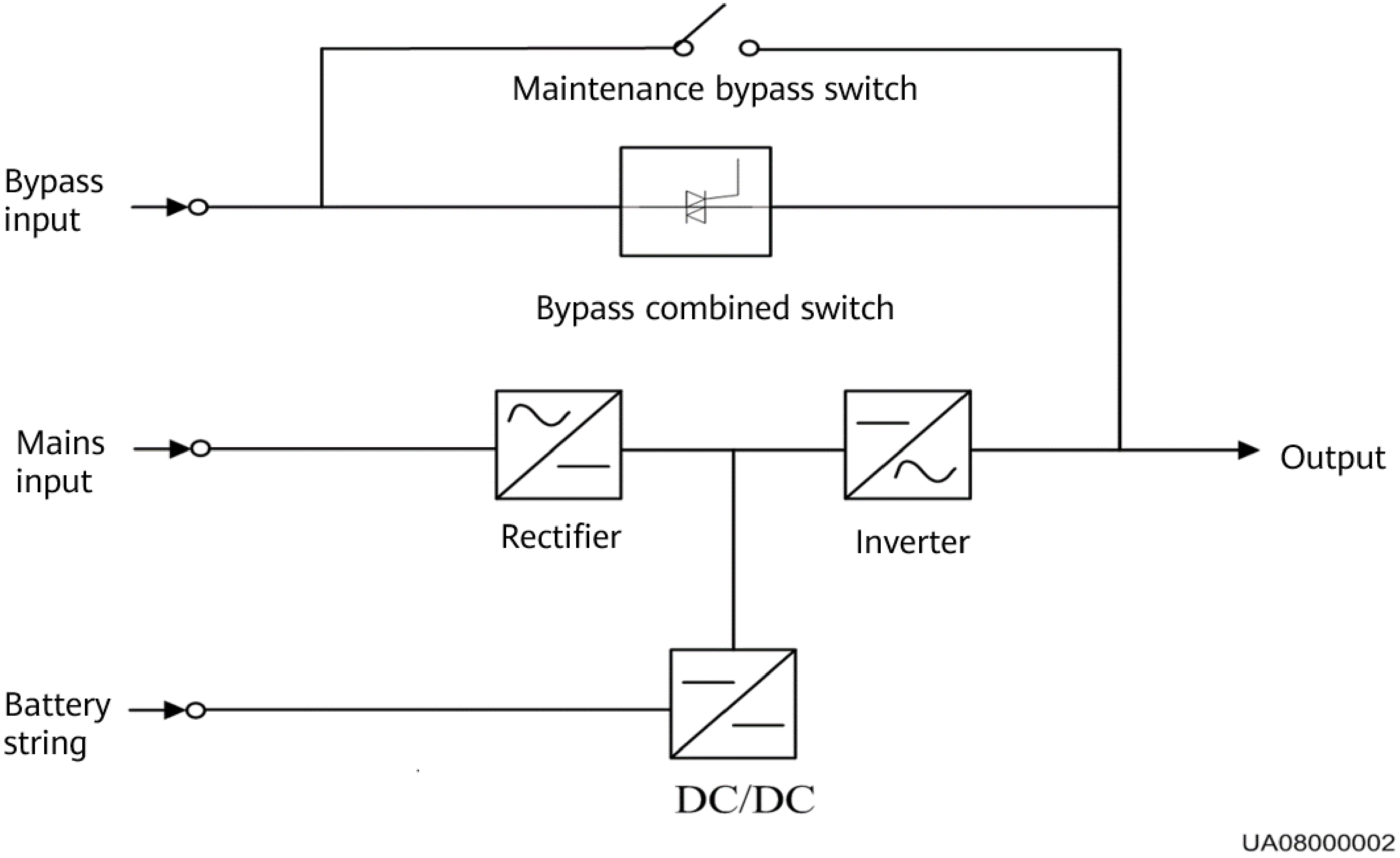
Power management

- **Solving the problem during AC power maintenance**
  - As an important power supply device, the UPS can be monitored by the network management system (NMS), ensuring easy maintenance.

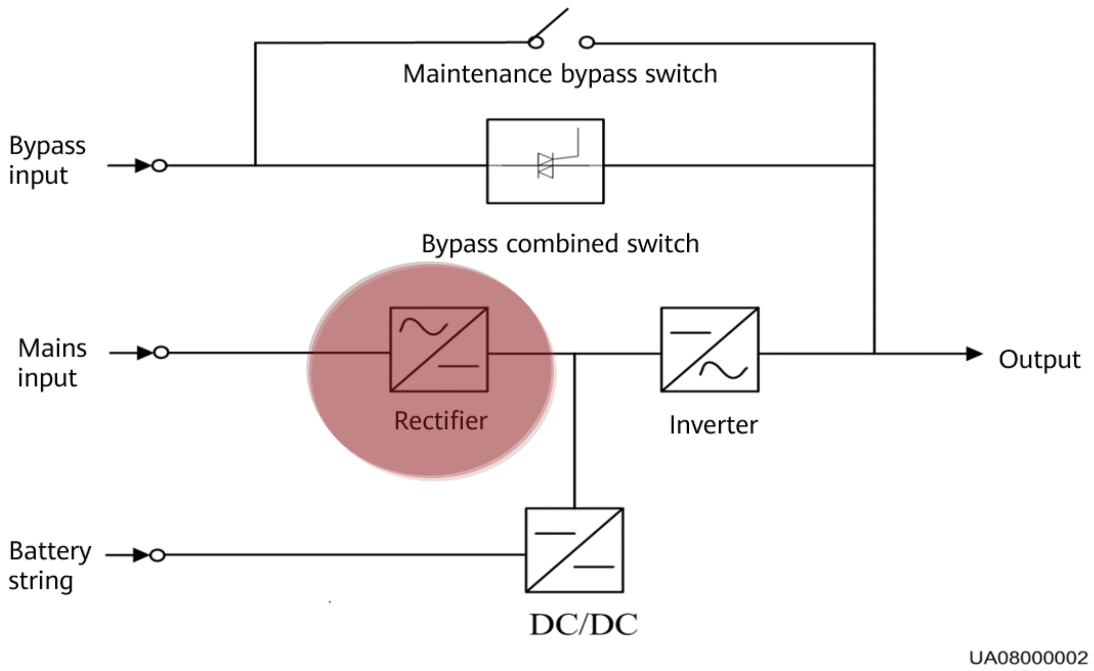
UPS System Classification

- By structure:
  - Offline UPS;
  - Line-interactive UPS;
  - Online UPS.
- By capacity:
  - Small-sized UPS (< 20 kVA);
  - Medium-sized UPS (20 kVA to 200 kVA);
  - Large-sized UPS (> 200 kVA).
- By installation method:
  - Tower-mounted UPS;
  - Rack-mounted UPS.

Composition of an UPS

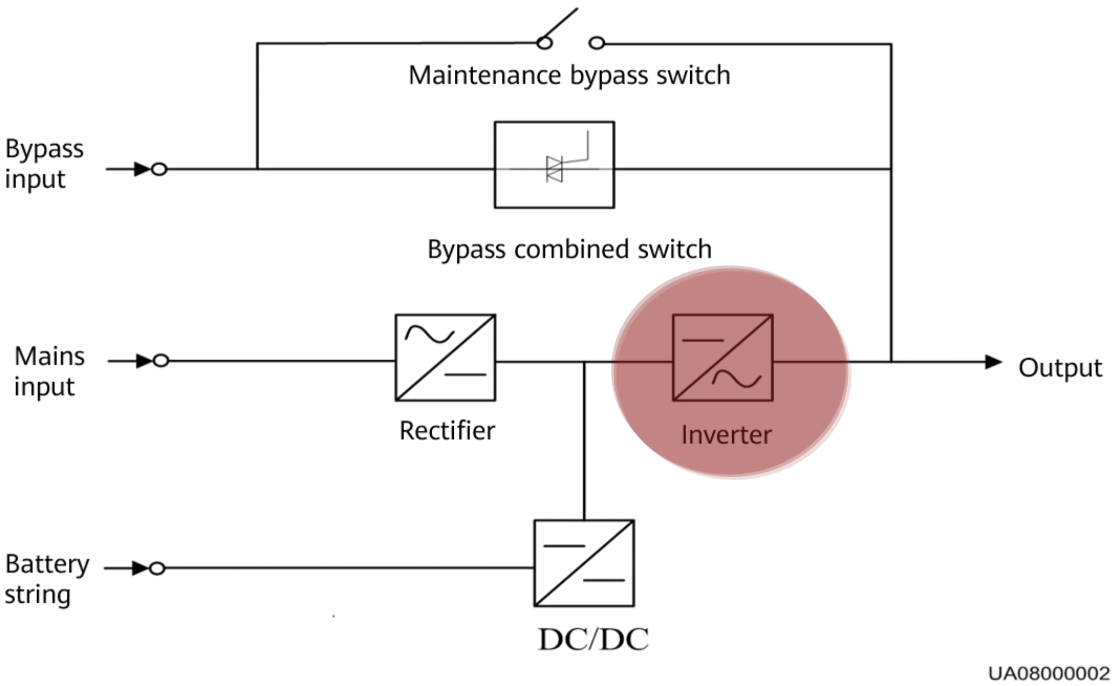


Main Function Units of the UPS – Rectifier



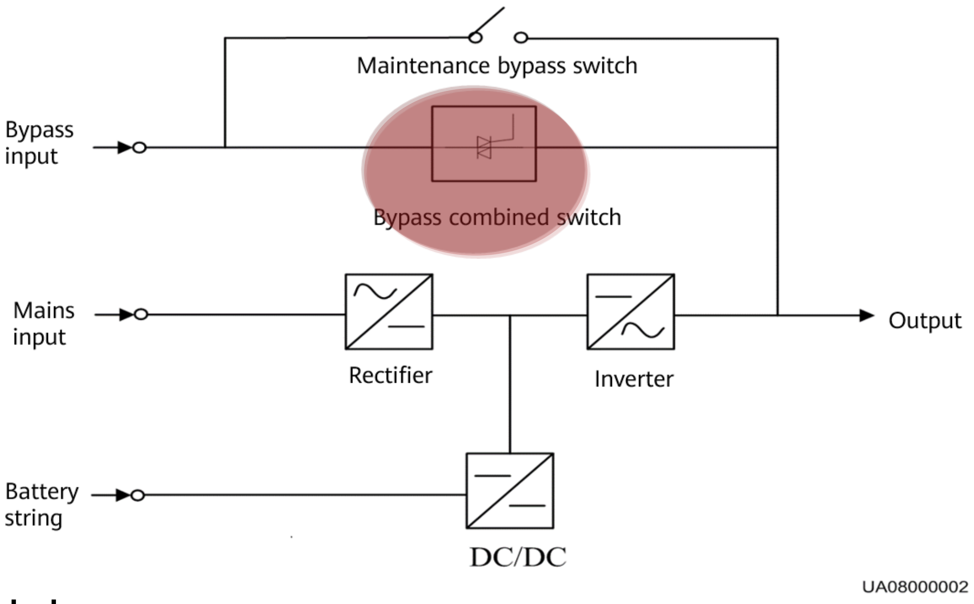
- Functions of the rectifier
  - Converts AC power into DC power.
  - Implements power factor correction (PFC) and voltage boosting.
  - Reduces the pollution to the power grid.

Main Function Units of the UPS – Inverter



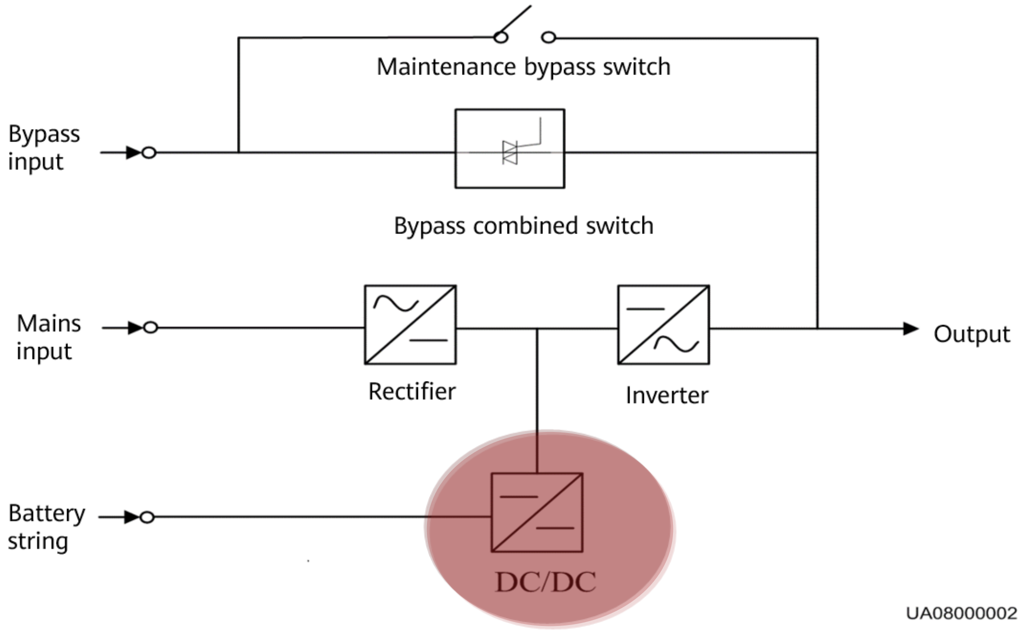
- Functions of the inverter module
  - Converts DC power into AC power.
  - Converts DC power from batteries into AC power.
  - Provides pure AC power by high-speed operation of switching diodes.

Main Function Units of the UPS – Bypass Module



- Functions of the bypass module
  - Internal bypass: When the main converter becomes faulty or fails to work properly, the UPS automatically transfers to internal bypass mode.
  - The maintenance bypass isolates the UPS to ensure safety and power continuity during maintenance.

Main Function Units of the UPS – Charger



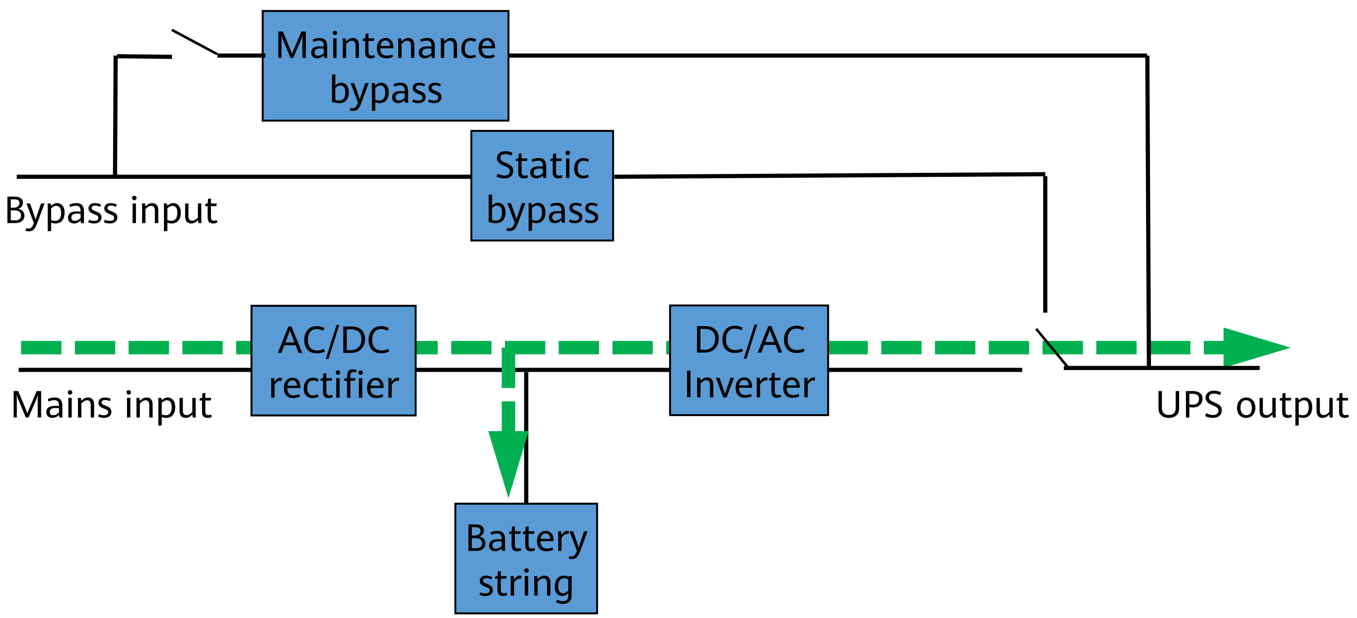
- Functions of the charger
  - Charges batteries when the AC input is normal.

UPS Working Modes – Classification

- The UPS has five working modes:
  - Normal mode
  - Battery mode
  - Bypass mode
  - Maintenance mode
  - Economy control operation (ECO) mode

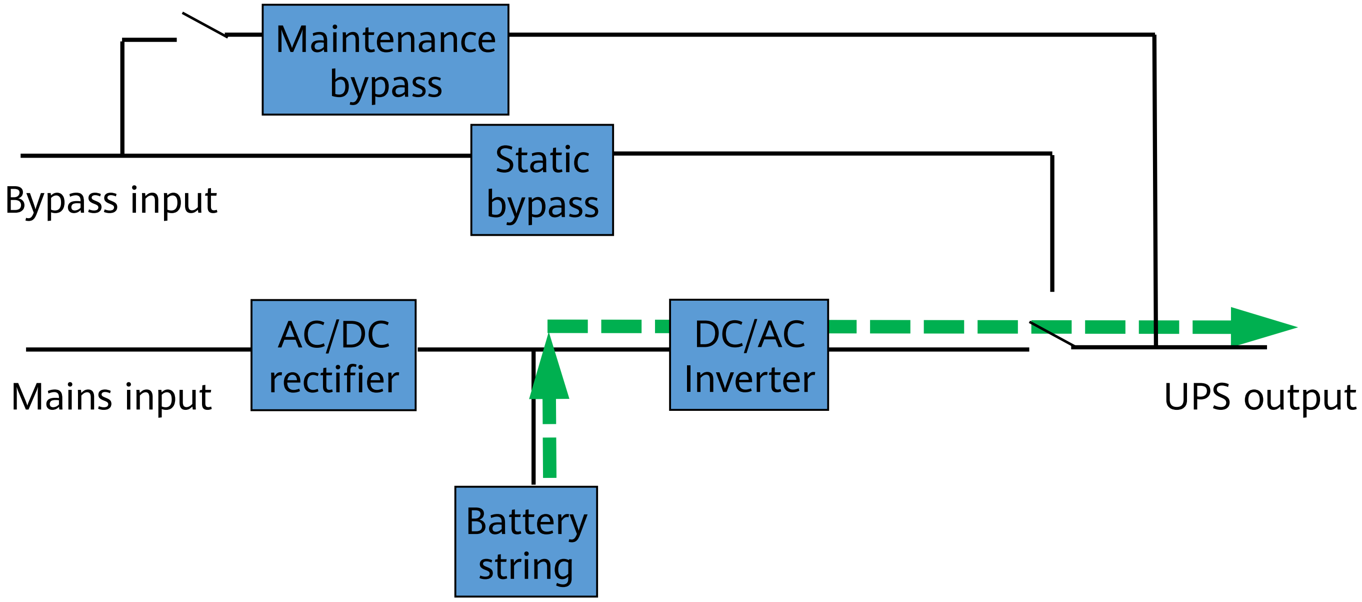
Online UPS - Normal Mode

- In normal cases, the UPS works in inverter mode (normal mode);
- In this mode, the mains supplies power to customers' loads using rectifiers and inverters;
- UPS supplies power to the batteries using chargers.



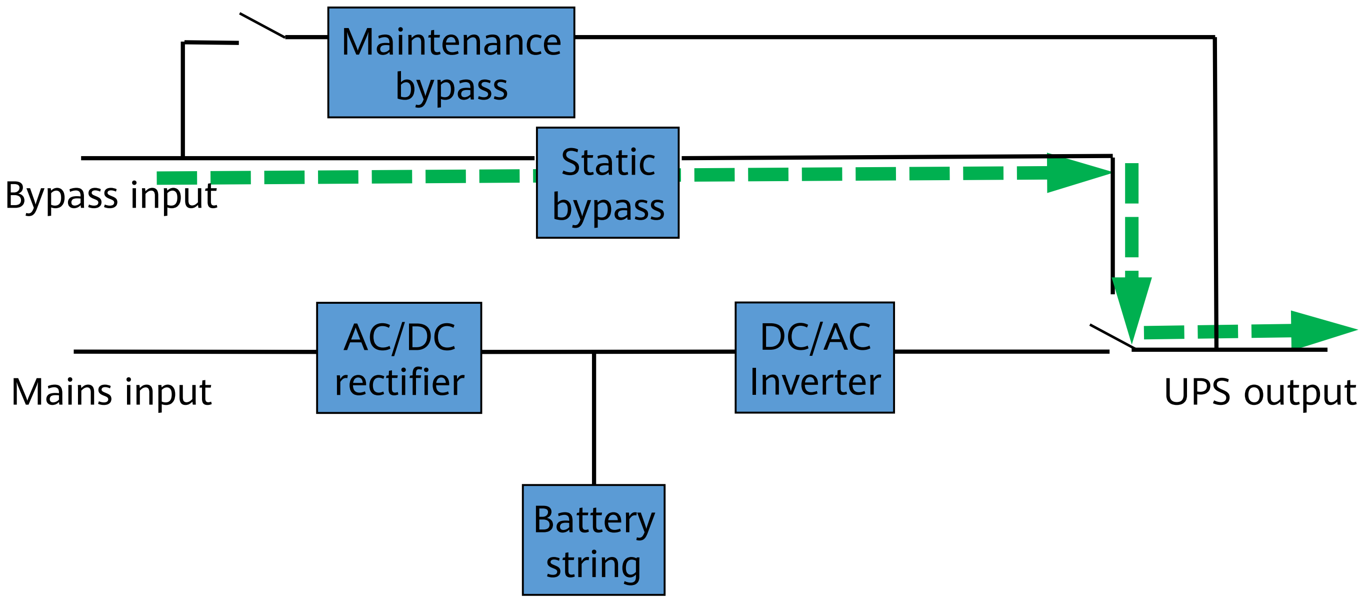
Online UPS - Battery Mode

- If the mains supply fails or exceptions occur, the UPS immediately switches to the battery mode.
- In this case, batteries supply power to customers' loads using inverters.
- After the mains recovers, the UPS immediately switches back to the normal mode.



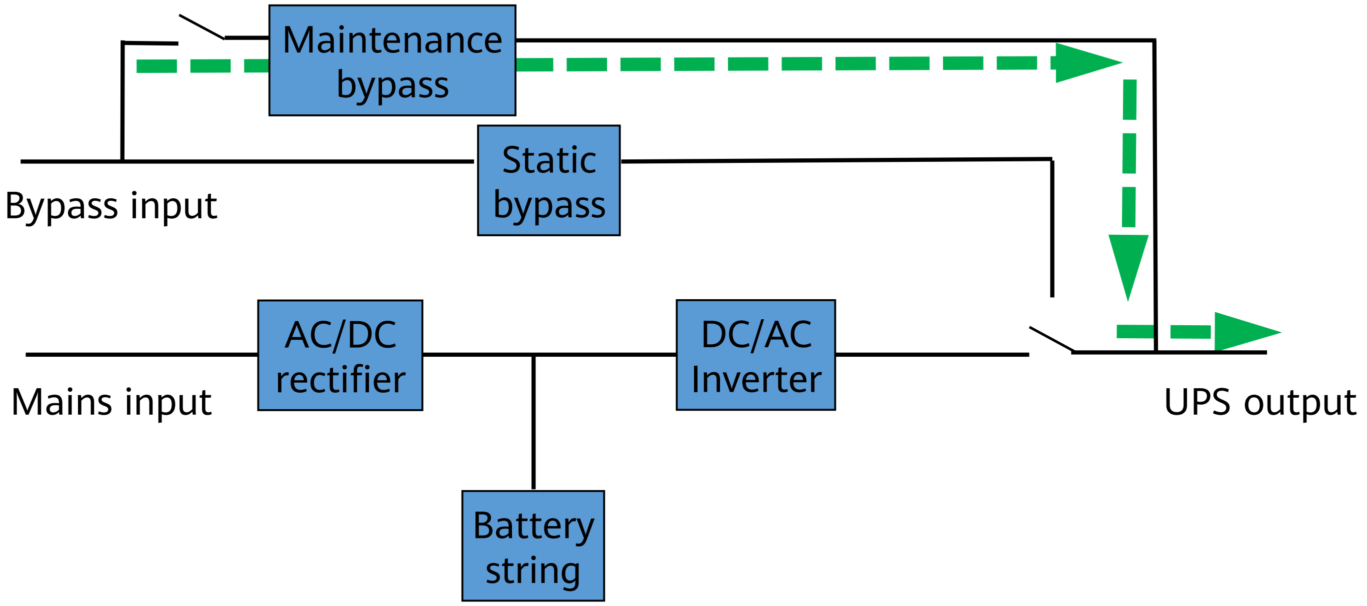
Online UPS - Bypass Mode

- If a UPS is faulty, it immediately switches to the bypass mode (static bypass mode) for power supply;
- In this case, the bypass power source supply power to customers' loads through the static bypass.



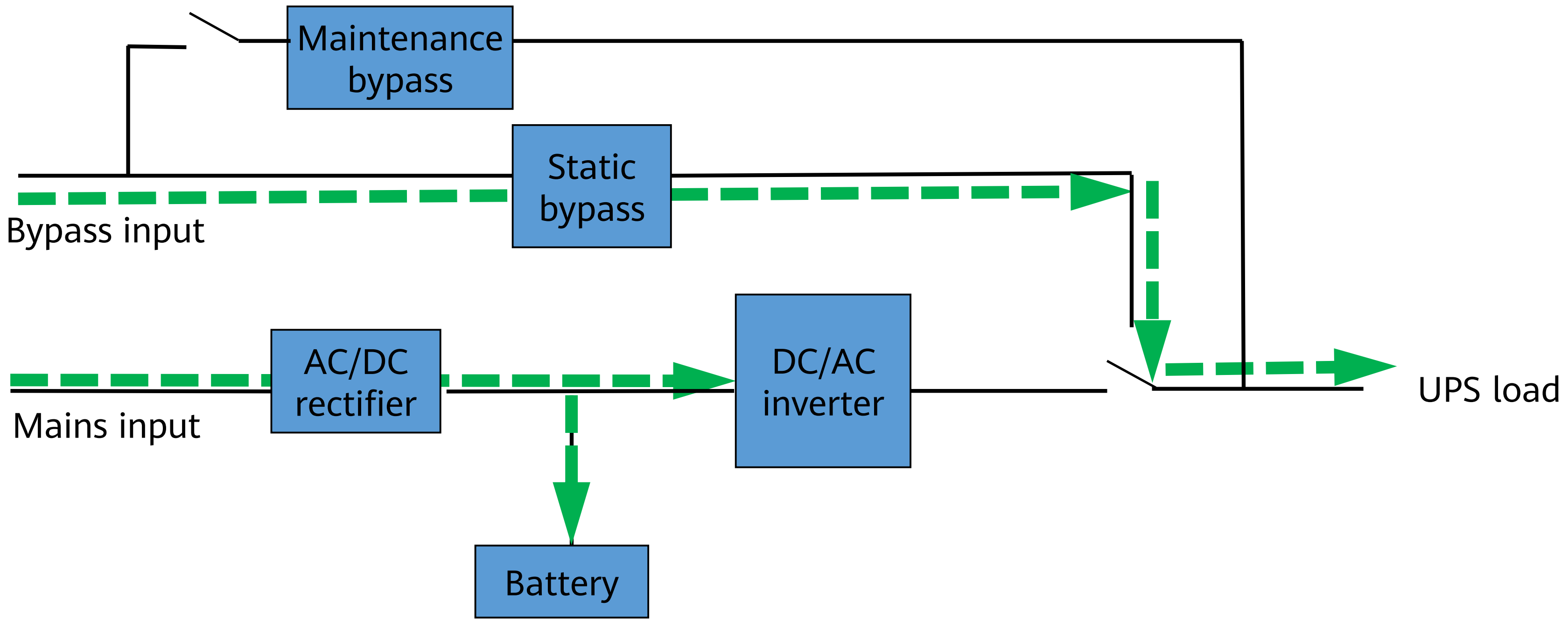
Online UPS - Maint. Mode

- When a faulty UPS is maintained, the UPS must be manually switched to the maintenance bypass mode.



Online UPS – ECO Mode

- In this mode, if the bypass voltage and frequency are in the specified range, the UPS supplies power to loads over the bypass. If the bypass voltage and frequency are outside the range, the UPS transfers to normal or battery mode.



UPS Key Parameters (1)

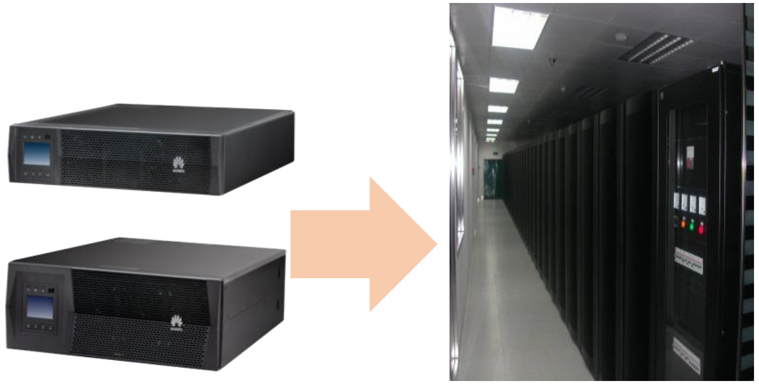
- Capacity
  - The UPS loading capability can be indicated by the apparent power (kVA) or active power (kW), for example, 200 kVA or 180 kW. Since output capacitors of inverter units generate reactive power, the active power value cannot exceed the apparent power value.
- Output power factor
  - The output power factor indicates the UPS capability for carrying loads with active power. Generally, the output power factor is 0.7, 0.8, 0.9, or 1.
- Efficiency
  - Under the same customers' loads, higher UPS efficiency leads to less UPS loss and operating expense (OPEX). In normal cases, efficiency of medium- and large-sized UPSs is higher than 0.9.

UPS Key Parameters (2)

- Input voltage and frequency range
  - If the input voltage and frequency range is wide, the UPS is adaptable to poor power grids. When the input voltage and frequency exceed the threshold, the UPS switches to the battery mode. A wide voltage range reduces the number of battery discharge times and therefore prolongs the battery lifespan.
- Overload capability
  - The high overload capability ensures power supply quality. If the UPS overloads, it works in normal mode for a short period and then switches to the static bypass mode. If overload persists, the UPS shuts down.
- Input current harmonic
  - The low total distortion of the input current waveform (THDi) reduces pollution to the power grid.

Rack&Tower - mounted UPS

- Can be placed in a standard 19-inch cabinet;
- Provides a 20 kVA power capacity or lower;
- Enables customers to use rack-mounted batteries.



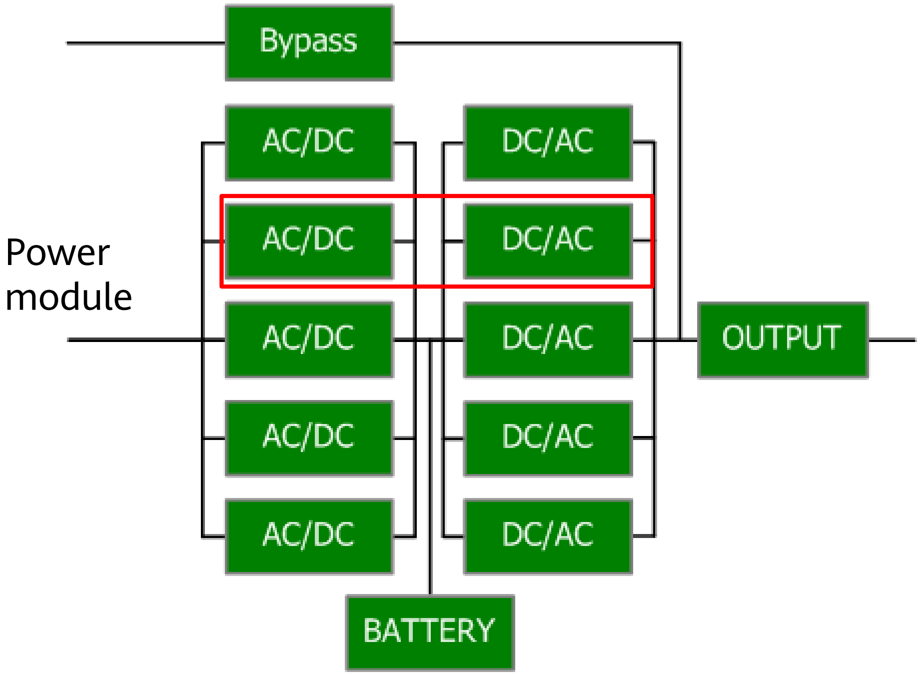
Rack-mounted UPS

- Can be placed on the ground or desk;
- Provides a power capacity of 0.5 kVA to 1500 kVA, capacity higher than 3 kVA is placed on the ground.

Tower-mounted UPS

Modularized UPS

- The modularized design facilitates capacity expansion and prevents excessive investment in initial construction.
- The redundancy design increases reliability and availability.



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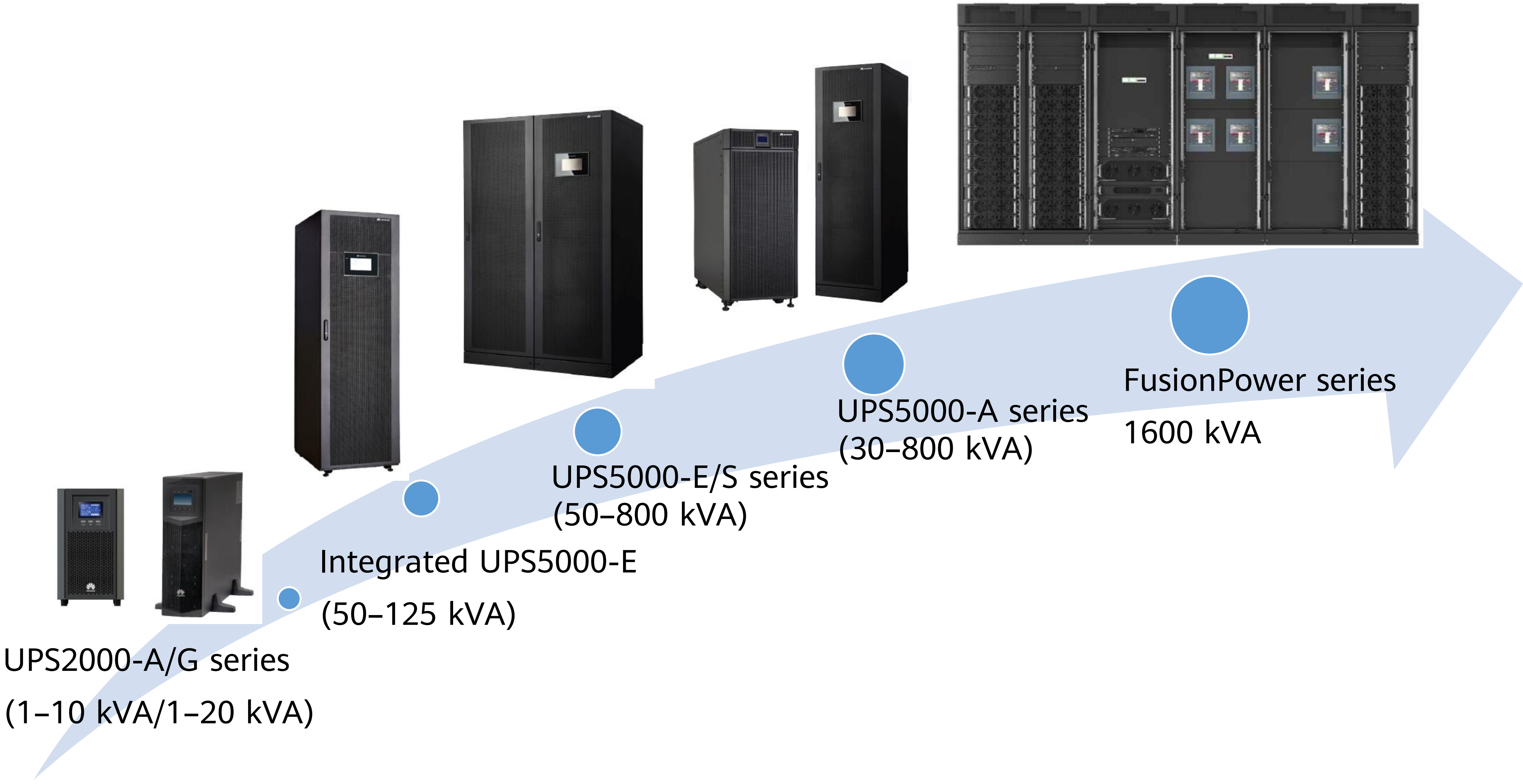
Contents

Huawei UPSs


UPS2000-A/G series
(1–10 kVA/1–20 kVA)
Integrated UPS5000-E
(50–125 kVA)
UPS5000-E/S series
(50–800 kVA)
UPS5000-A series
(30–800 kVA)
FusionPower series
1600 kVA

UPS2000-G Small-sized UPS Solution

- Introduction
  - N+X redundancy and single UPS configuration based on different reliability requirements;
  - Power backup time from 10 minutes to 2 hours and an intelligent management solution;
  - Network-wide monitoring platform.
- Advantages
  - High reliability and efficiency, ensuring power supply continuity and reducing the OPEX;
  - Intelligent battery management, prolonging the battery lifespan;
  - Network-wide monitoring platform, improving system maintainability and reducing the OPEX.

UPS2000-G:
1 kVA to 20 kVA

L and M-sized UPS5000-A Solution

- Introduction
  - N+X redundancy and dual-bus configuration based on different reliability requirements;
  - Power backup time from 10 minutes to 2 hours;
  - Compatible with the NetEco.
- Advantages
  - High reliability and efficiency, protecting investment and reducing the OPEX;
  - Flexible configuration, meeting different requirements;
  - Intelligent battery management and network-wide monitoring platform, improving system maintainability.

L and M-sized UPS5000-E/S Solution

- Introduction
  - Modularized design, enabling smooth capacity expansion with load increasing;
  - N+X redundancy and dual-bus configuration based on different reliability requirements;
  - Network-wide monitoring platform, covering all power supply facilities.
- Advantages
  - High efficiency and modularization, preventing low-efficiency power system running as services increase in initial construction;
  - Network-wide monitoring platform, improving system maintainability and reducing the OPEX.

UPS5000-E-(50–200 kVA)

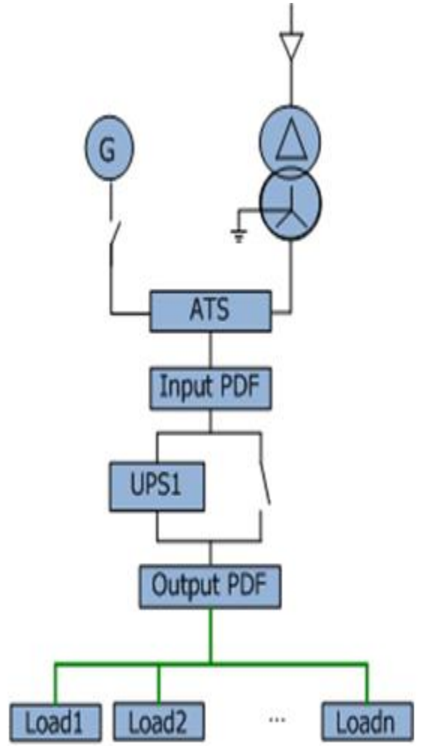
FusionPower

- Introduction
  - Integrates the UPS input and output cabinets and UPS, and achieves a system efficiency of 97%.
  - Uses the iPower intelligent technology to improve system reliability and reduce O&M costs for customers.
  - Adopts the all-in-one design to effectively reduce the power distribution workload, as well as save footprint and installation time.
- Feature
  - The redundancy design for all modules improves reliability. Visualized monitoring of all links improves O&M efficiency.
  - The iBattery monitors the battery status to eliminate fire risks.
  - High efficiency at low load: The efficiency is higher than 96% when the load rate ranges from 20% to 50%, saving electricity fees.

Contents

Single UPS System

- Single UPS system advantages
  - Simple configuration and low cost;
  - High running efficiency.
- Single UPS system disadvantages
  - The usability is limited. If the UPS is faulty, loads are powered in bypass mode, and the power supply quality cannot be guaranteed;
  - During UPS, battery, or power distribution device maintenance, the load power supply quality cannot be guaranteed;
  - No redundant system exists. When the UPS is faulty, loads are lack of protection;
  - Multiple single point failures exist.

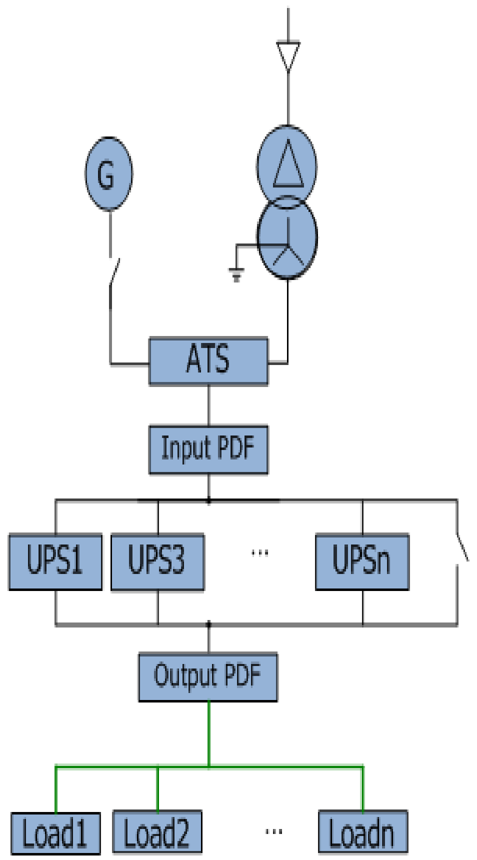


ATS: automatic transfer switch

PDF: power distribution frame

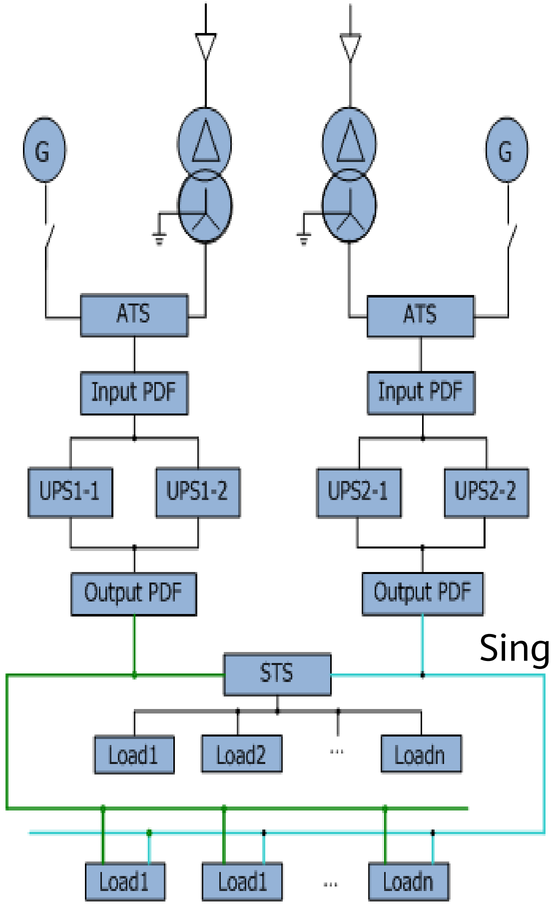
Redundant Parallel or N+1 System

- N+1 system advantages
  - The N+1 system can properly run if a UPS is faulty, which has higher reliability than the N system;
  - The system design is simple with low costs.
- N+1 system disadvantages
  - UPSs used in an N+1 system must be of the same design, manufacturer, rated specifications, technique, and configurations;
  - Single point failures exist in inputs and outputs of the N+1 system;
  - If a single UPS and its downstream devices (except for batteries) are maintained, loads cannot be protected;
  - The UPS load ratio and the operation efficiency is low.



Dual-Bus Redundancy System

- Dual-bus system advantages
  - Two independent power supplies are available, preventing single point failures and providing powerful fault tolerance;
  - The system provides comprehensive input and output redundant configuration;
  - UPSs, batteries, and other power distribution devices can be maintained without transferring loads to the bypass mode.
- Dual-bus system disadvantages
  - Redundancy design, leading to high costs;
  - Low load ratio and low efficiency.



Single input load

Dual input load

Contents

UPS Application

Government

- Data center;
- Monitoring center;
- E-government.

Transportation

- Communications scheduling center;
- Data center;
- Basic power supply system.

Finance

- Data center;
- Business hall;
- Self-service terminal.

Retail

- Data center;
- Billing system;
- Logistic scheduling center.

Communications

- Data center;
- Central equipment room;
- Site equipment room;
- Customer service center.

ISP

- IDC;
- E-office system;
- Basic power supply system.

Energy

- Scheduling center;
- Monitoring center;
- Data center;
- Data center for short message service.

Manufacturing

- Control center;
- Data center;
- Office system.

UPS Load Types

- IT equipment
  - Server and storage device
  - Switch and router
  - Terminal
  - ATM
- Industrial facilities
  - Industrial control system
  - Automated production line
  - Precision instrument
- Personal use
  - PC
  - Household appliance such as acoustics

Enterprise network equipment room

Data center

Automated production line

System control center

Office

Household acoustics

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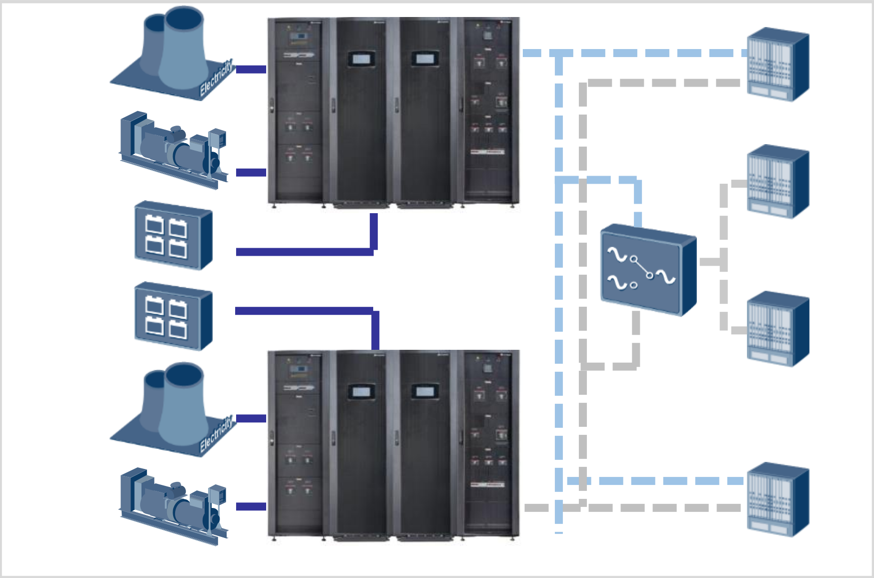
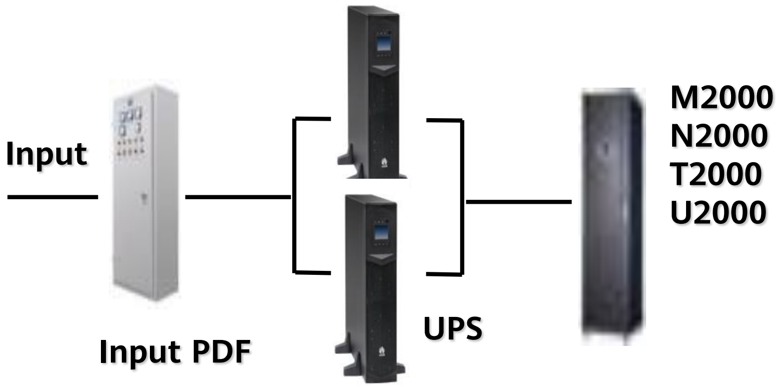
Scenario (1) - Large-sized IDC

- Important loads, such as servers and storage devices, require reliable power supply systems.
- Large- and medium-sized equipment rooms require the UPS capacity of 300 kVA or higher and power backup time from 10 minutes to 2 hours.



Scenario (2) - NMS

- High load importance requires a reliable power supply system.
- NMSs require that UPSs be fast deployed, easily installed and maintained, and transferred between tower-mounted and rack-mounted.



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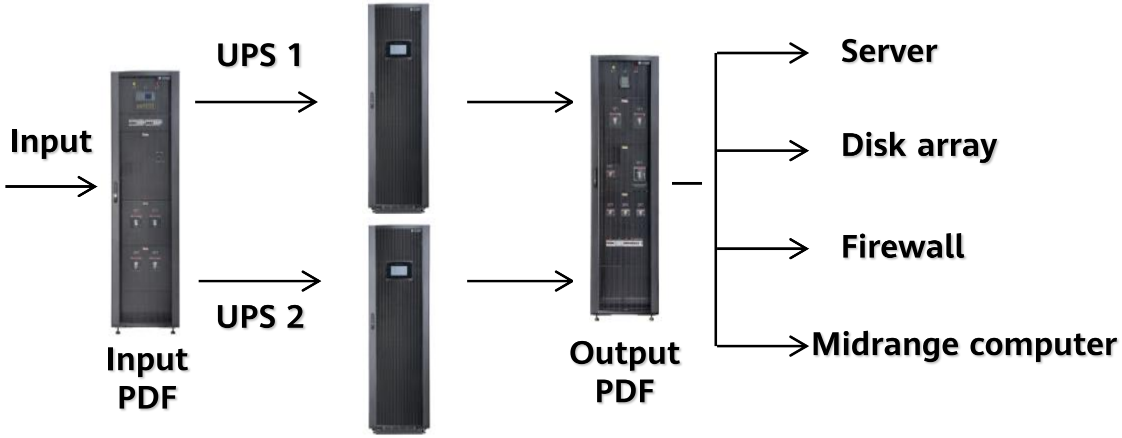
Scenario (3) - Centralized Equipment Room

- High service importance requires a reliable power supply system.
- Provincial centralized equipment rooms require the UPS capacity of 60 kVA to 200 kVA and more than 1 hour power backup time.
- The UPSs must be applicable to multiple types of loads and servers and meet efficiency and energy conservation requirements.



Quiz

1. (Short Answer Question) Why do we need UPS ?
2. (Short Answer Question) What is the benefit of module UPS?
3. (Short Answer Question) Which configuration solution is used at your site?

Summary

- The chapter describes UPS basic knowledge, including the function and work principle of UPS and the common configuration solution.

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise： http://support.huawei.com/enterprise/
  - Online Learning： http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

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Thank you.

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每个组织，构建万物互联的智能世界。

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Basic Knowledge of Huawei DC Power Systems

Foreword

- DC power systems are widely used in communication base stations and some data center CT scenarios. The slides describe the basic knowledge of Huawei –48 V DC power systems.

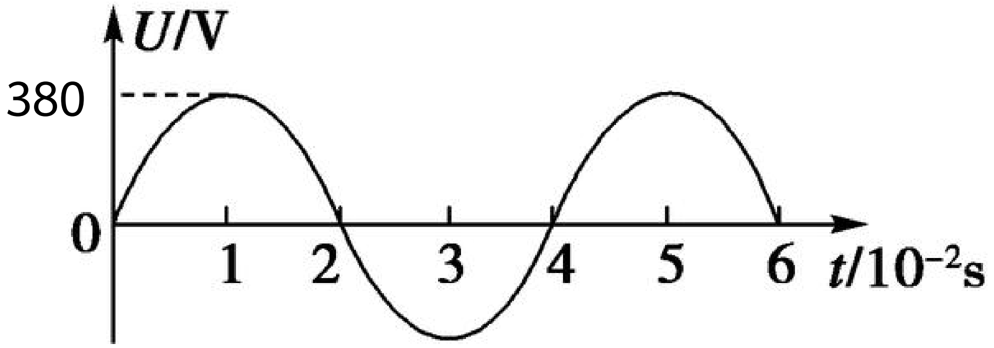
Objectives

Upon completion of this course, you will be able to understand the main functions of Huawei DC power systems, understand the architecture and basic composition of DC power systems, and master the basic knowledge of DC power system battery management.

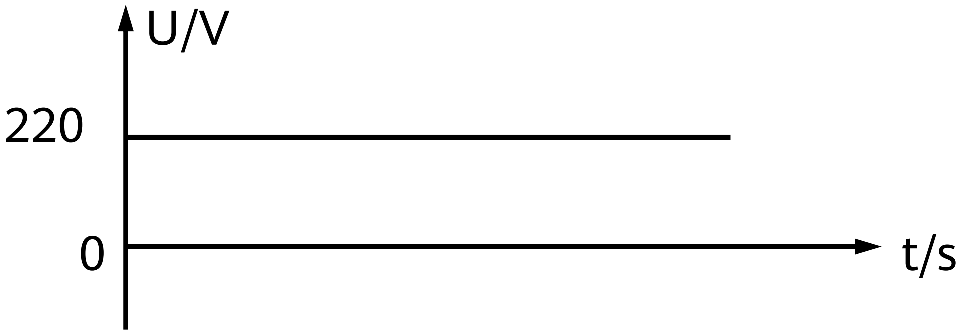
Contents

DC Power System Application Scenarios

- AC power (mains) and its direction change periodically as time changes.
- DC power and its direction do not change with time. It is steady current.



AC power



DC power

- DC power is used for powering electronic devices, and AC power is used for upstream electric energy transmission.
- DC arcs are more difficult to be extinguished than AC arcs. Unless otherwise specified, do not mix AC and DC devices.

Basic Functions of Huawei DC Power Systems

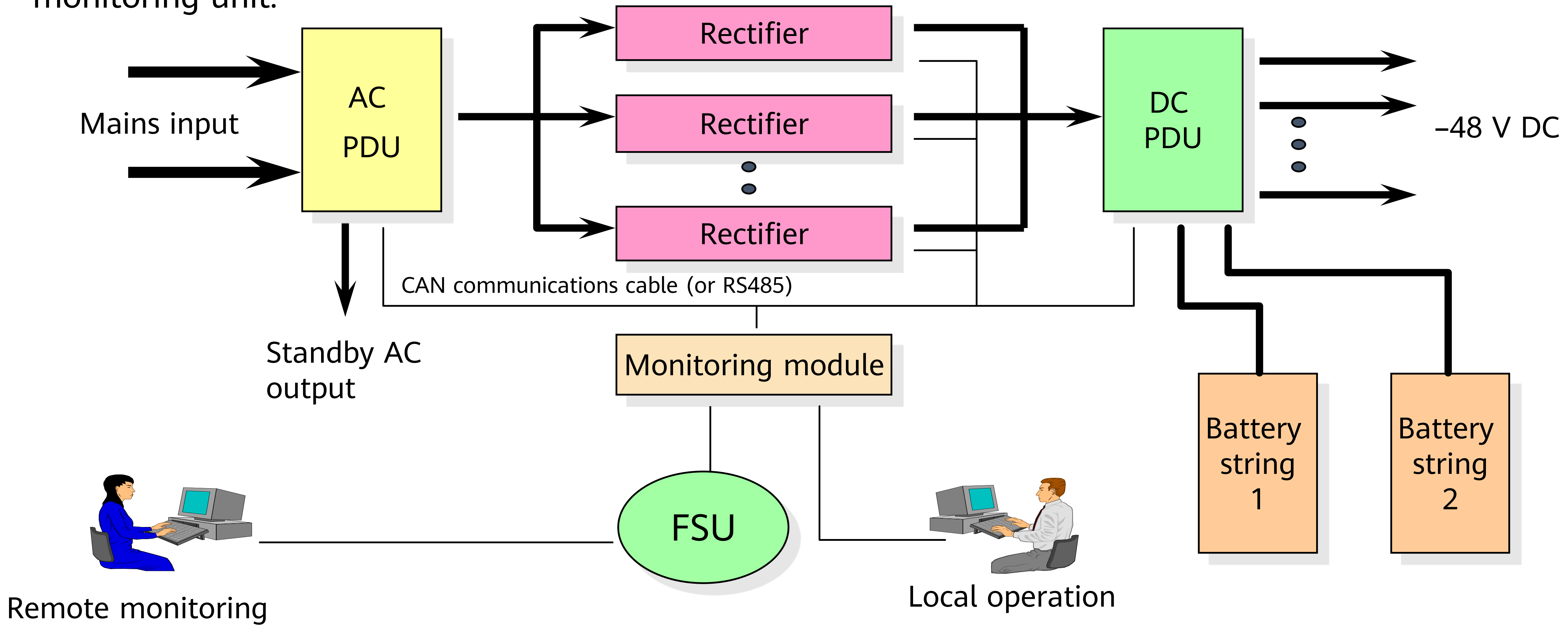
- Two basic functions
  - Rectification
    - Converts 220 V AC or 380 V AC power into –48 V DC power.
    - Provides redundancy for rectifiers.
  - Battery management
    - Manages the charge and discharge of batteries connected in parallel on the output side. That is, batteries can be charged and discharged with appropriate voltages, currents, and modes to ensure that the DC load operates uninterruptedly when the AC power failure occurs.

Output Voltage

- Why is the polarity negative?
  - Due to historical reasons, the positive pole of the telecom power supply was grounded at the early stage, forming a loop through the ground and saving cables.
  - The positive grounding can reduce the corrosion of negative devices.
- Why is the voltage –48 V?
  - The early-stage power systems use the original lead-acid batteries, and the voltage is a multiple of the basic (single battery) voltage 1.2 V.
  - According to the device component and line capabilities, 48 V voltage is selected to ensure the communication distance of local calls and security.

Logical Composition

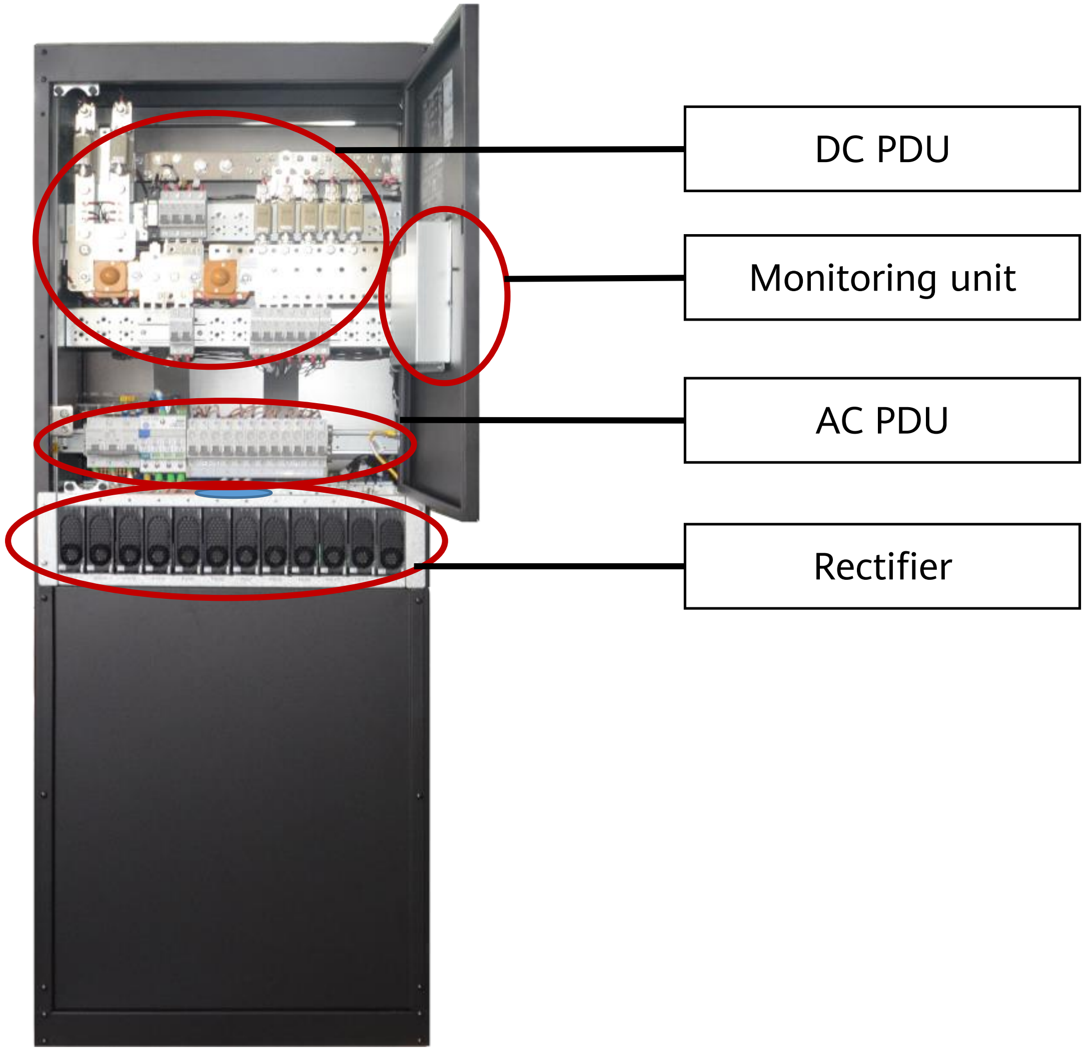
- The telecom power system consists of the AC power distribution unit (PDU), DC PDU, rectifier, and monitoring unit.



Contents

Physical Architecture

- Basic components
  - AC PDU
    - AC input, AC output, AC surge protective device (SPD), and line protection
  - Rectifier
    - Converts AC power into DC power (high-frequency switch rectification).
  - DC PDU
    - DC junction, output, SPD, load power-off, and battery protection
  - Monitoring unit
    - Measures AC and DC power distribution signals; manages, controls, and monitors rectifiers; analyzes and outputs alarms; manages loads and batteries.



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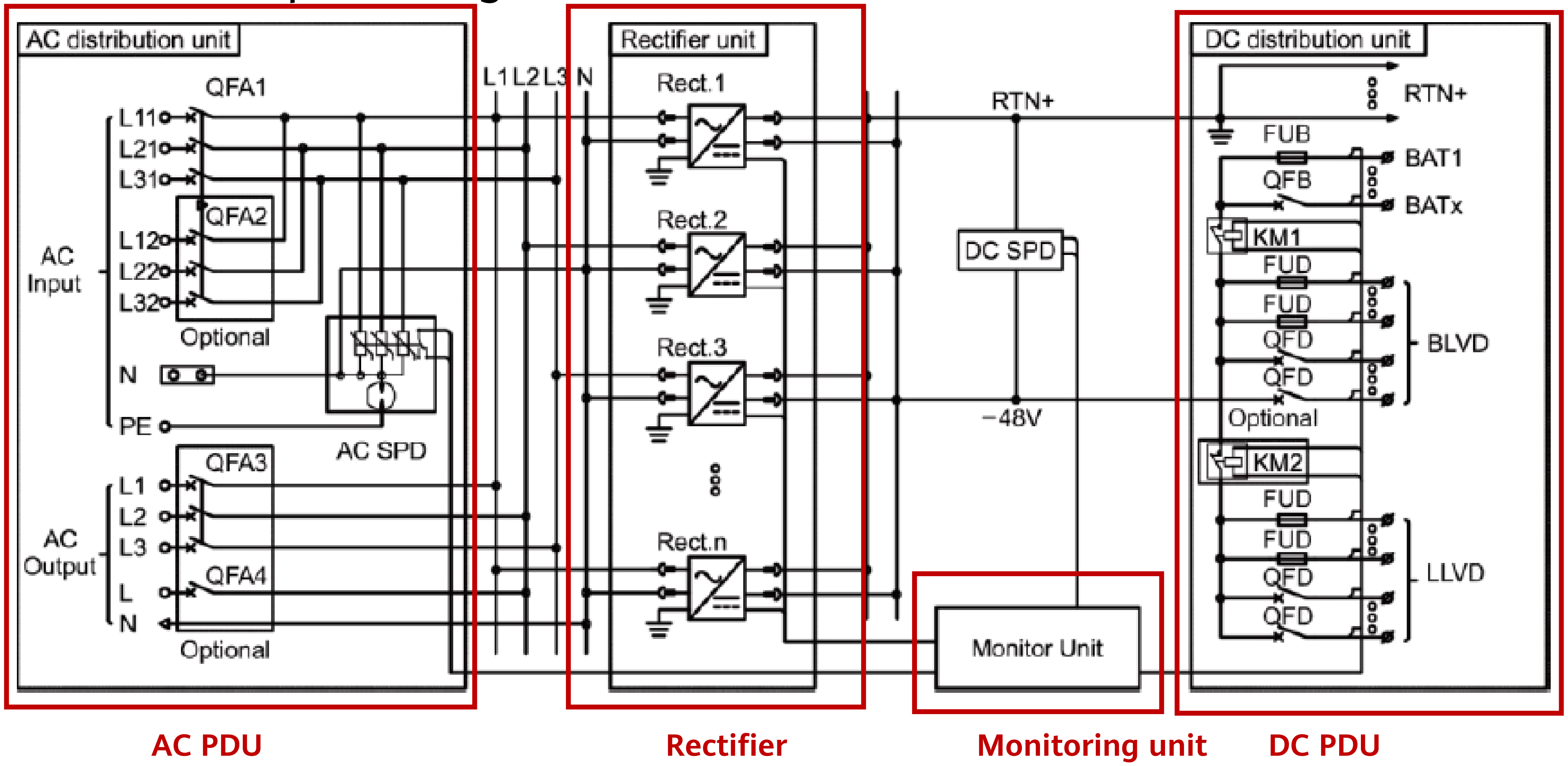
Electrical Conceptual Diagram

- Electrical conceptual diagram



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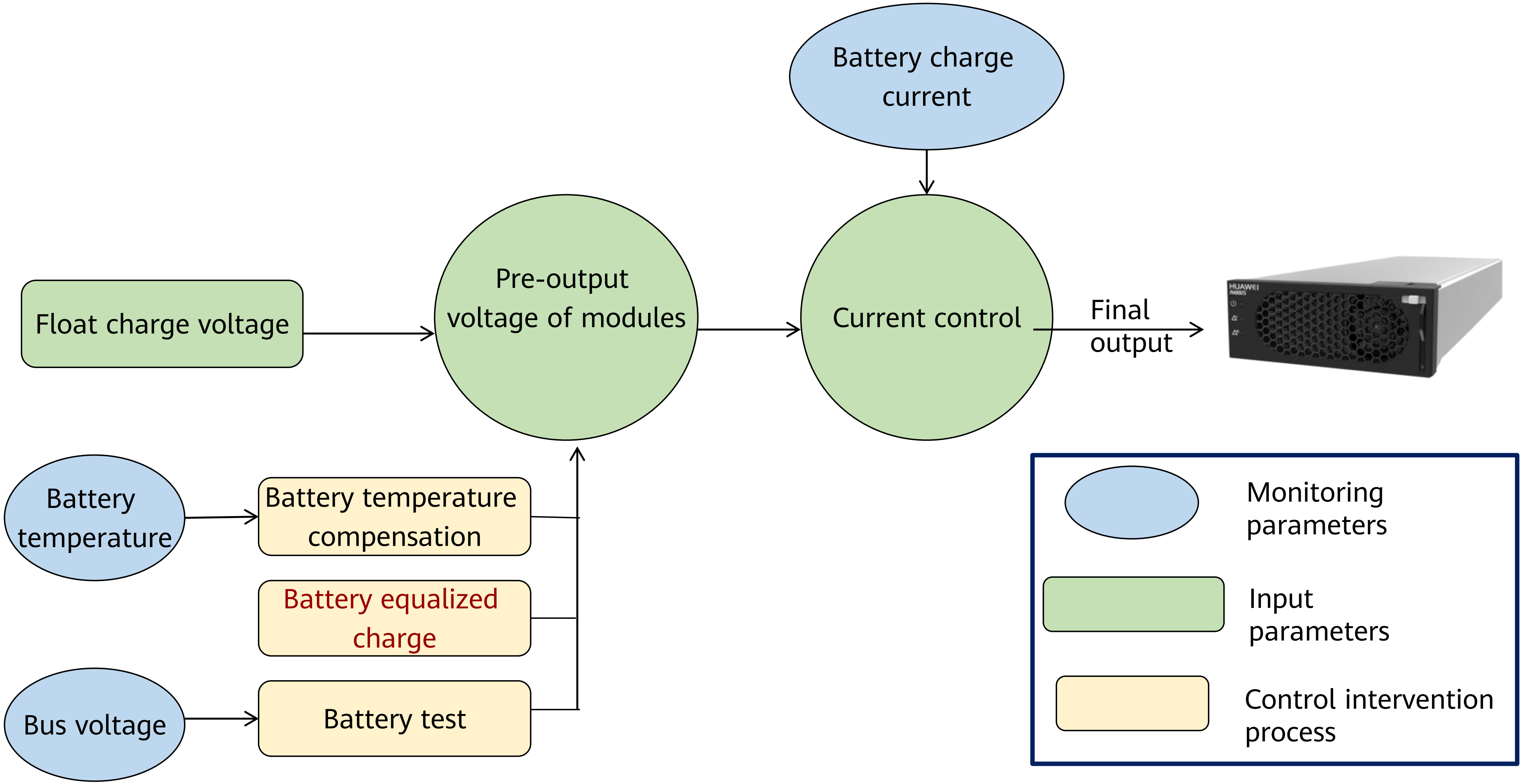
Rectifier Parameters

- Input
  - Input voltage range
  - Input frequency range
  - Power factor
- Output
  - Output voltage adjustment range
  - Output current adjustment range
  - Regulated voltage precision

Contents

Working Principle



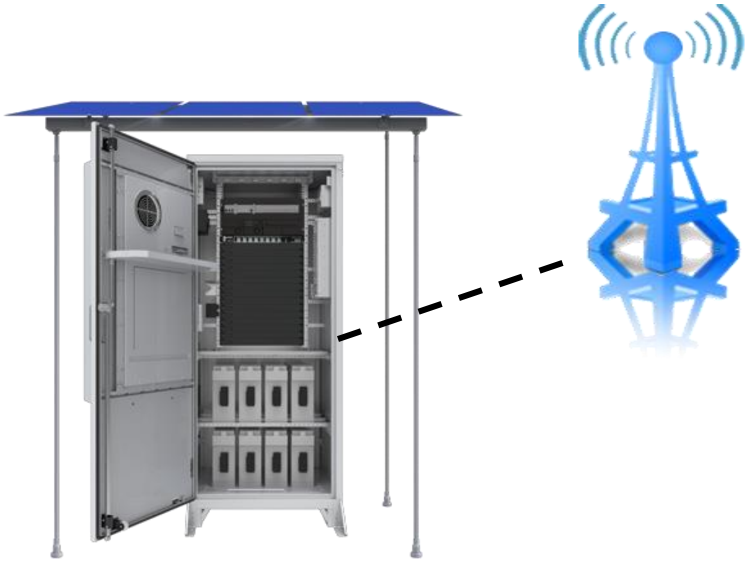
Main Functions

- Equalized charge and floating charge management:
  - When the real-time battery capacity, charge current, and charge time meet certain conditions, the equalized charge and float charge modes switch with each other.
- Battery disconnection protection:
  - After an AC outage occurs or rectifiers become faulty, batteries start discharging and the battery voltage decreases. If the AC power does not recover when the battery voltage decreases to a certain extent, batteries need to be disconnected to prevent battery damage.
- Temperature compensation:
  - When the batteries are being charged, the temperature increases slowly. To ensure that the batteries work at a proper temperature, the battery charge voltage is decreased when the battery temperature is too high and the battery charge voltage is increased when the battery temperature is too low.

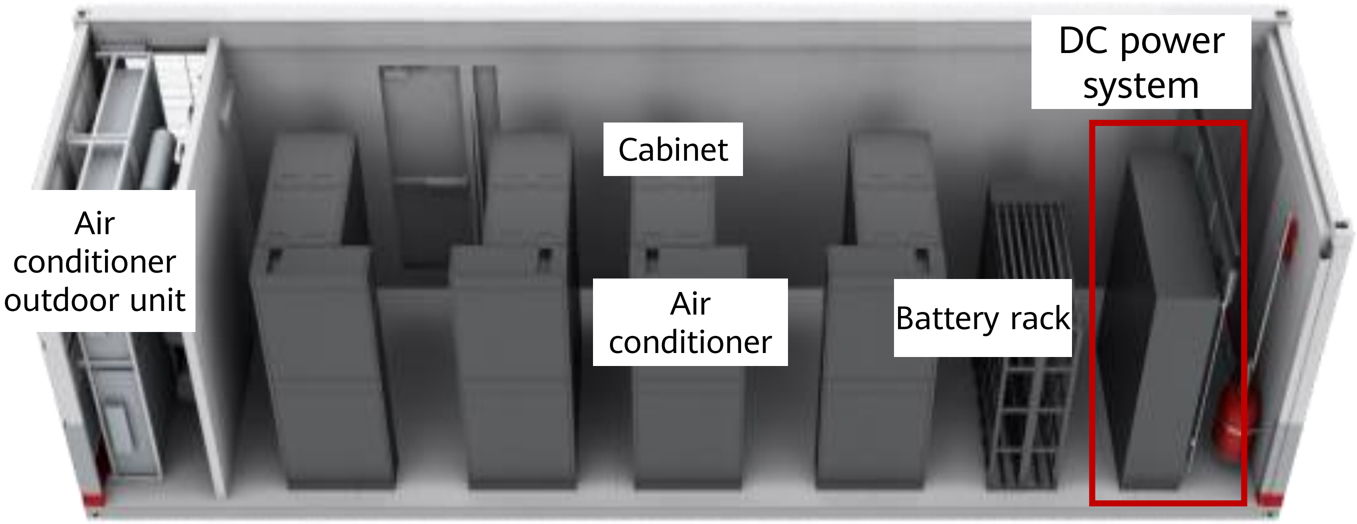
Contents

Application Scenarios

- DC power systems are widely used in communication base stations and some data center CT scenarios.



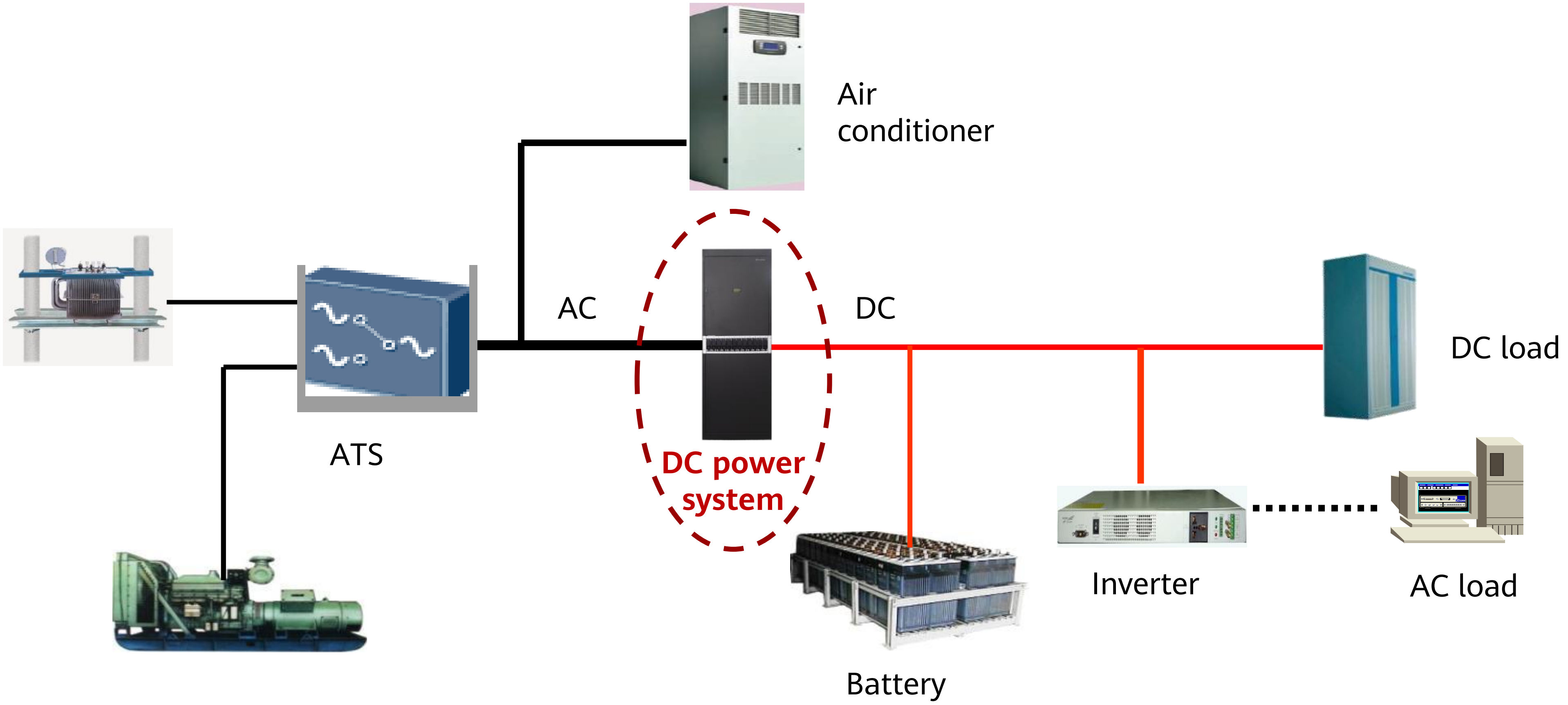
Communication base station scenario



Data center CT scenario

Position in the Power Distribution System

- The mains enters the rectifiers through the AC PDU. The rectifiers convert AC power into –48 V DC power, and then the DC PDU distributes the power to DC devices.



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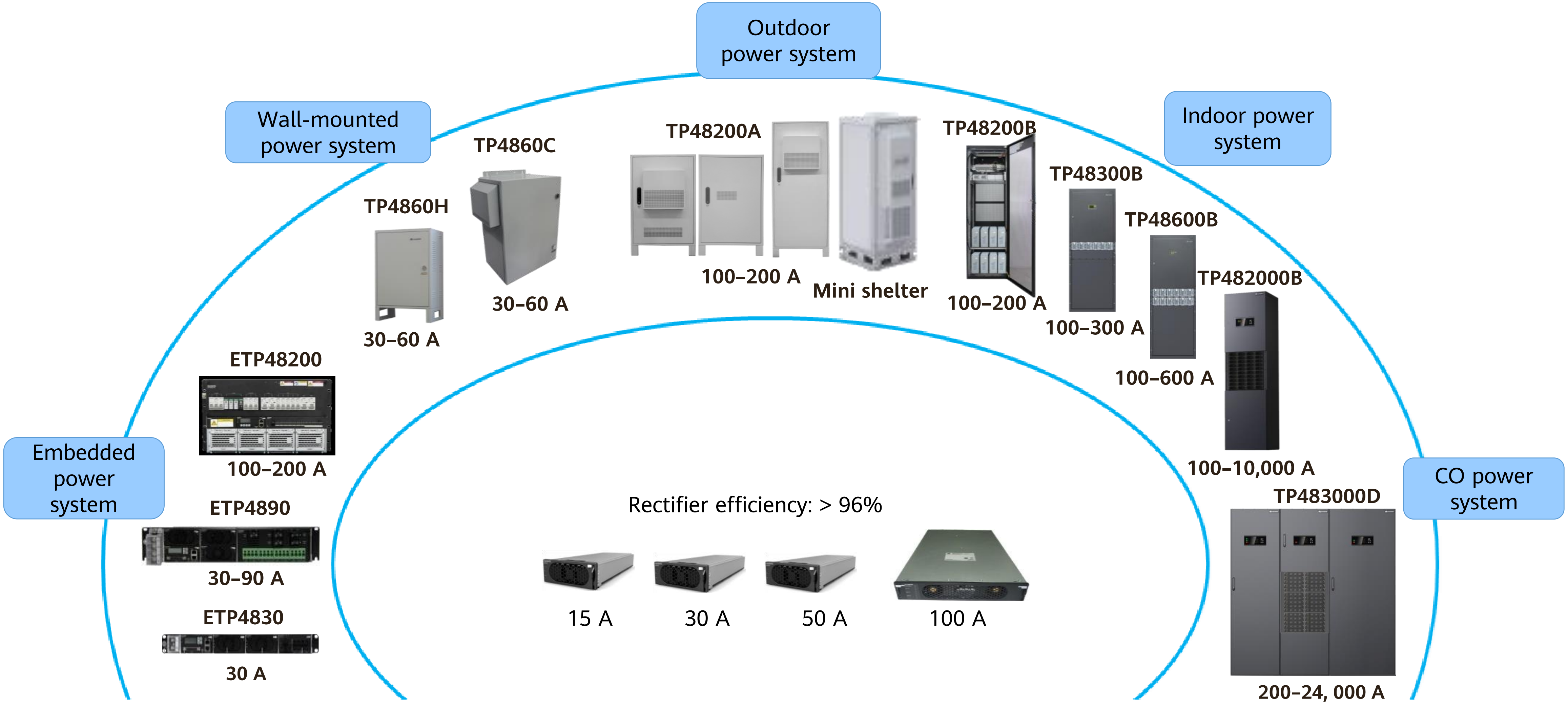
Huawei DC Power Systems



Quiz

1. (Short Answer Question)What are the basic functions of DC power systems?
2. (Short Answer Question)What are the basic components of a DC power system?

Summary

- After learning this chapter, we are able to:
  - Understand the telecom power.
  - Understand the architecture and composition of DC power systems.
  - Master the principles and features of DC power systems.

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise：http://support.huawei.com/enterprise/
  - Online Learning：http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

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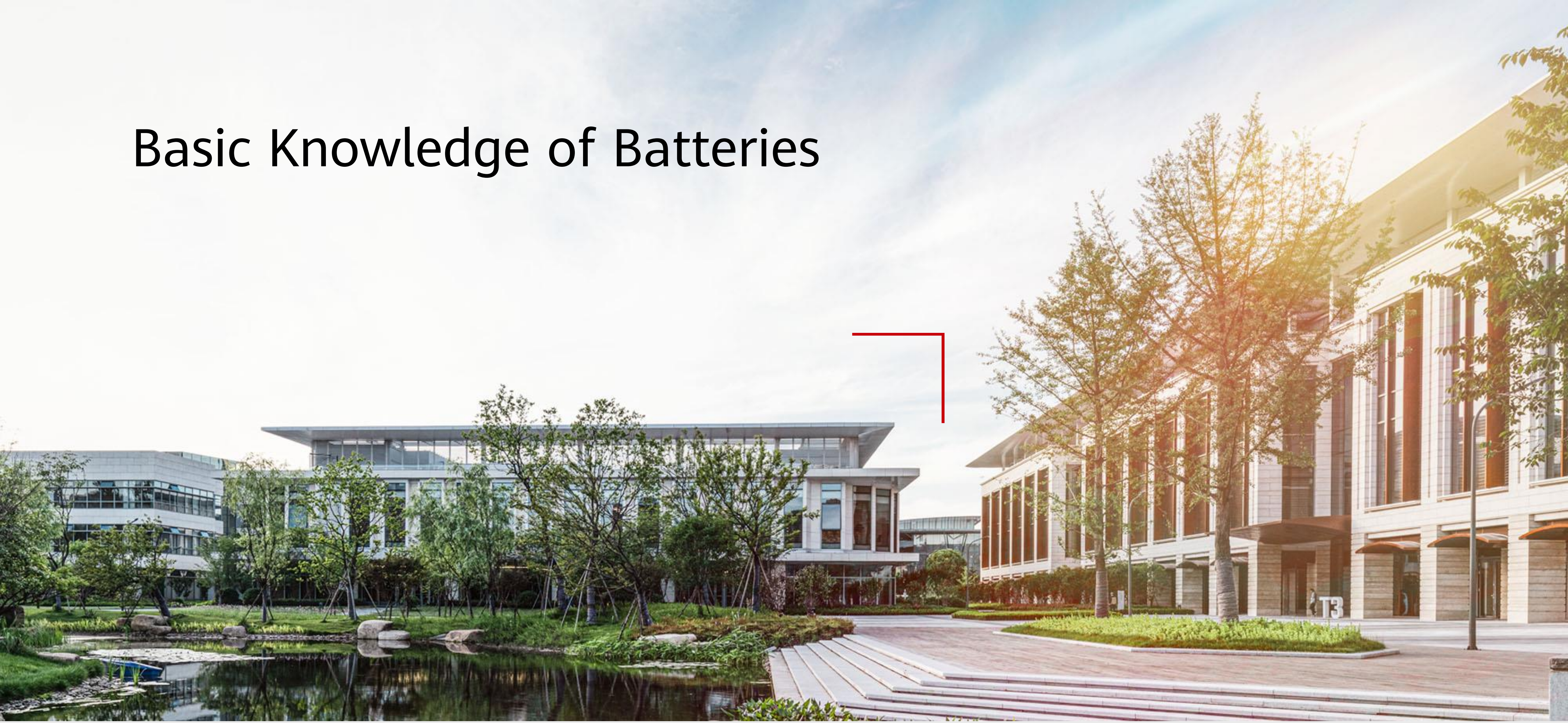
Basic Knowledge of Batteries



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Objectives

On completion of this course, you will be able to:

- Understand the battery development and application in the ICT field.
- Get familiar with the classification and naming of batteries.
- Get familiar with the basic principles and structure of batteries.
- Understand the performance differences between lead-acid and lithium-ion batteries.

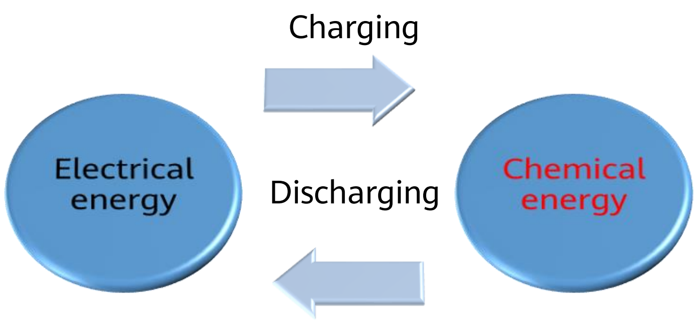
Contents

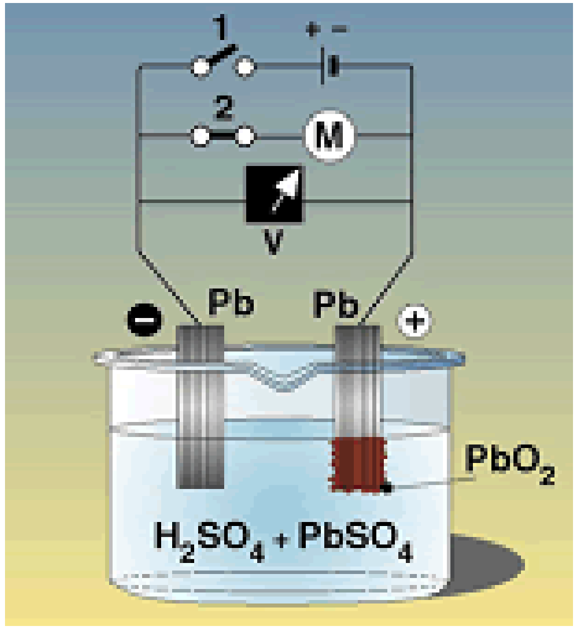
History

- 1859: French physicist Gaston Planté invented the (open-type) lead-acid battery.
- 1957: Sonnenschein invented the gel battery.
- 1975: Gates Corporation applied for the invention patent of the valve regulated lead acid (VRLA) battery.
- 1991: Sony released the first lithium-ion battery.
- 1992: The use of VRLA batteries increased significantly in Europe and the Americas. In Asian countries, the telecommunications sector advocated the use of VRLA batteries.
- 1994: Bellcore launched the lithium polymer battery for mobile phones.
- 2004: Valence started commercial application of lithium iron phosphate (LFP) materials.
- 2005: Saft launched lithium-ion batteries for telecommunications.
- 2010: The Nissan Leaf, equipped with lithium-ion batteries, was launched.

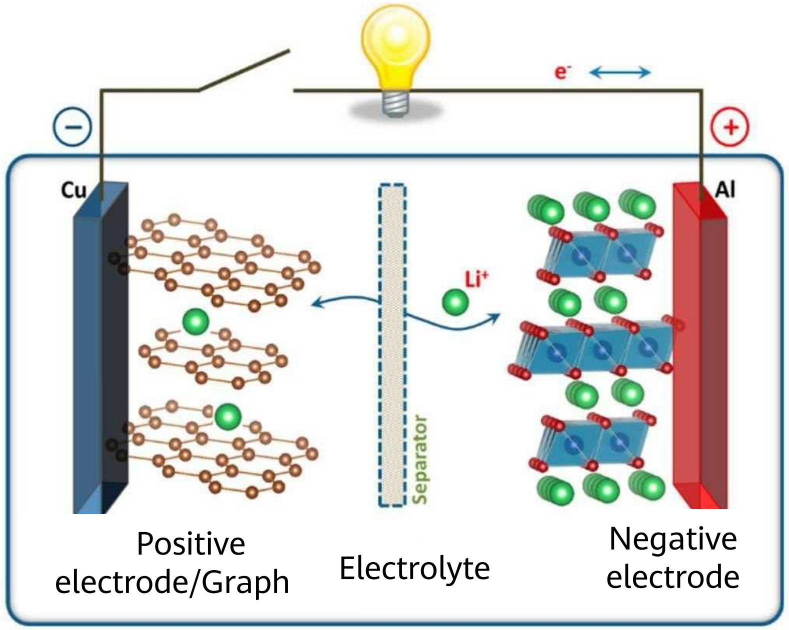
Definition

- A chemical battery, generally referred to as battery, is a device that converts chemical energy into electrical energy. After a battery is discharged, it can be recharged to regenerate the internal active substances, that is, to convert the electrical energy into chemical energy. It converts chemical energy into electrical energy again when it is discharged. This type of battery is called storage battery or secondary cell.
- Main rechargeable batteries in the market include nickel metal hydride batteries, lead-acid batteries, lithium-ion batteries, and lithium polymer batteries.





Lead-acid battery



Lithium-ion battery

Function

- Storage battery are sound DC power sources and are stable in voltage, free of fluctuation, and easy and reliable to use. Therefore, storage battery are widely used in the communications systems. Storage battery can be backup power sources for the AC UPS and DC power system, the startup power source, and the DC operation and control power source in the high-voltage power distribution system.

Technical Specifications (1)

- Rated capacity: refers to the nominal capacity, which indicates the minimum capacity that can be discharged according to standards or industrial standards.
- Actual capacity: refers to the capacity that can be discharged after a fully charged battery is discharged to the specified end-of-discharge (EOD) voltage under certain discharge conditions. The unit is Ah or Wh.
  - Discharge rate: For example, C10. C indicates the capacity, and 10 indicates the number of hours for the battery to discharge to the specified voltage at a certain current. The rated discharge current can be obtained by dividing the capacity by the number of hours.
- SOH: State of health, refers to the Percentage of actual capacity to rated capacity.
- SOC: State of charge, refers to the Percentage of current remaining capacity to actual capacity.

Technical Specifications (2)

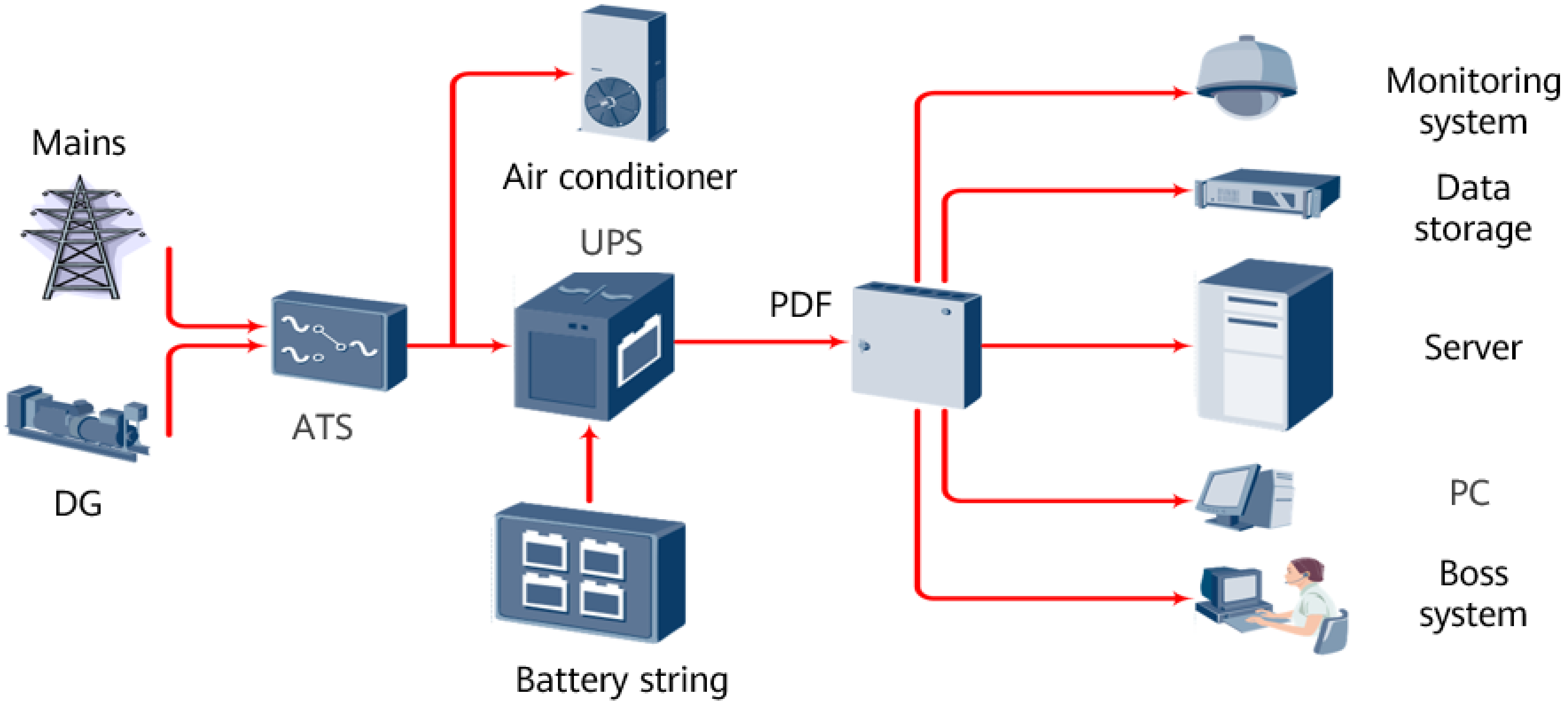
- Rated voltage: refers to the approximate value used to identify the voltage of a battery type. For example, the rated voltage of a single VRLA battery is 2 V.
- Open-circuit voltage: refers to the terminal voltage of a battery in the open-circuit state. The open-circuit voltage of a battery is equal to the electric potential difference between the positive electrode and the negative electrode when the battery is open-circuited (that is, when no current passes through the two electrodes).
- EOD voltage: indicates the voltage when a battery is used up. If the voltage decreases due to continuous discharging, the battery will be damaged. EOD voltage is the protection voltage set to prevent battery overdischarge. When the voltage reaches the value, the discharging should be terminated.

Technical Specifications (3)

- Equalized charging: During the use of batteries, battery voltages are unbalanced due to the individual difference and temperature difference of batteries. To avoid the deterioration of this imbalance trend, the charge voltage of the battery string needs to be increased to activate the batteries. In this way, characteristics of each battery in the battery string are balanced.
- Float charging: To balance the capacity loss caused by battery self-discharge, batteries need to be charged at a constant voltage for a long time.
- Depth of discharge (DOD): indicates the percentage of battery discharge capacity to rated battery capacity. Generally, when the discharge capacity of a battery exceeds 80% of its rated capacity, it is considered that DOD is achieved.

Application in Data Centers

- In a data center, batteries are installed at the end of the UPS. When the mains fails, batteries supply DC power to the UPS, and the UPS converts the DC power into AC power required by loads to ensure continuous operation of devices.



Contents

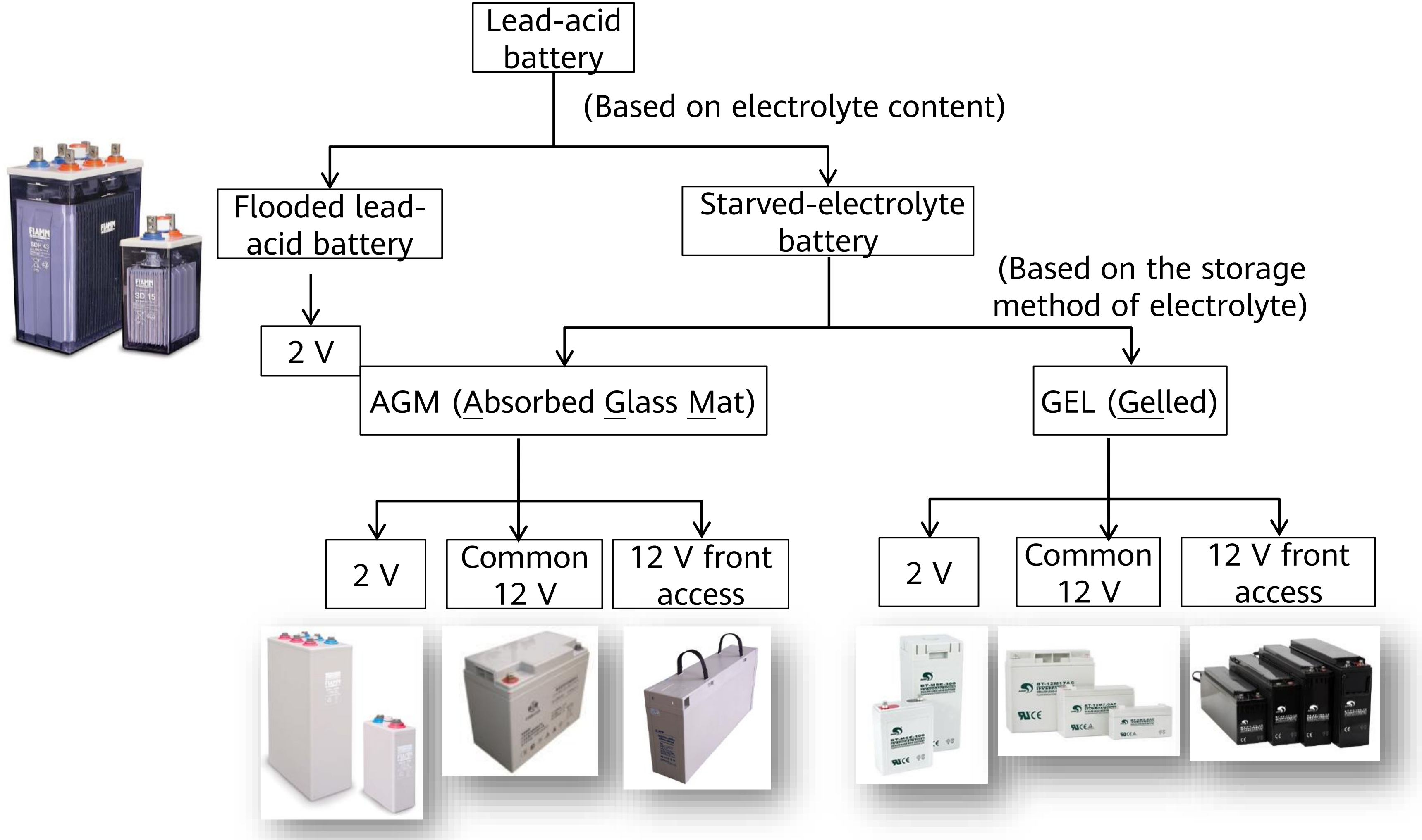
Definition

- VRLA battery is a battery improved in material, structure, and process based on the common anti-acid and explosion-proof lead-acid storage battery.
- The basic feature is that the battery does not need to be maintained by refilling acid or water during operation. Thanks to its sealing structure, the battery does not leak acid or exhaust acid smog.
- On the battery cover is a one-way exhaust valve (safety valve), which automatically exhausts the excessive gas in the battery when the internal battery pressure increases to the threshold and automatically closes itself after the exhausting to avoid gas entry.

General Category

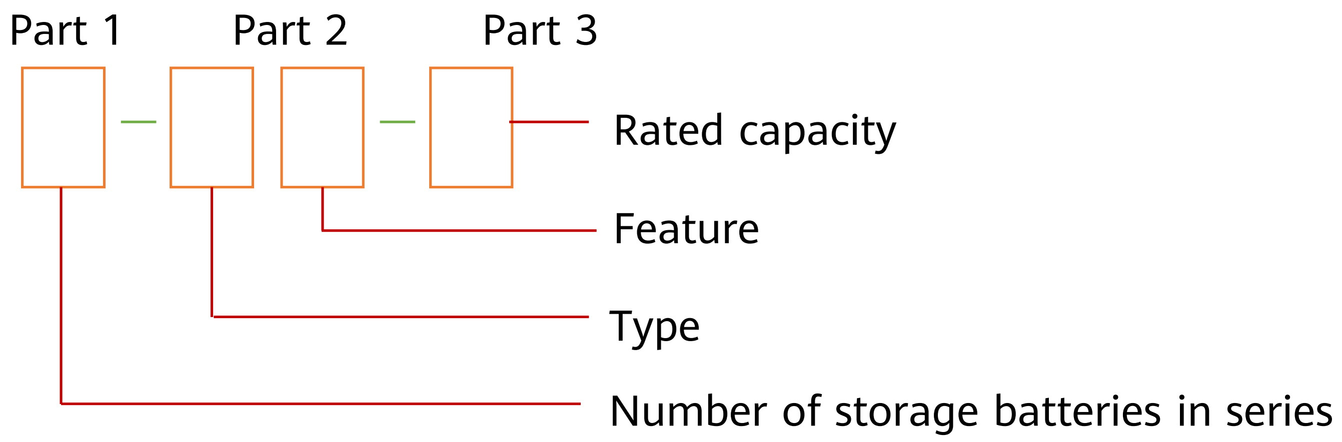
- Based on electrolyte: acid battery and alkaline battery
- Based on electrolyte content: flooded battery and starved-electrolyte battery
- Based on vent plug structure: open-type battery, vented battery, and acidapray-proof battery
- Based on cell voltage: 2 V battery, 6 V battery, and 12 V battery
- Based on purpose: stationary battery, mobile battery, starter battery, traction battery, railway battery, motorcycle battery, coal mine battery, energy storage battery, and battery for other purposes

Battery Classification in ICT



Naming Rule

- The model number of the lead-acid battery is composed of three parts. Part 1 indicates the number of storage battery in series; part 2 indicates the type and feature of the storage battery; part 3 indicates the rated capacity of the storage battery. Other codes can also be added on the right after the rated capacity if necessary.



Examples

- GFM-1000: a stationary valve-regulated sealed lead-acid battery, rated capacity 1000 Ah (common in ICT scenarios).
- 6-GFM-100: six stationary valve-regulated sealed lead-acid batteries in series, rated capacity 100 Ah (common in ICT scenarios).
- 6-Q-150: a lead-acid battery string of six batteries in series for startup, rated capacity 150 Ah.

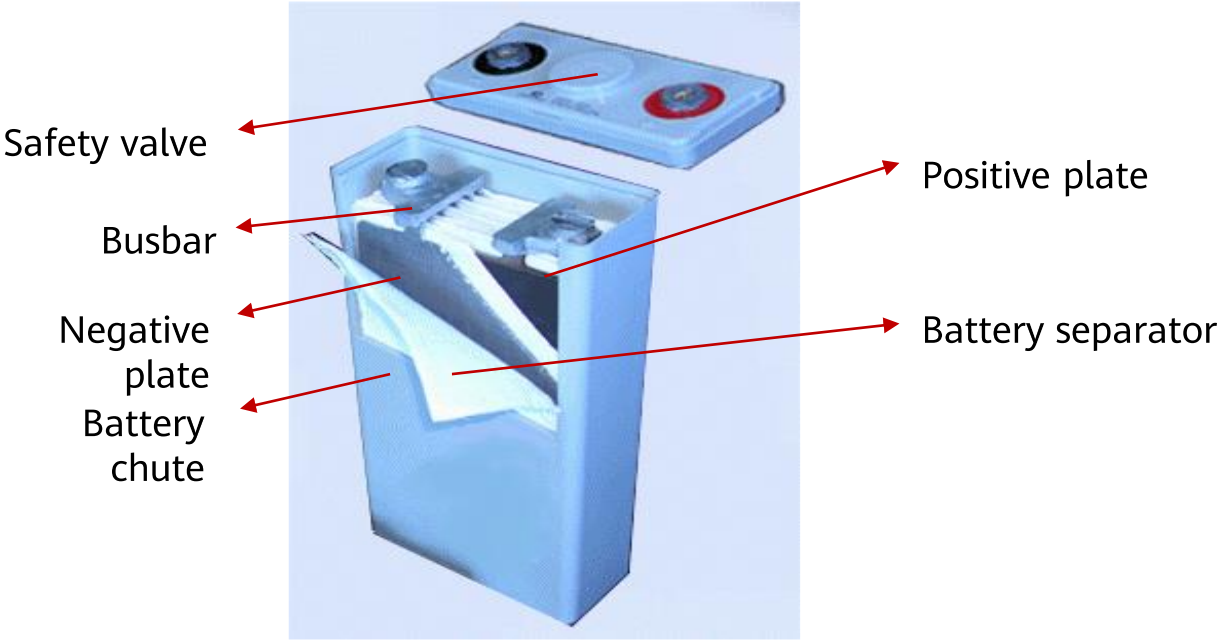
No.	Battery Type (Purpose)	Code
1	Starter	Q
2	Stationary	G
3	(Electric) Traction	D
4	Valve-regulated	F
5	Energy storage	U

No.	Battery Feature (Purpose)	Code
1	Sealed	M
2	Maintenance-free	W
3	Antiacid	F
4	Gel electrolyte	J
5	Air-tightness	Q

Contents

Main Components

- Take the most widely-used AGM lead-acid battery for example, its main components include the positive plate, negative plate, electrolyte, battery separator, battery chute, and other parts, such as the terminal, busbar, and safety valve.

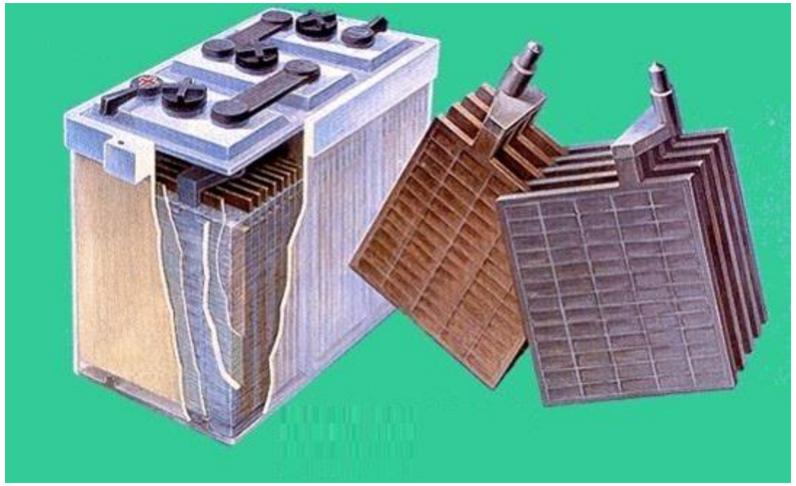


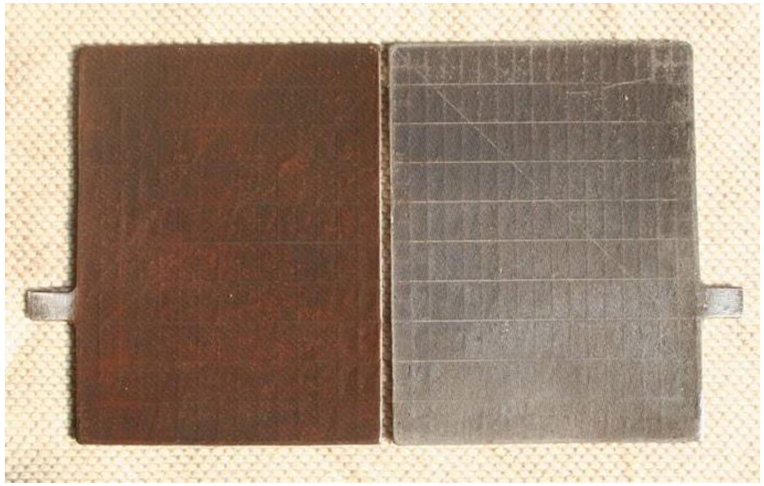
Safety Valve

- The safety valve is a key component of VRLA battery. The quality of the safety valve directly determines the lifespan, performance uniformity, and safety of the VRLA battery. The function of the safety valve is:
  - To automatically exhaust the excessive gas in the battery to lower the internal battery pressure when the internal pressure increases to the threshold.
  - Unidirectional exhausting means that air cannot enter the battery, which avoids battery self-discharge.

Plate

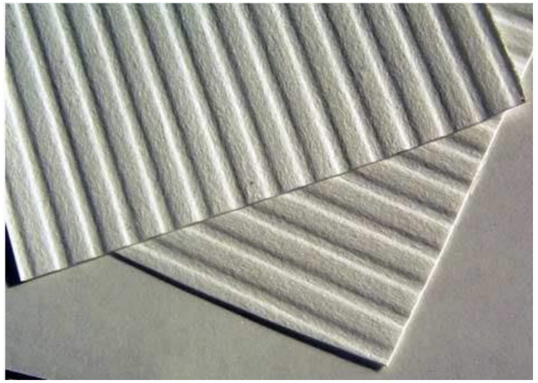
- The battery plate can be positive or negative. Battery plates are composed of active substances and plate grids, and there is a separator between the positive and negative plates, as shown in the following figures. Active substances for the positive and negative plates are lead dioxide (PbO_2) and gray sponge lead (Pb) respectively.

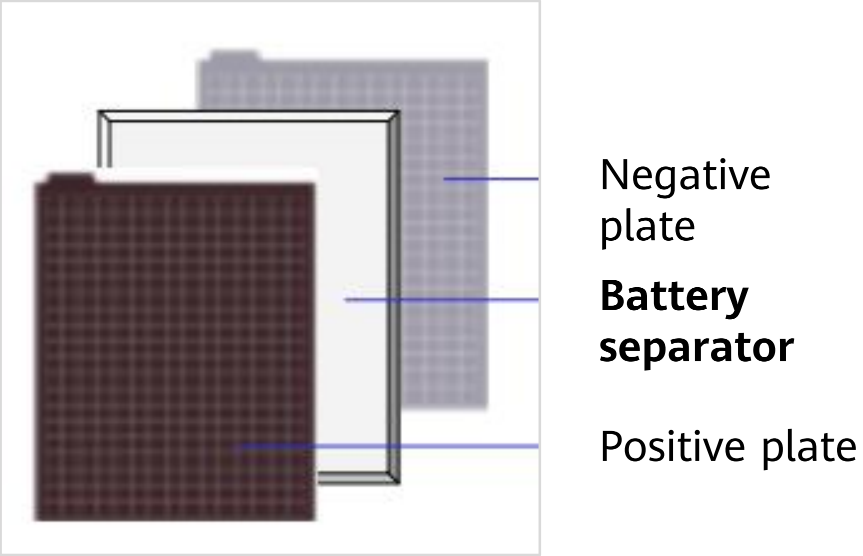




Separator

- The battery separator has the following functions:
  - Keeps the positive and negative plates insulated from each other.
  - Absorbs electrolyte, and ensures that the electrolyte does not flow and that the negative plate is damp.
  - Serves as the gas channel. Many holes in the battery separator facilitate the oxygen moving from the positive plate to the negative plate.
  - Slows the disconnection of active substances.

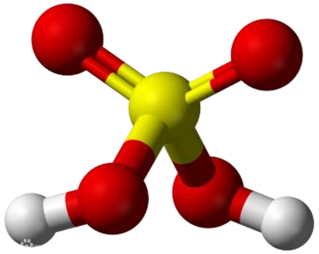




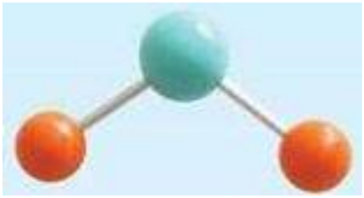
Battery Structure – Electrolyte

- The electrolyte, composed of pure concentrated sulfuric acid and pure water, is absorbed in the separator to conduct electricity and participate in electrochemical reaction. The post terminal is the external terminal. The safety valve is used to unidirectionally adjust the internal pressure of the battery to prevent air from entering the battery.

H_2SO_4 molecular ball-and-stick model



H_2O molecular ball-and-stick model



- In a VRLA battery, the electrolyte does not flow, that is, the electrolyte is absorbed by active substances on the plate and the separator film, and the saturation degree of the electrolyte is 60%–90%.
- When the saturation degree of the electrolyte is lower than 60%, it indicates that the battery loses electrolyte seriously, and the active substances on the plate cannot fully contact the electrolyte. If the saturation is higher than 90%, the diffusion channel of the oxygen from the positive electrode is blocked by the electrolyte, which affects the diffusion of the oxygen to the negative electrode. In addition, the gel electrolyte does not flow.

Container and Cover

- The battery chute houses the electrolyte, battery plate, battery separator, and accessories. For example, there are the positive terminal, negative terminal, and exhaust unit in a VRLA battery. The battery chute must be made of corrosion-, vibration-, and high/low-temperature-resistant materials.

Contents

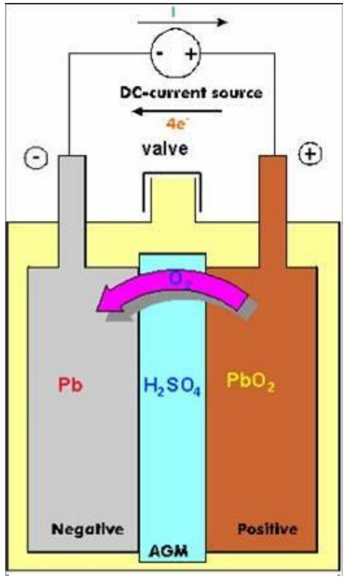
Working Principles – Main Reaction

- Double-sulphate theory
  - This theory can be described as follows: When a lead-acid battery is discharged, the active substances at the positive and negative electrodes change to lead sulfate ($PbSO_4$). After the battery is charged, the active substances return to the original state. That is, the active substances at the positive electrode change to lead dioxide (PbO_2), and those at the negative electrode change to sponge lead (Pb).
- The main reaction constitutes a chemical system of 2 V electromotive force for a single cell.

Main reaction: $PbO_2 + 2H_2SO_4 + Pb \underset{\text{Charging}}{\overset{\text{Discharging}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$

Positive electrode: $PbO_2 + 3H^+ + HSO_4^- + 2e \Leftrightarrow PbSO_4 + 2H_2O$

Negative electrode: $Pb + HSO_4^- \Leftrightarrow PbSO_4 + H^+ + 2e$



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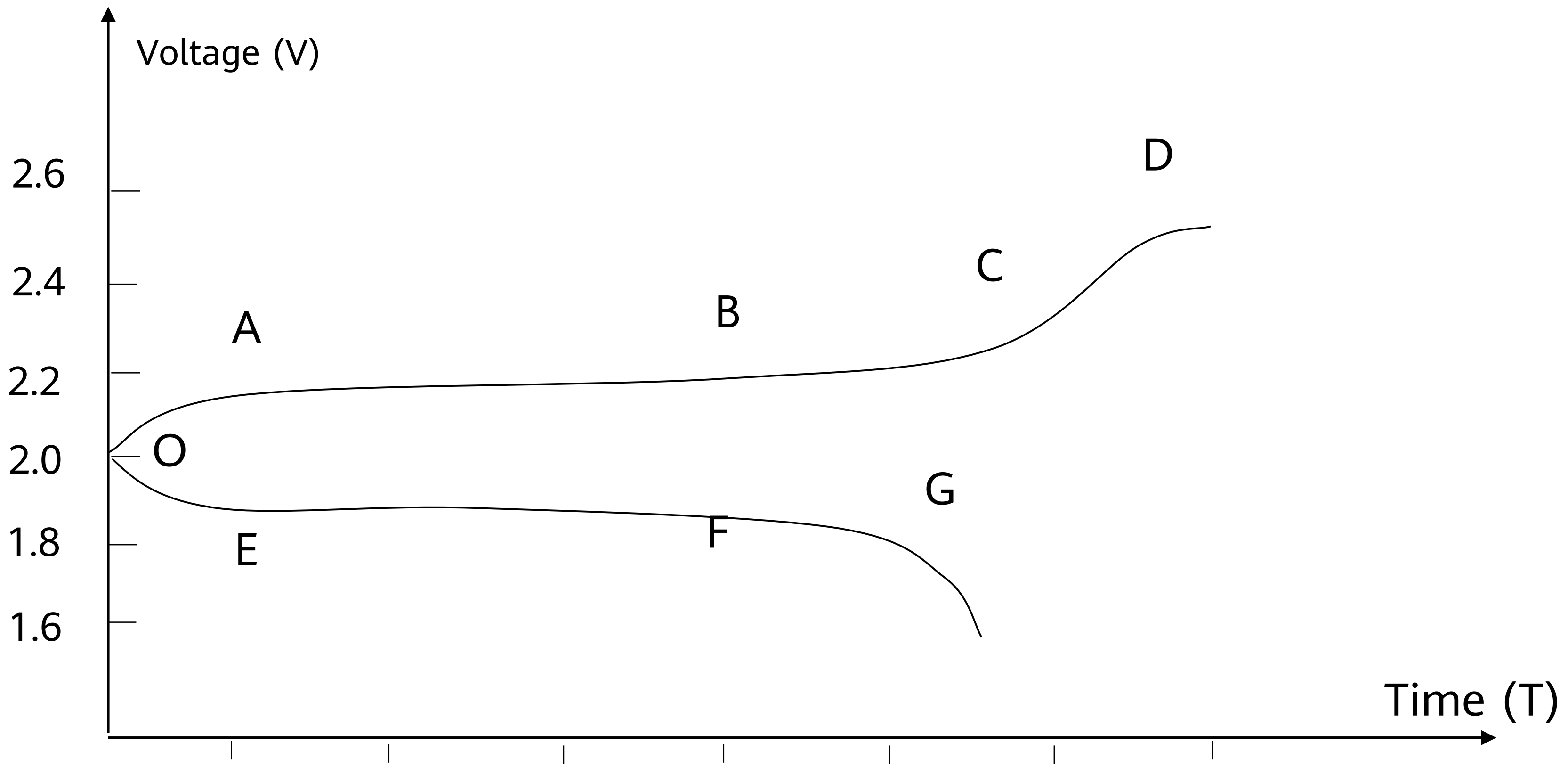
Working Principles – Side Reaction

- **Positive electrode:** $2H_2O \rightarrow O_2 + 4H^+ + 4e$
- **Negative electrode:** $2H^+ + 2e \rightarrow H_2$
- At the end of charging and during overcharging, in addition to the reaction of active substances, the preceding two reactions occur at the positive and negative electrodes. At this time, $PbSO_4$ is almost completely converted to PbO_2 and Pb in charging state. The potential of the reaction increases. The side reactions including oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) will dominate.
- Therefore, overcharging may cause battery swelling due to the side reactions.

Working Principle – Terminal Voltage Changes During Charging and Discharging



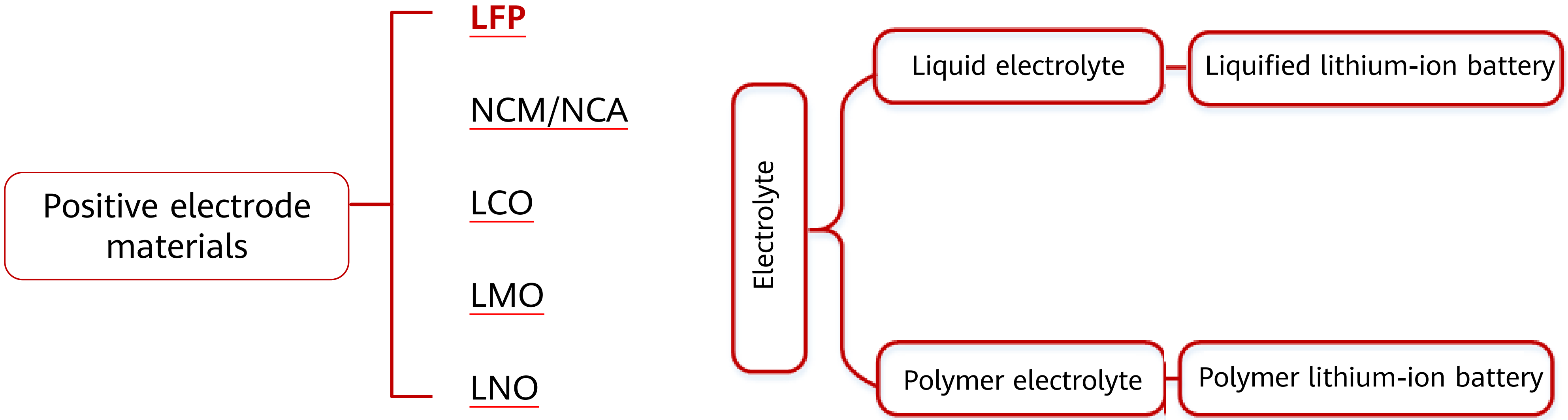
Contents

Definition

- Lithium-ion batteries are secondary batteries developed based on lithium batteries.
  - The positive electrode material of lithium batteries is manganese dioxide or thionyl chloride, and the negative electrode material is metal lithium. After a battery is assembled, the battery has voltage and does not need to be charged.
  - In the early 1990s, Sony invented batteries with carbon materials as the negative electrode and lithium compounds as the positive electrode. In the process of charging and discharging, lithium ions, instead of lithium, exist. These batteries are called lithium-ion batteries.

Classification

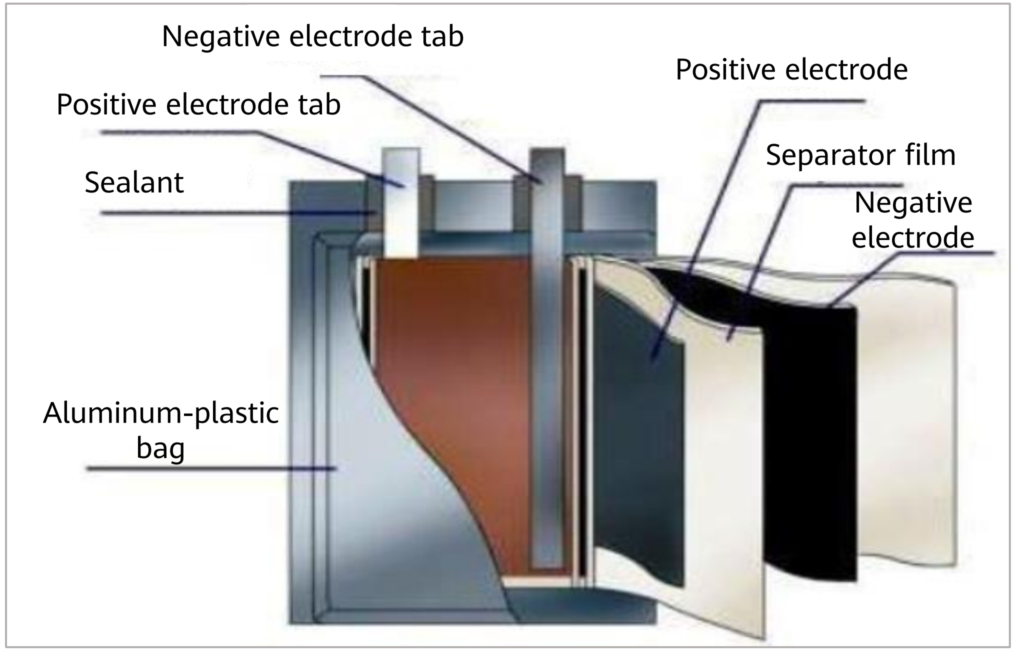
- Lithium-ion batteries use positive electrode materials such as lithium cobalt oxide (LCO), lithium nickel oxide (LNO), lithium manganese oxide (LMO), lithium nickel manganese cobalt oxide (NCM)/lithium nickel cobalt aluminum oxide (NCA), and LFP.
- Based on the electrolyte form, lithium-ion batteries are classified into liquified lithium-ion batteries and polymer lithium-ion batteries.
- LFP batteries with liquid electrolytes are commonly used in data centers.



Contents

Internal Structure

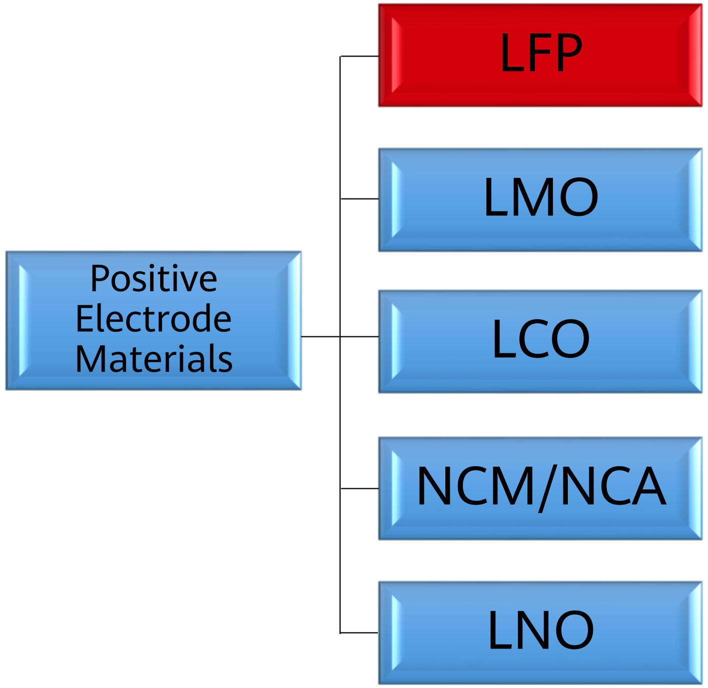
- Positive electrode: transition metal oxides (containing lithium) with a conductive agent and an adhesive, coated on an aluminum foil to form a positive plate
- Negative electrode: formed by coating a laminated graphite with a conductive agent and an adhesive on a copper foil
- Electrolyte: composed of electrolyte and organic solvent
- Separator film: composed of a polyethylene (PE) or polypropylene (PP) microporous film. It isolates the positive and negative electrodes, preventing the passage of electrons while allowing that of lithium ions.
- Shell: aluminum foil (pouch), steel shell, or aluminum shell.

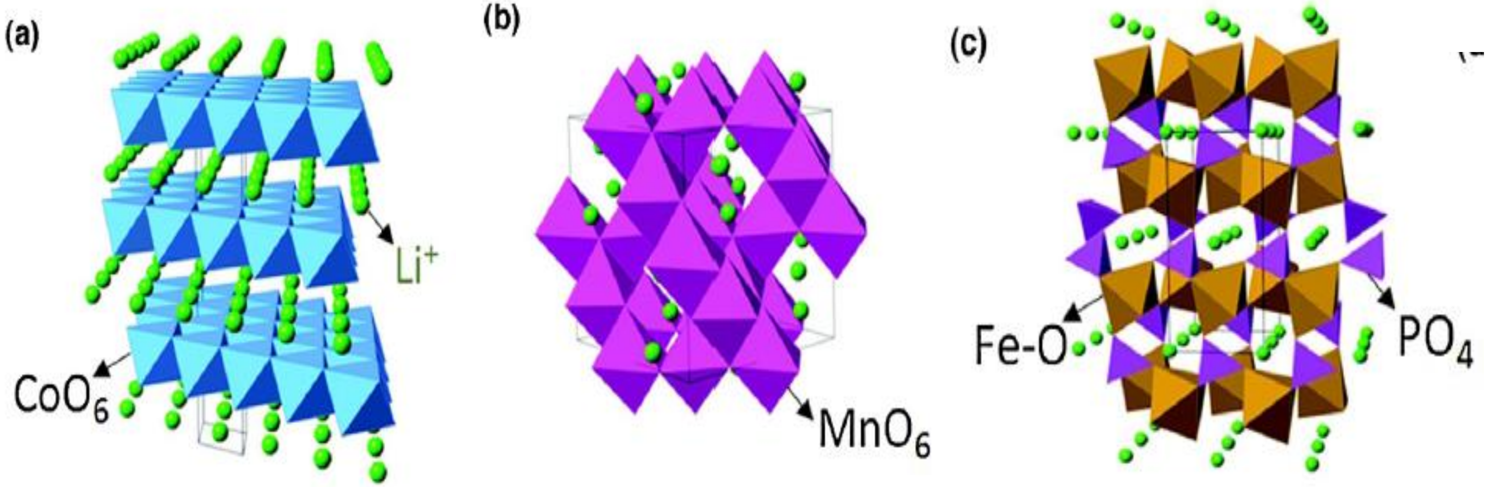


Structure of a lithium-ion battery

Positive Electrode Materials

- Positive electrode material: Positive electrode materials include transition metal oxides or polyanionic compounds containing lithium and have a layered, spinel, or olivine structure. The materials provide a lithium source and have a stable lithium deintercalation capability, which determines the lower limit of safety of a lithium-ion battery.

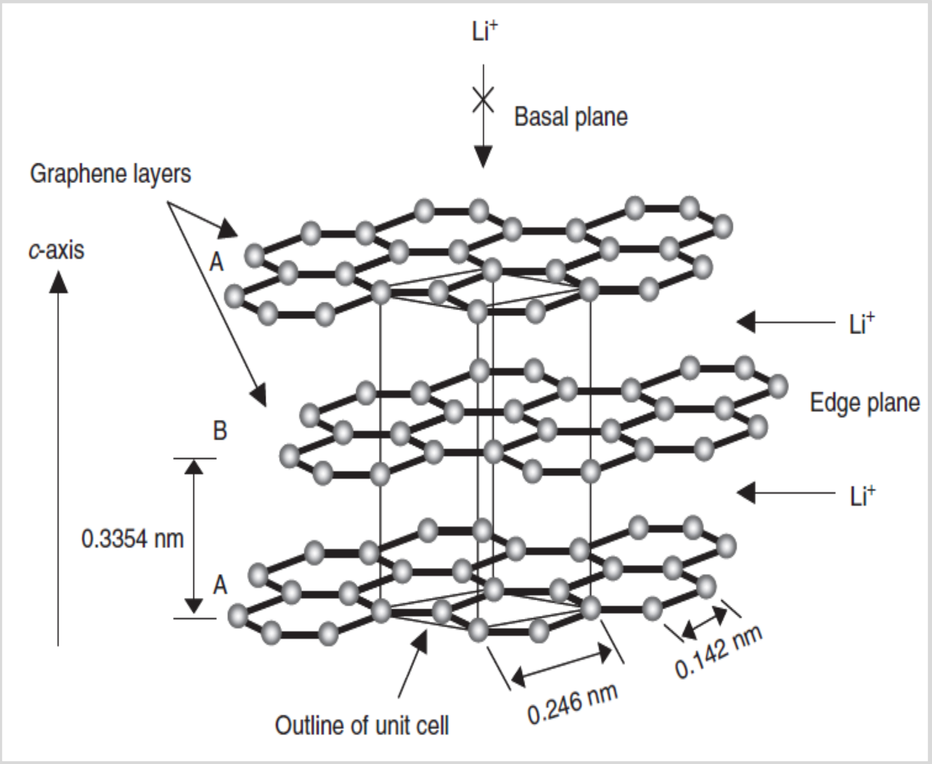




Layered $LiCoO_2$ Spinel $LiMn_2O_4$ Olivine $LiFePO_4$

Negative Electrode Materials

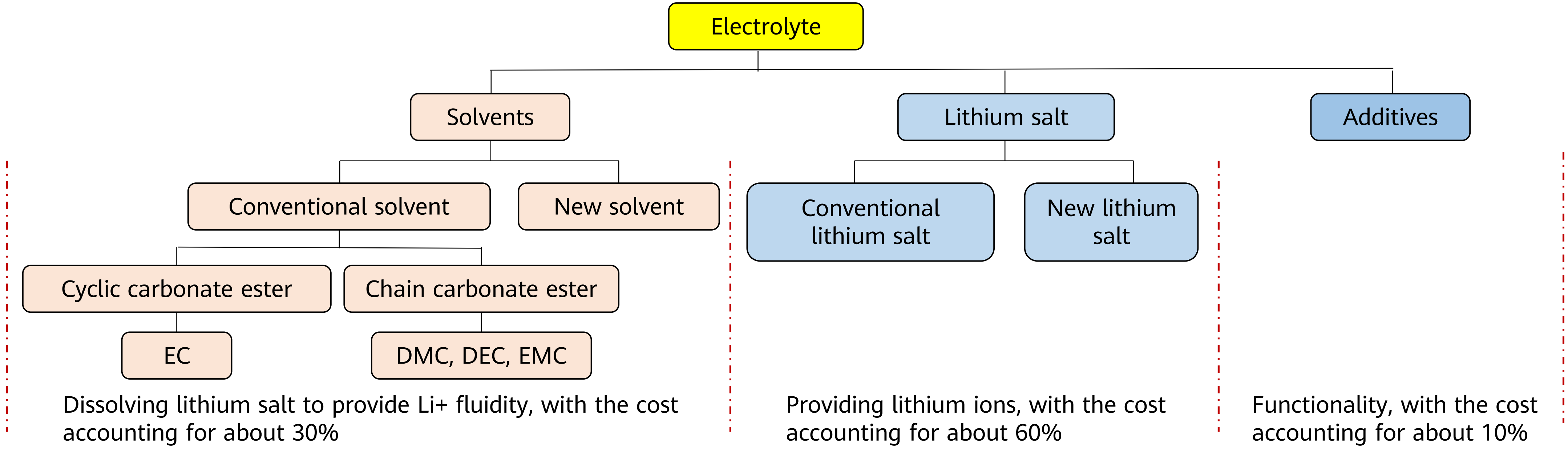
- Requirements for negative electrode materials:
  - Electronic conductivity and ion conductivity are excellent.
  - Intercalation and deintercalation reactions of lithium ions in carbon are fast.
  - The existence of lithium ions in electrode materials is stable.
  - A compact and stable solid electrolyte interphase (SEI) can be generated on the negative electrode surface to prevent the electrolyte from continuously reducing on the surface.
  - In the charge and discharge cycle of the battery, the volume of the carbon material at the negative electrode changes slightly.
- Common negative electrode material: graphite



Graphite molecular structure

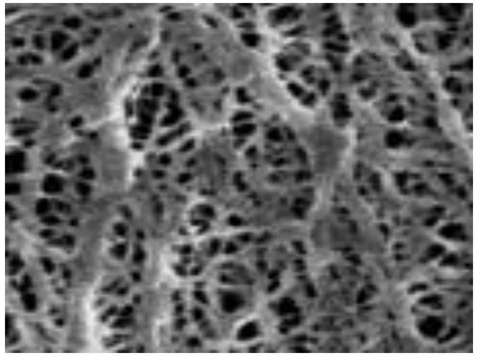
Electrolyte

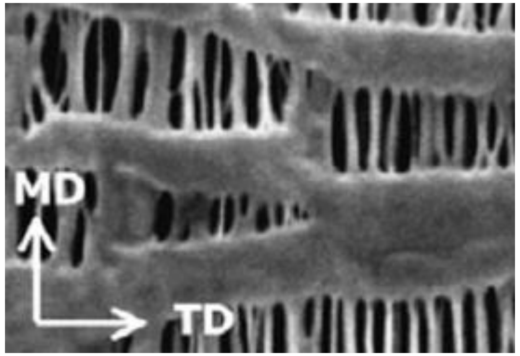
- Electrolyte:
  - Provides a medium for rapid conduction of lithium ions, and requires lithium ions (dissociating lithium salts).
  - To dissolve the preceding lithium salt and additives, a solvent is required, which determines a lower limit of high and low temperature characteristics of batteries.
  - To protect the reaction interface, a protective film (SEI) is formed on the (positive) negative electrode surface, and a film additive is required. The additive determines the interface of the material and the upper limit of the battery cycle.



Separator Film

- The separator film must meet the following requirements:
  - Has direct contact with the positive and negative electrodes (high and low potentials) as well as the electrolyte, requiring electrochemical stability (against electrochemical and other corrosion).
  - Provides physical barriers between positive and negative electrodes to prevent short circuits, featuring insulation (separating electrons) and strength against puncture. Allows lithium ions to pass through. Currently, a micro porous structure is used to absorb the electrolyte.
  - Provides an automatic shutdown mechanism with low shutdown temperatures and high rupture temperatures, ensuring good protection performance.
  - Determines the lower limit of the battery safety, does not provide active substances. A thinner separator film is better in terms of energy density.
  - A thin separator film requires a ceramic coating for separation; to ensure that the positive and negative electrodes are adhered to each other, glue is required sometimes.





Contents

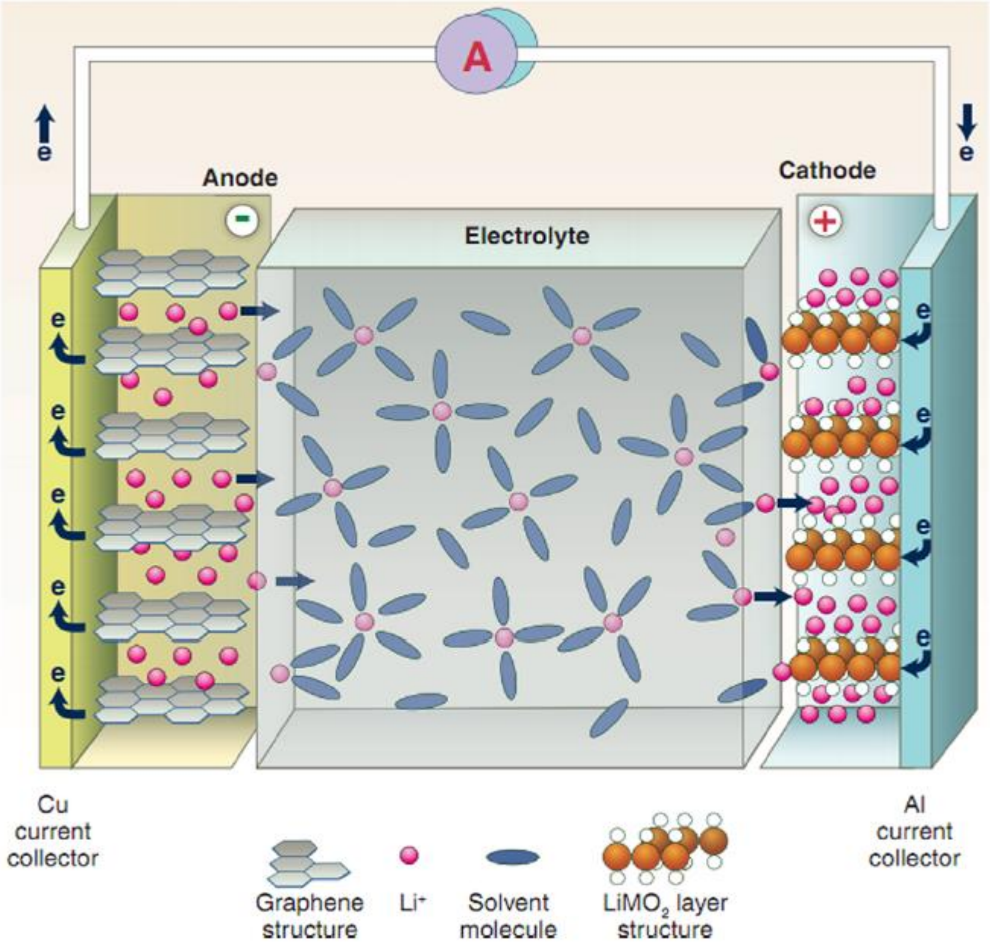
Working Principle

- Li+ intercalation and deintercalation repeatedly occur at the positive an negative electrodes.
- During charging, Li+ is deintercalated from the positive electrode and intercalated into the negative electrode (obtaining electrons).
- During discharging, Li+ is deintercalated from the negative electrode an intercalated into the positive electrode (obtaining electrons).
- Use compounds that can be intercalated into lithium ions as the positiv and negative electrodes, so that the flow of lithium ions changes from uncontrollable to controllable after guidance.

Positive electrode reaction: $LiMO_y \underset{\text{Discharging}}{\overset{\text{Charging}}{\rightleftharpoons}} Li_{1-x}MO_y+xLi^++xe$

Negative electrode reaction: $nC+xLi^++xe \underset{\text{Discharging}}{\overset{\text{Charging}}{\rightleftharpoons}} Li_xC_n$

Battery reaction: $LiMO_y+nC \underset{\text{Discharging}}{\overset{\text{Charging}}{\rightleftharpoons}} Li_xC_n+Li_{1-x}MO_y$



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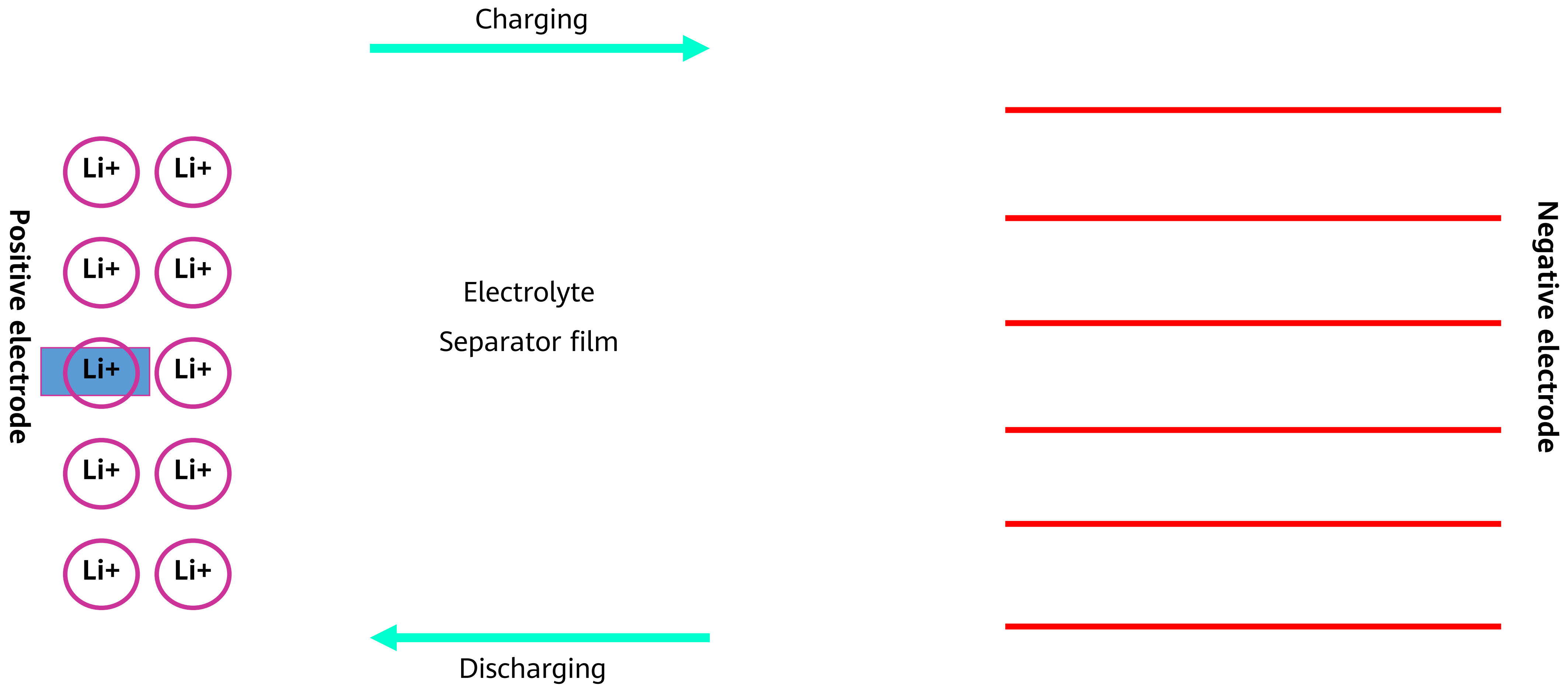
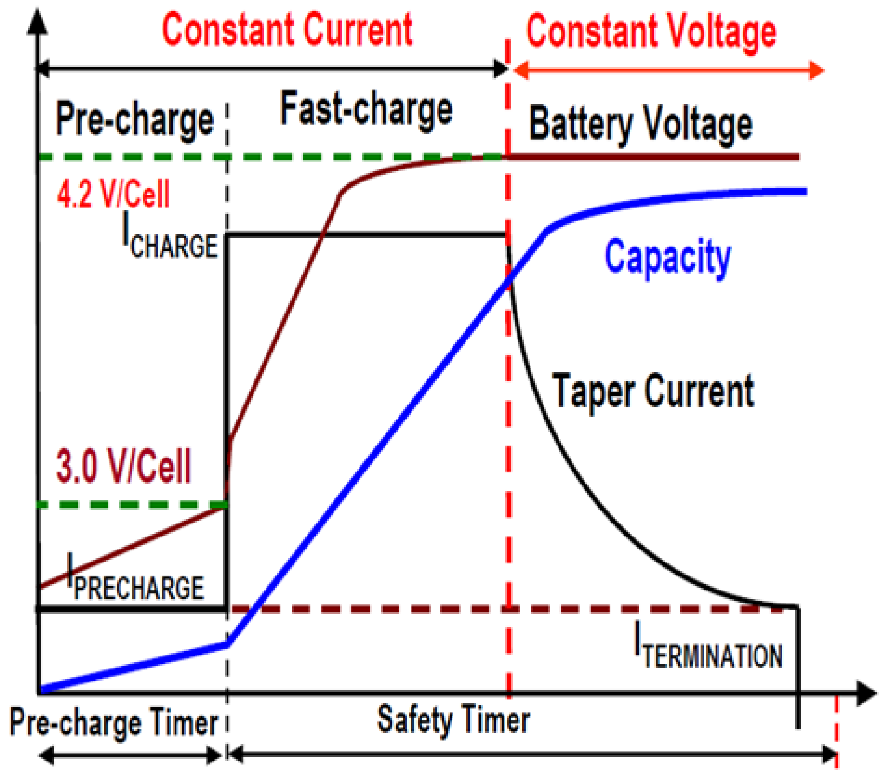
Working Principle



Charging Management

- The CC-CV two-stage charging method is used. In the CC charging stage, the 0.5C–1C charge current is used.
- Restricted voltages in the CC charging stage are as follows:
  - When $LiFePO_4$ materials are used for the positive electrode, the maximum value is 3.650 V. If 16 lithium-ion batteries are cascaded, the maximum value is 3.650 V x 16 = 58.40 V.
  - If the positive electrode material is not $LiFePO_4$, the maximum value is 4.100 V. If 16 lithium-ion batteries are cascaded, the maximum value is 4.100 V x 14 = 57.40 V.
- Charging termination conditions in the CV charging stage are as follows:
  - At the end of the CC charging stage, when the battery voltage reaches the charge voltage limit, the CV charging mode is used. The charging stops until the charge current is less than or equal to 0.01C, and the entire charging process is complete.

Lithium-ion battery charge curve



- Constant Current: 20-30% charging time, 70-80% capacity
- Constant Voltage: 70-80% charging time, 20-30% capacity

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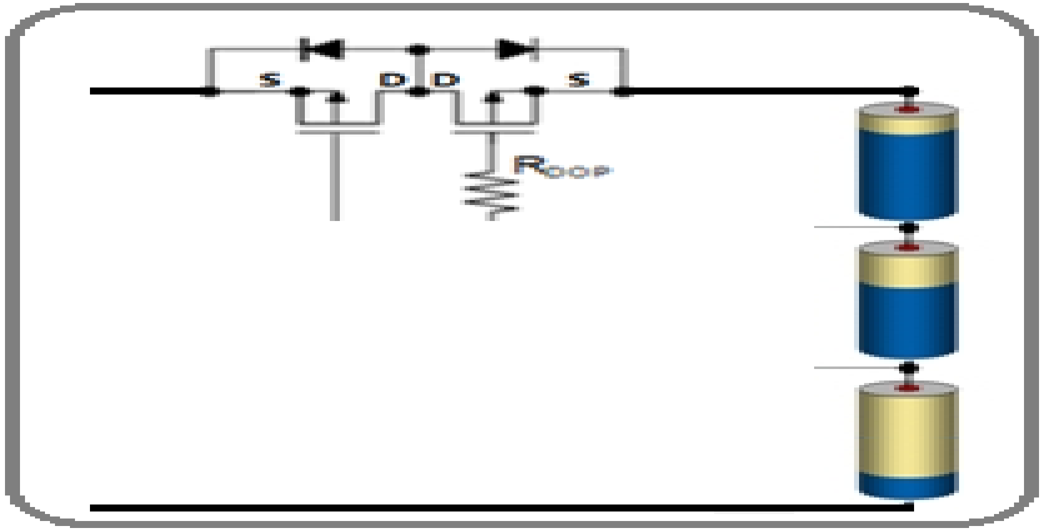
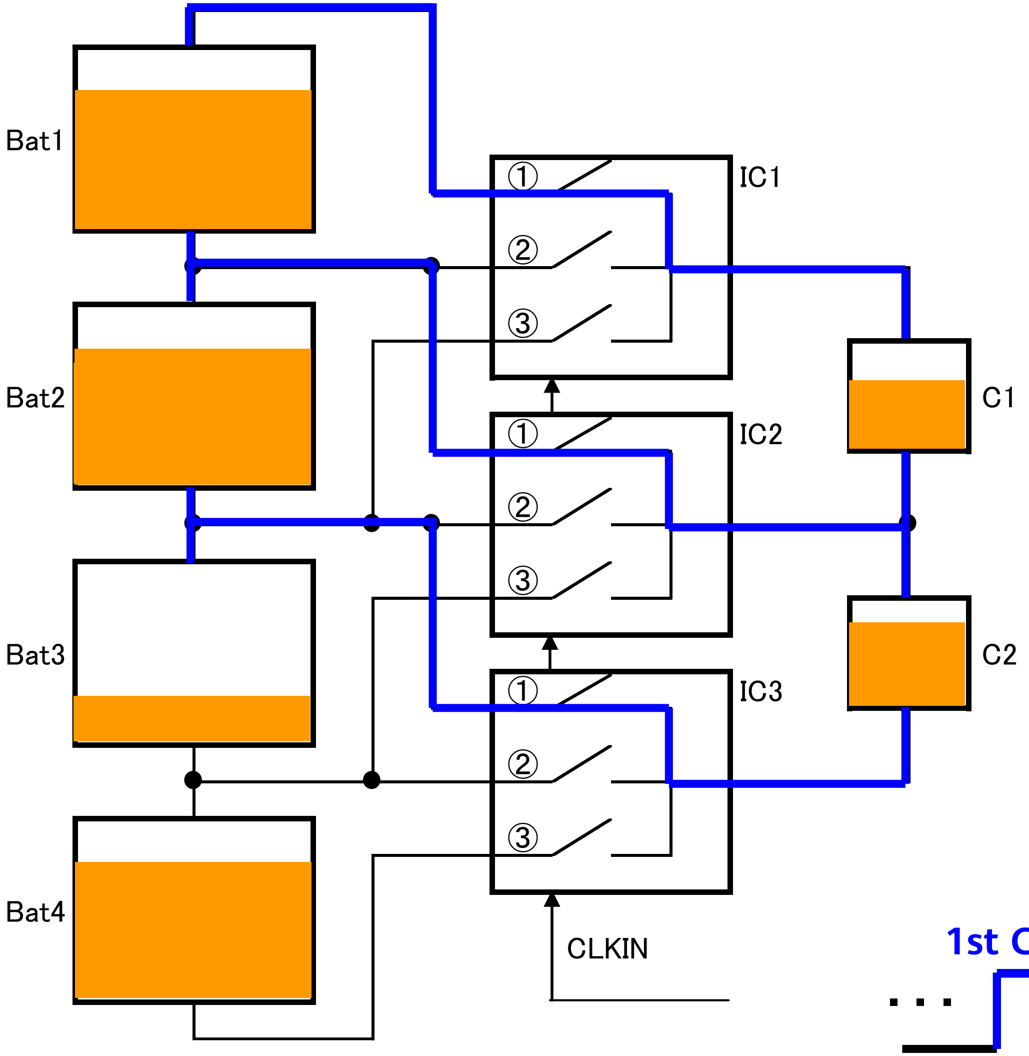
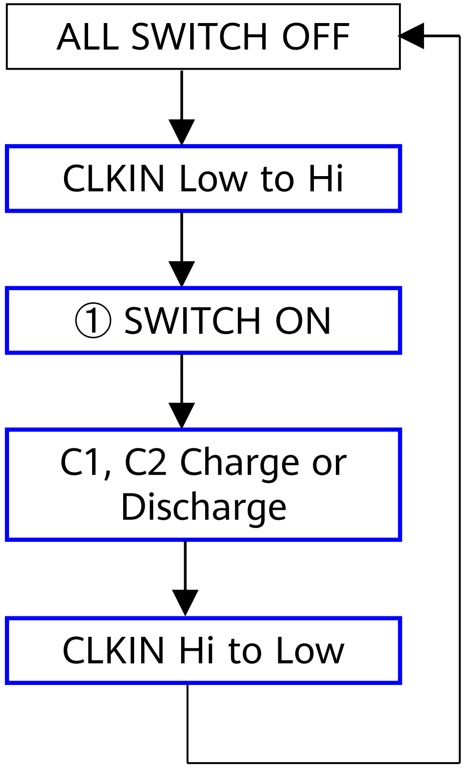
Balancing Problems

- The most difficult problem of lithium-ion batteries is inconsistency. The causes of inconsistency are as follows:
  - Internal causes: material or manufacturing difference, capacity, internal resistance, self-discharge and cyclic attenuation rate
  - External causes: temperature, charge current, and discharge current
- Solutions:
  - Remove the first and last batteries.
  - Perform balancing management.
  - Form battery groups.

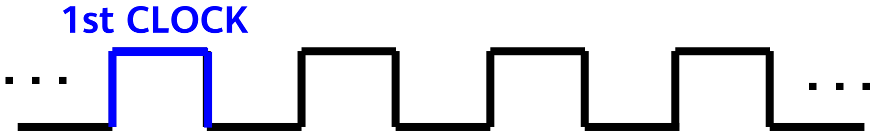


Balancing Management (1)

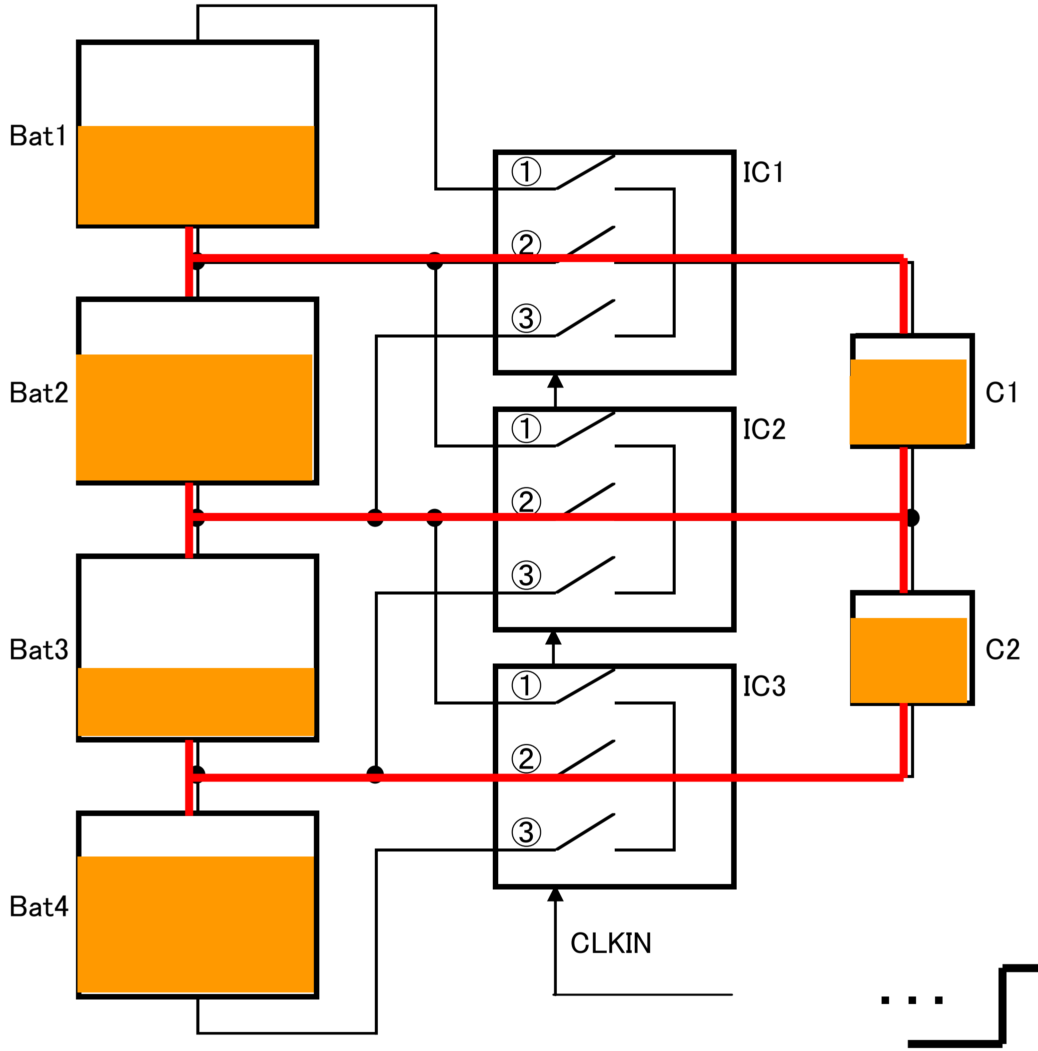


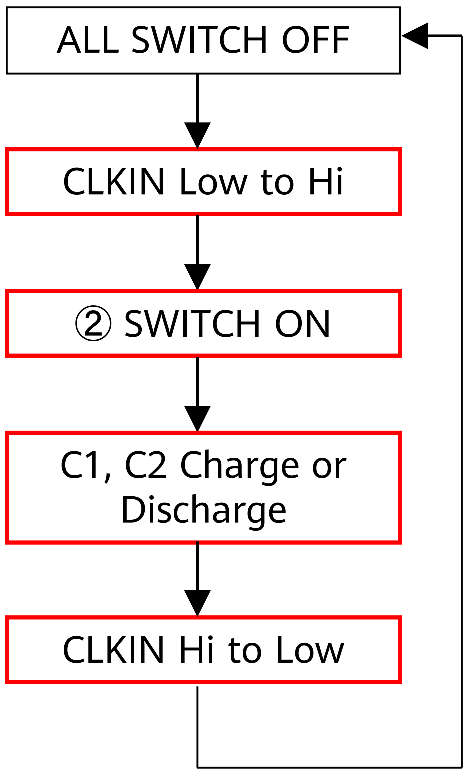


1. The voltages of batteries 1, 2, and 4 are high. The voltage of battery 3 is low. All switches are off. C1 and C2 are not charged.
2. The pulse changes from low level to high level.
3. Switch 1 is turned on, and loop 1 is connected.
4. Battery 1 charges C1, and battery 2 charges C2. The voltages of batteries 1 and 2 decrease, and the voltage of battery 1 recovers.
5. The pulse changes from high level to low level, and switch 1 is off.

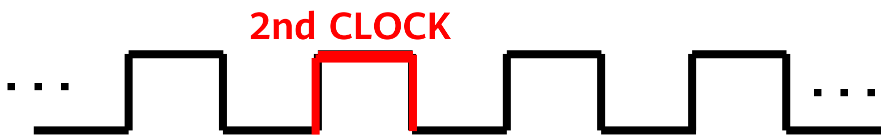


Balancing Management (2)

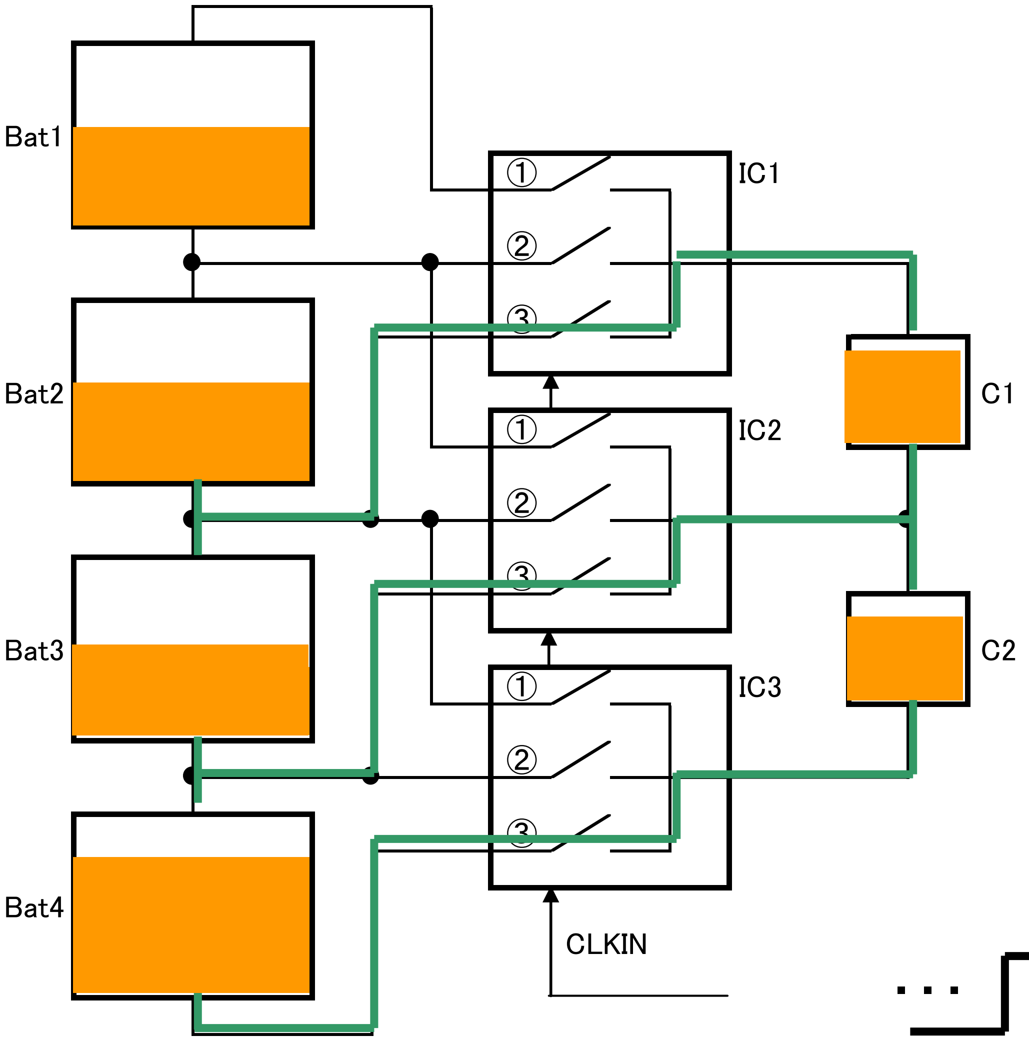


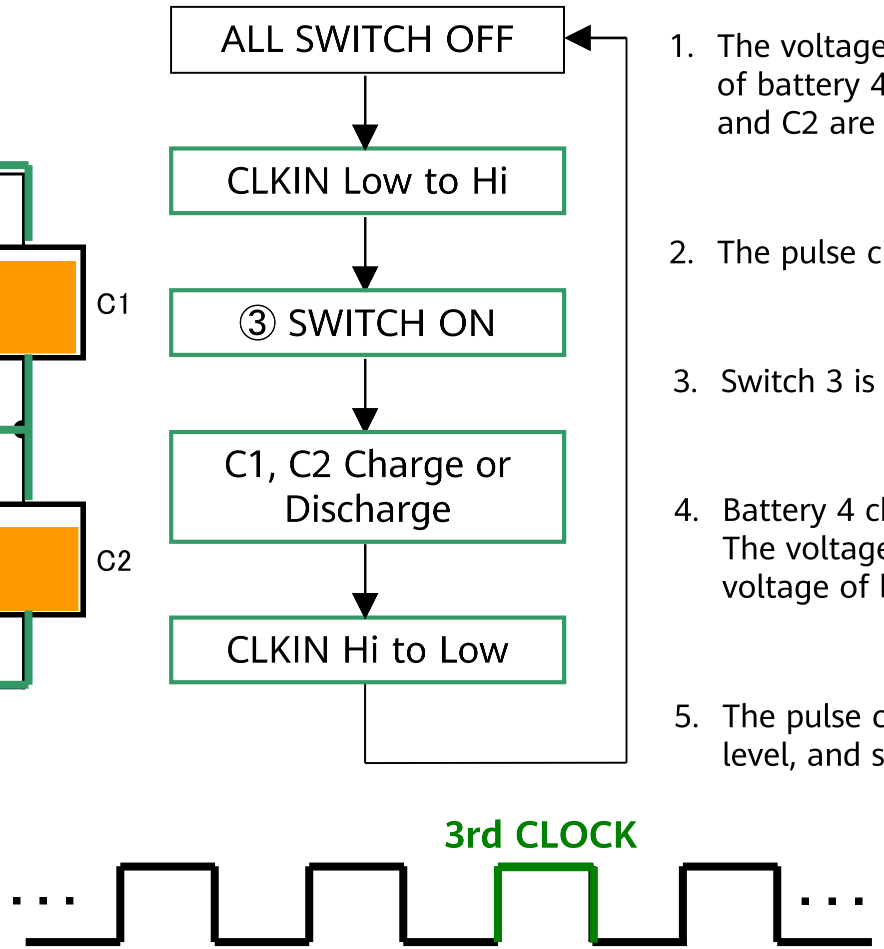


1. The voltages of batteries 2 and 4 are high. The voltage of battery 3 is low. All switches are off. C1 and C2 are charged.
2. The pulse changes from low level to high level.
3. Switch 2 is turned on, and loop 2 is connected.
4. Battery 2 charges C1, and C2 charges battery 3. The voltage of battery 2 decreases and then returns to normal. The voltage of battery 3 increases.
5. The pulse changes from high level to low level, and switch 2 is off.



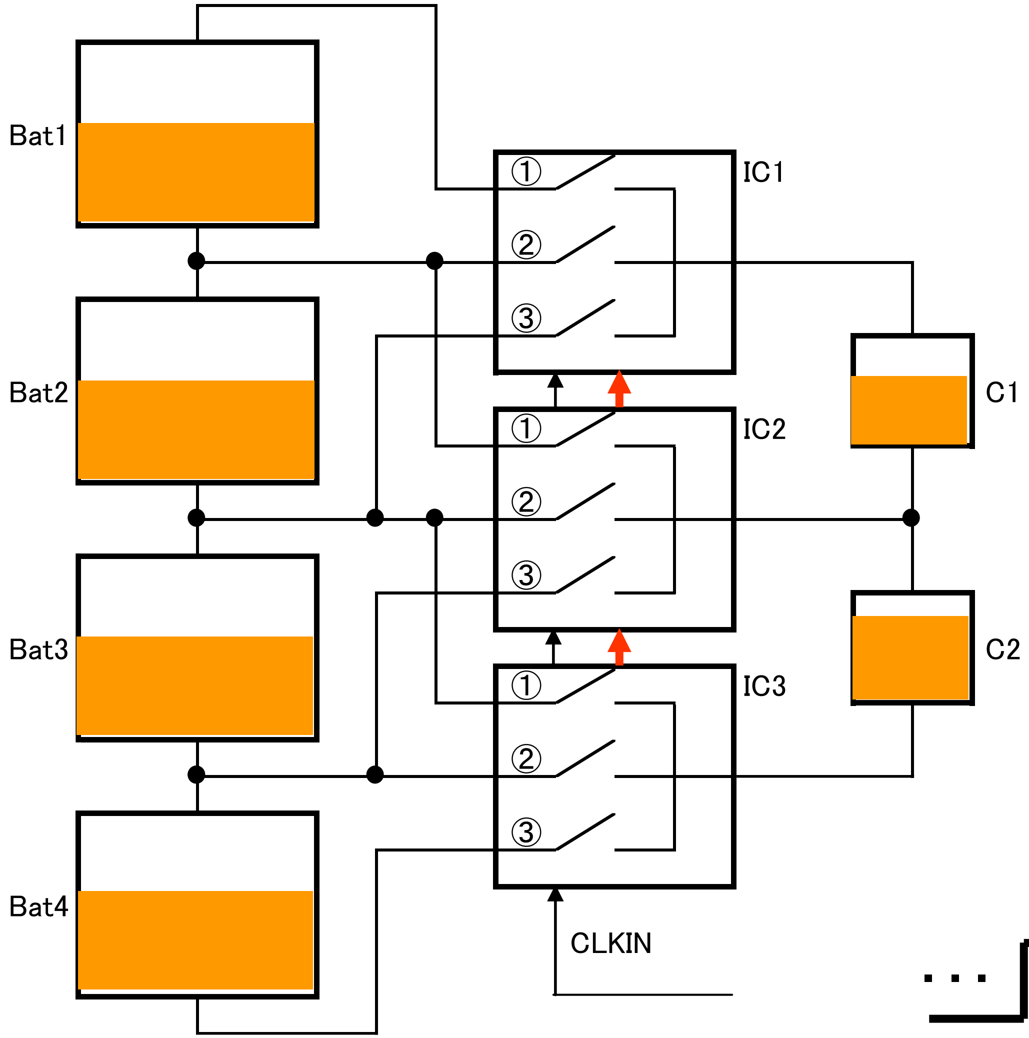
Balancing Management (3)

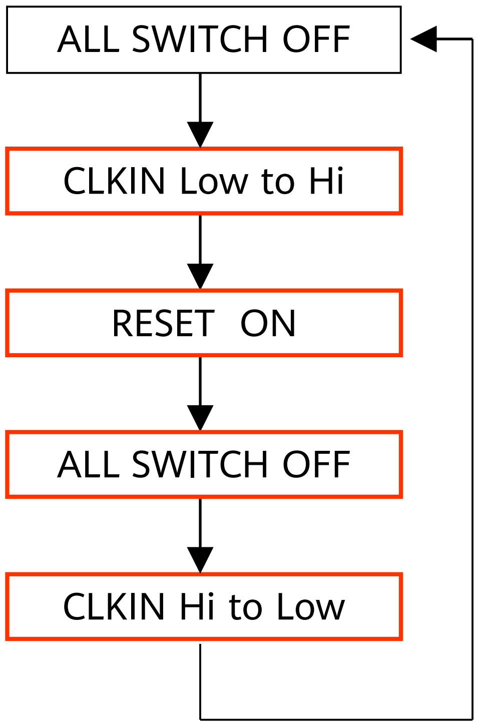




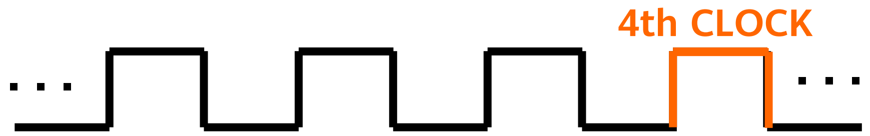
1. The voltage of battery 3 is low. The voltage of battery 4 is high. All switches are off. C1 and C2 are charged.
2. The pulse changes from low level to high level.
3. Switch 3 is turned on, and loop 3 is connected.
4. Battery 4 charges C2, and C1 charges battery 3. The voltage of battery 3 increases, and the voltage of battery 4 decreases to normal.
5. The pulse changes from high level to low level, and switch 3 is off.

Balancing Management (4)





1. The voltage of all battery is normal. All switches are off. C1 and C2 are charged.
2. The pulse changes from low level to high level.
3. Reset.
4. All switches are off.
5. The pulse changes from high level to low level.



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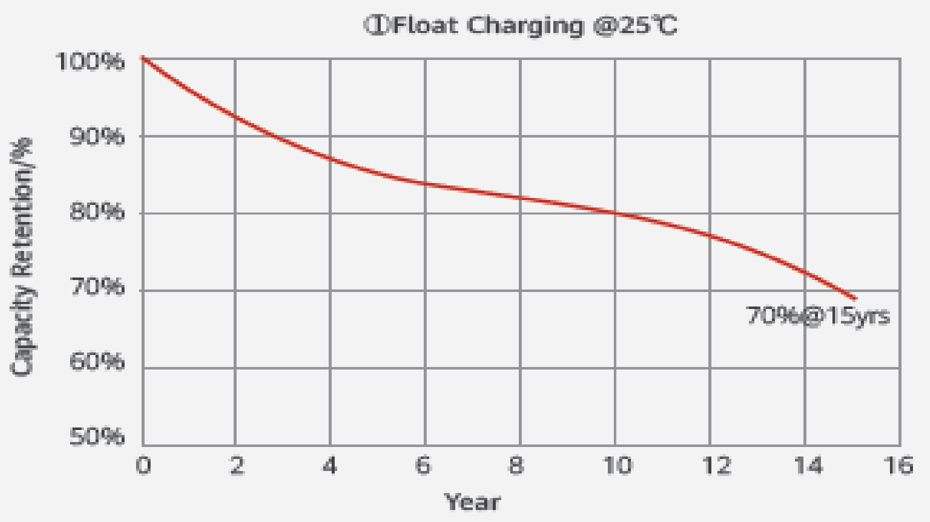
Contents

Cycle Life

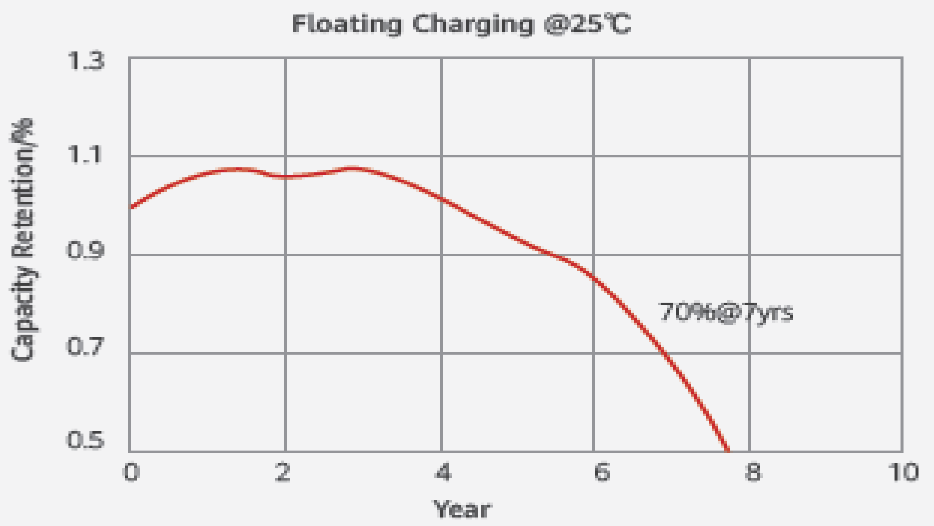
- Lithium-ion battery
  - 100% DOD: up to 3000 cycles; deep discharge: at least 3000 cycles.
  - 50% DOD: up to 6000 cycles; shallow discharge: at least 6000 cycles.
- Lead-acid battery
  - 100% DOD: about 150 cycles; deep discharge: frequently replacing lead-acid batteries in case of poor grid power.
  - 50% DOD: about 600 cycles; shallow discharge: frequently replacing lead-acid batteries in case of poor grid power.

Float Charging Life

- 70% EOL float charge at 25° C for lithium-ion batteries: up to 15 years; no need to replace within the life cycle of 15 years if grid power is good.
- 70% EOL float charge at 25° C for lead-acid batteries: up to 7 years; need to replace every 3–7 years even if grid power is good; labor-intensive and high battery cost.



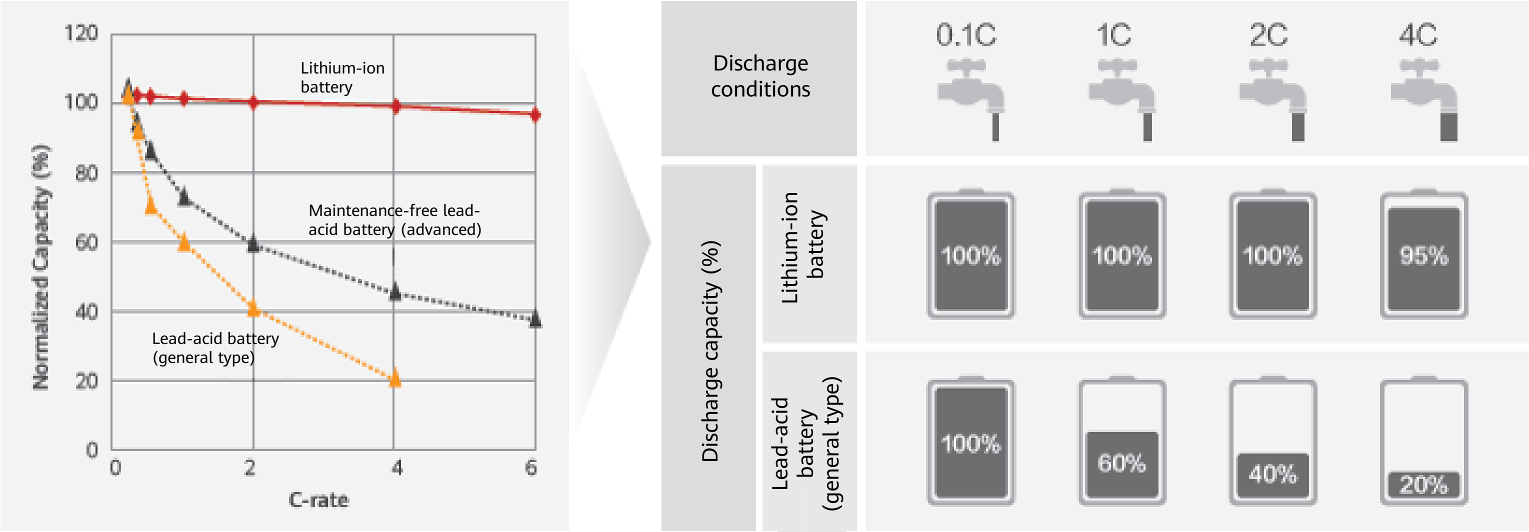
Float charging life of lithium-ion batteries (15 years)



Typical float charging life of 12 V lead-acid batteries (3–7 years)

Discharge Characteristics at Different Rates

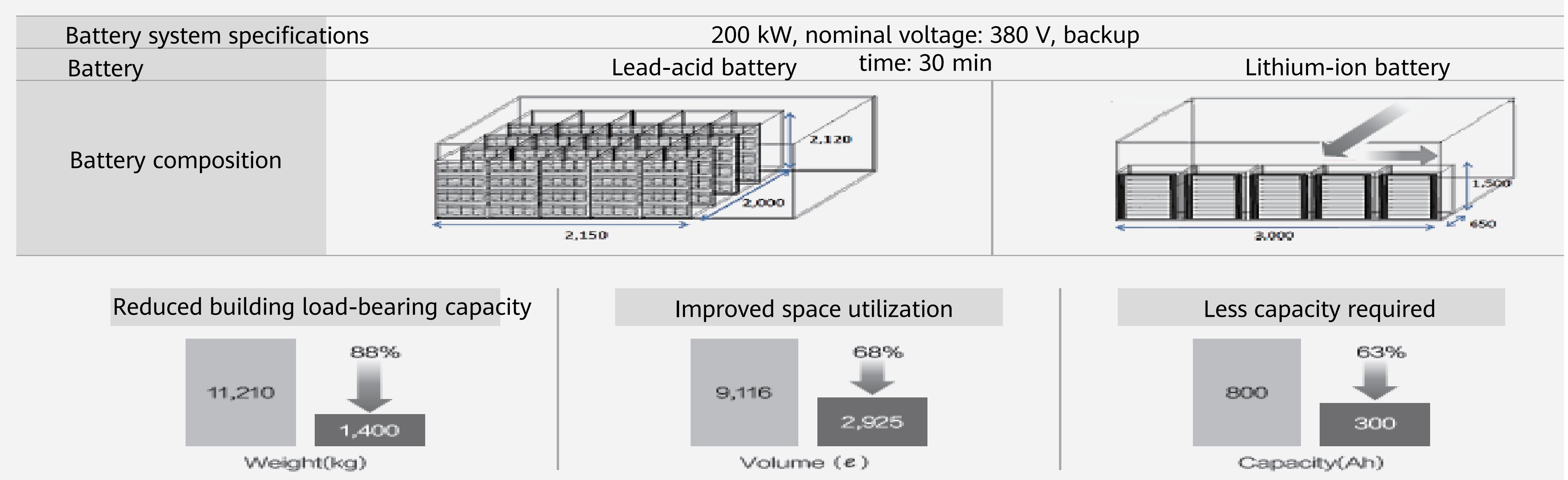
- Short-time discharge at a high rate for lithium-ion batteries: More energy is discharged. As the discharge rate increases, the discharge capacity remains stable and can exceed 90%.
- Short-time discharge at a high rate for lead-acid batteries: Less energy is discharged. As the discharge rate increases, the discharge capacity decreases rapidly. More batteries are required to offset the disadvantage, which increases the battery investment.



Comparison of discharge characteristics between lead-acid and lithium-ion batteries at different rates

Footprint and Bearing Capacity

- Weight/Energy density (Wh/kg) ratio: 3:1
  - Lithium-ion battery: 100–150; lead-acid battery: 30–50
- Volume/Energy density (Wh/L) ratio: 3:1
  - Lithium-ion battery: 200–300; lead-acid battery: 60–90



Footprint and bearing capacity comparison between lead-acid batteries and lithium-ion batteries

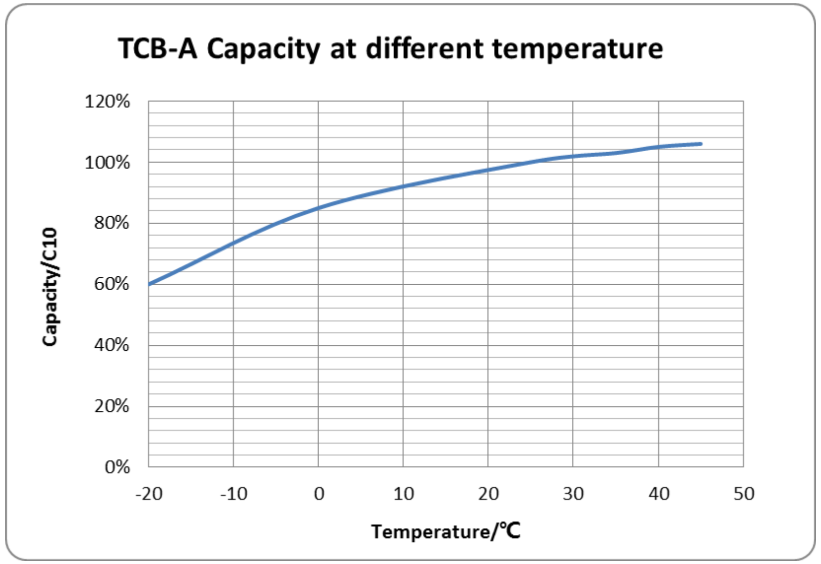
Storage Environment Requirements

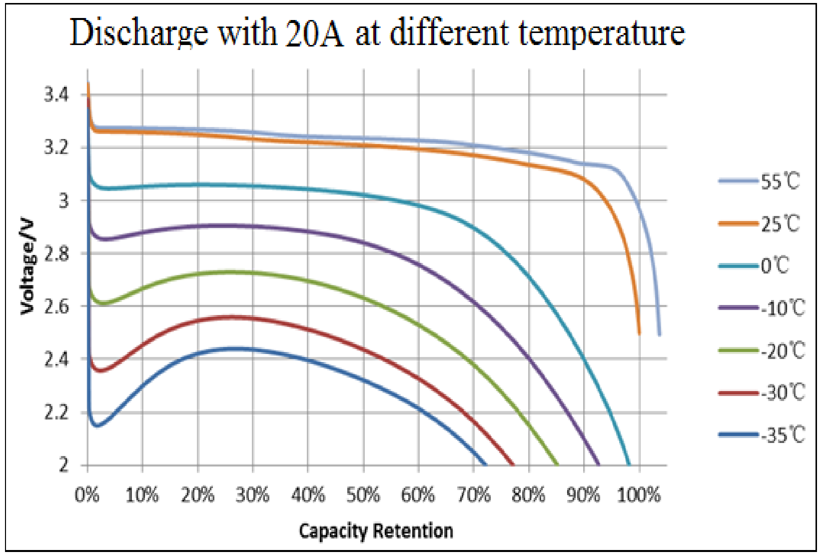
- For a data center that requires high availability, a small number of spare batteries are required for backup to shorten the maintenance preparation time. These batteries must be stored according to the requirements of the battery manufacturer.

Item	Lead-acid Battery	Lithium-ion Battery
Ambient temperature	5–40° C (recommended temperature: 20–30° C)	0–40° C (recommended temperature: 20–30° C)
Relative humidity	≤ 95%	
Others	The environment is dry, ventilated, and clean. Batteries must not contact with corrosive or organic solvents. Keep batteries away from direct sunlight and at least 2 meters away from heat sources.	

Operating Temperature

- The operating temperature of common lithium-ion cells ranges from –20° C to +55° C. Therefore, no air conditioner is required.
  - When the temperature is low, the dynamics deteriorates, and lithium plating tends to occur during charging. Generally, only discharging is performed.
  - The oxidation-reduction reaction on the surface of the positive and negative electrode material is more intense at a higher temperature.
- The operating temperature of lead-acid batteries ranges from 15° C to 25° C. Therefore, air conditioners are required.





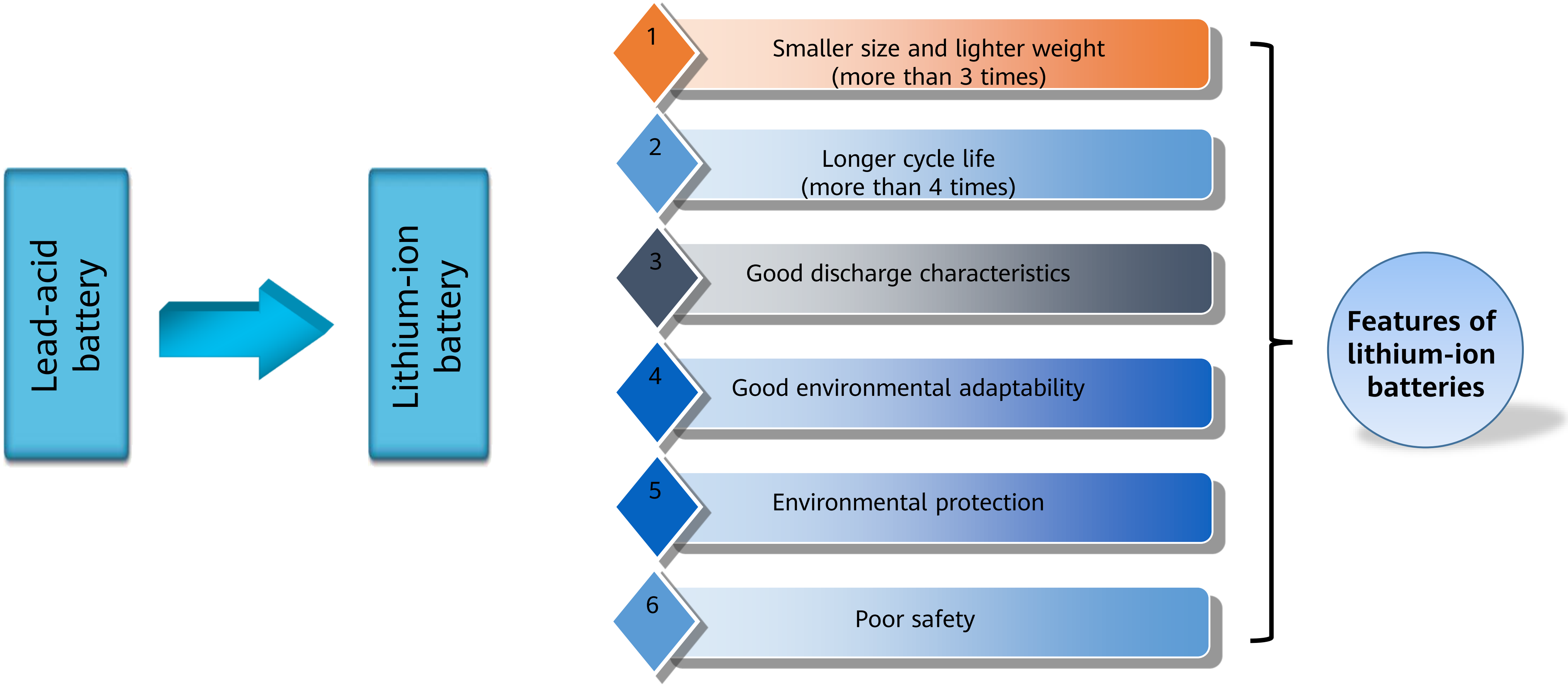
Safety Comparison

- Our pursuit is to maximize stored and released energy and meet high energy density requirements within a safe and controllable range during the life cycle. With existing technology, a lithium-ion battery can be safe and controllable. From this perspective, a current lithium-ion battery is a relatively ideal battery product.

Safety comparison between lithium-ion batteries and lead-acid batteries

	Lithium-ion battery	Lead-acid battery
Positive and negative electrodes	LFP, NCM, and graphite materials are combustible and flammable.	Pb and PbO_2 are flame retardants.
Electrolyte	Non-aqueous organic solvent, flammable	Sulfuric acid solution, non-flammable
Barrier	Separator film, PP/PE, flammable	Grid, non-flammable
	10–20 µm thick, easy to be pierced by dust and crystal dendrites. Internal short-circuits are easily caused by heat shrinkage.	3–5 mm thick, difficult to be pierced; no heat shrinkage
Combustion	Internal short circuit, combustion, and explosion	Shell combustion

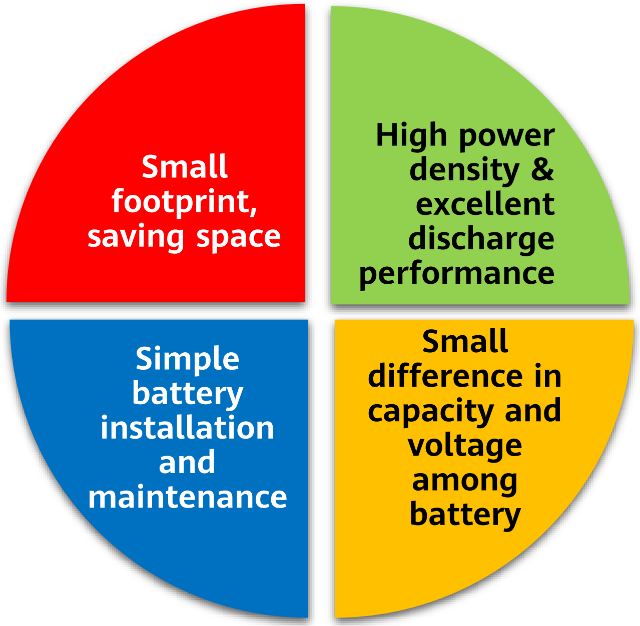
Summary



Lead-acid battery
Lithium-ion battery
1
Smaller size and lighter weight (more than 3 times)
2
Longer cycle life (more than 4 times)
3
Good discharge characteristics
4
Good environmental adaptability
5
Environmental protection
6
Poor safety
Features of lithium-ion batteries

Battery characteristics for Data Center

- In recent years, with the rapid development of the Internet industry, many IT companies, such as Baidu, Alibaba, Tencent, Google, and Microsoft, are building more and more large data centers for the new network services. Geographical centralization and size expansion are the transformations facing data centers. High density and high reliability are the higher demands posed on storage battery.



Quiz

1.(Single)Based on the electrolyte content, storage battery can be classified into (   ).

A. Flooded lead-acid battery and Starved-electrolyte battery

B. AGM and GEL storage battery

C. Lead-acid and alkaline storage battery

D. Primary and secondary storage battery

2.(Single)Which of the following components is responsible for exhausting the excessive gas in the battery? (   )

A. Battery chute

B. Battery plate

C. Safety valve

D. Electrolyte

Quiz

1. (Short Answer Question)What does a lithium-ion battery consist of?
2. (Short Answer Question)What are the common positive electrode materials for lithium-ion batteries?
3. (Short Answer Question)What is the working principle of lithium-ion batteries?

Summary

- Basic Knowledge of Batteries
- Knowledge About Lead-acid Batteries
- Knowledge About Lithium-ion Batteries
- Comparison Between Lead-acid Batteries and Lithium-ion Batteries

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise： http://support.huawei.com/enterprise/
  - Online Learning： http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Air Conditioning System Introduction

Foreword

- This chapter describes working principles of an air conditioning system, classification of air conditioning system, common air processing devices.

Objectives

On completion of this course, you will be able to:

- Understand working principles of air conditioning systems;
- Understand classification principles and types of air conditioning systems;
- Have general knowledge of some common air handling equipment;
- Understand basic knowledge of air conditioning air systems;
- Understand common air conditioner terms.

Contents

Development History of Air Conditioning Systems

In 1901, Dr. Willis Carrier established the world's first air-conditioning test lab in the United States.

In 1902, Dr. Carrier designed the world's first set of scientific air conditioning systems.

In 1922, Dr. Carrier invented the world's first centrifugal chiller.

In 1930, comfort air conditioners grew rapidly all over the world and applied to cinemas, theaters, and shopping malls.

In 1980, a computer room air conditioner (CRAC) cut a striking figure in China as a dedicated air conditioning model.

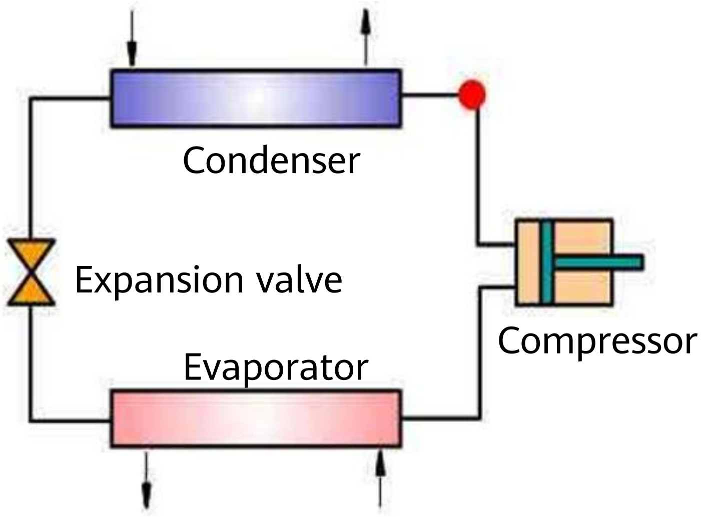
After 2002, data centers develop rapidly, further promoting the growth of CRACs.

What is an Air Conditioner?

- An air conditioner performs air conditioning;
- The following indicators are designed for air: temperature, humidity, and cleanliness;
- An air conditioner is designed to adjust the temperature, humidity, and cleanliness of air, with the goal of creating a comfort living and working environment.

Refrigeration Principle (1)

- Refrigeration process
  - After absorbing the heat of substances to be cooled in an evaporator, a liquid refrigerant vaporizes and becomes low-pressure and low-temperature steam. After being absorbed and compressed by a compressor, the steam becomes high-pressure and high-temperature steam. Then, the steam enters a condenser and discharges heat to cooled substances, and is condensed into a high-pressure and medium-temperature liquid. After passing a throttling device, the liquid becomes the low-pressure and low-temperature liquid refrigerant. The liquid refrigerant then enters the evaporator. As such, cyclic refrigeration is realized.



Refrigeration Principle (2)

Air Conditioner

Compression

A compressor compresses the low-temperature and low-pressure saturated or superheated gas into a high-temperature and high-pressure superheated gas, for outdoor heat exchanging purposes.

Condensing

The high-temperature and high-pressure superheated gas is condensed into a high-temperature and high-pressure saturated or supercooled liquid in a condenser.

Throttling (Pressure Releasing)

After a throttle, the high-temperature, high-pressure liquid releases pressure. As a result, the refrigerant vaporizes. The high-temperature, high-pressure liquid also absorbs much heat to reduce the temperature of the liquid refrigerant. As a result, a low-temperature and low-pressure substance in both gas and liquid forms is formed.

Vaporizing

A refrigerant vaporizes in an evaporator and becomes a low-temperature and low-pressure saturated or superheated gas, and then absorbs heat from indoor air.

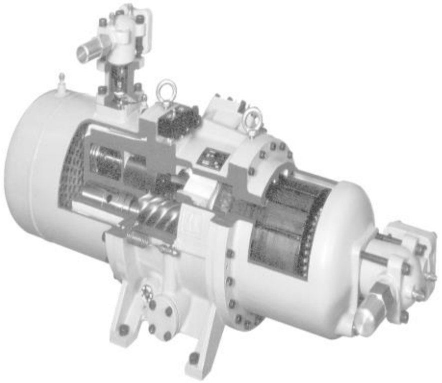
Refrigeration Principle (3)

Component	Refrigerant Status	Pressure Change	Temperature Change
Evaporator	Liquid – gas	Low pressure	Low temperature
Compressor	Gas – gas	Low pressure – high pressure	Low temperature – high temperature
Condenser	Gas – liquid	High pressure	High temperature – normal temperature
Expansion valve	Liquid – liquid/gas	High pressure – low pressure	Normal temperature – low temperature

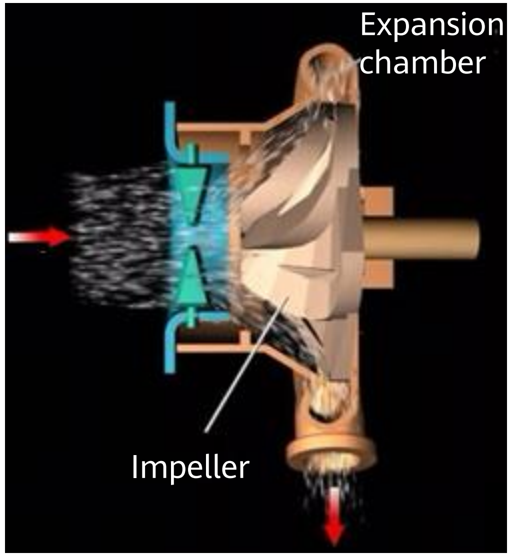
Introduction to the Four Major Components (1)

- Four major components of a cooling system
  - Compressor: Being the core of the refrigeration cycle, a compressor is the power device that enables a refrigerant to circulate in the cooling system. The compressor maintains low pressure for the refrigerant in an evaporator and high temperature and high pressure for the refrigerant in a condenser.

Scroll compressor



Screw compressor



Centrifugal compressor

Introduction to the Four Major Components (2)

- Four major components of a cooling system
  - Condenser: Working with a condensing medium, a condenser condenses the saturated or superheated steam discharged by a compressor into a liquid;
  - Evaporator: After passing a throttle, a liquid refrigerant enters an evaporator, absorbs heat, and vaporizes. As a result, the temperature of the substances to be cooled decreases, and refrigeration is realized.

Water-cooled condenser

Air-cooled condenser

Evaporator

Introduction to the Four Major Components (3)

- Four major components of a cooling system
  - Throttling device: A throttling device performs throttling. Specifically, a throttling device regulates the circulation flow volume of a refrigerant. The throttling device regulates the flow of a high-pressure liquid refrigerant and reduces the pressure of the refrigerant so that the refrigerant can absorb heat and evaporate at the desired low pressure in an evaporator. In addition, the throttling device can automatically adjust the volume of the refrigerant that enters the evaporator based on the change in the heat load of the medium to be cooled.

Thermal expansion valve

Electronic expansion valve

Capillary tube

Contents

Classification of Air Conditioners - By Application (1)

- Air conditioners are classified into the following by application:
  - Industrial air conditioner: Selected parameter values must meet requirements of the industrial process for air parameters;
  - Comfort air conditioner: Selected parameter values must meet requirements for working conditions and rest conditions of people.

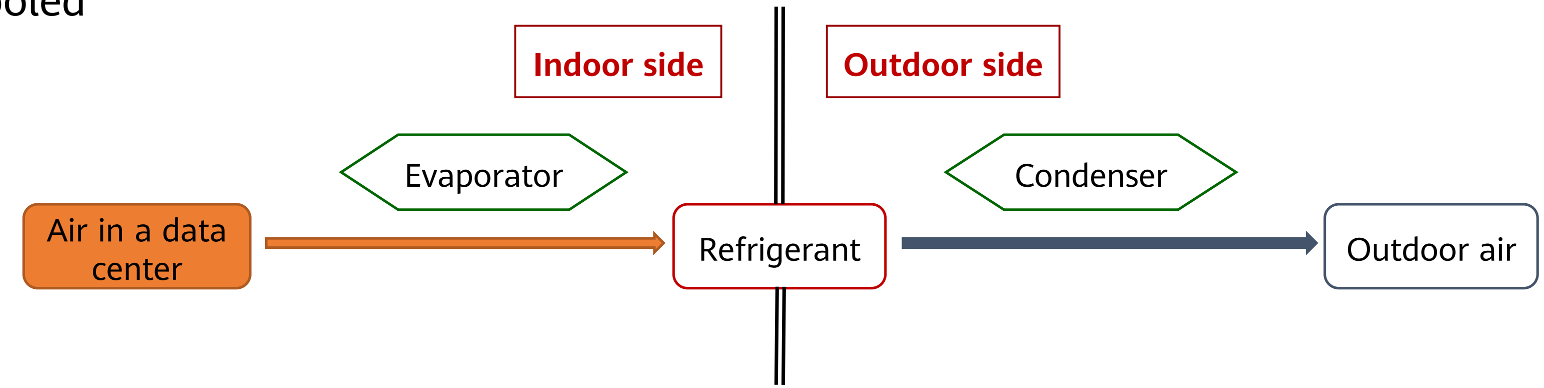
Classification of Air Conditioners - By Application (2)

- Air conditioners are classified into the following by application:

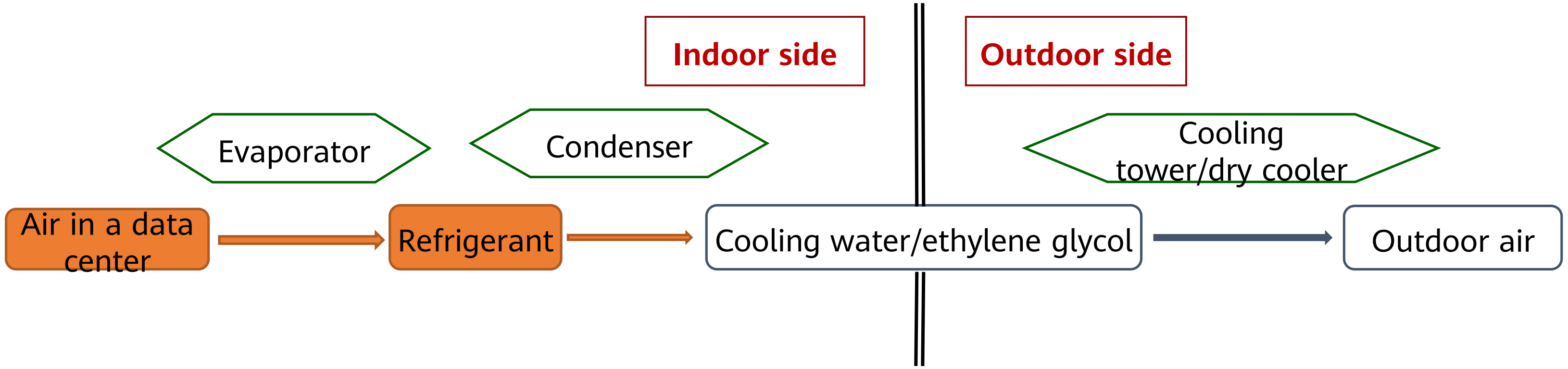
Adjustment Parameter / Type of an Air Conditioner		Temperature	Humidity	Cleanliness	Airflow Speed	Operating Life
Industrial air conditioner	CRAC (precision)	Constant	Constant	Cleanliness required by data centers		Uninterruptible operation > 10 years
	Clean air conditioner	Adjustable	Adjustable	Cleanliness required by industrial buildings		Intermittent operation ≤ 10 years
	Medical air conditioner	Adjustable	Adjustable	Cleanliness required by the medical industry	< 0.25 m/s	Intermittent operation ≤ 10 years
Comfort air conditioner	Home air conditioner	Adjustable				Intermittent operation ≤ 10 years
	Commercial air conditioner	Adjustable				Intermittent operation ≤ 10 years
	Central air conditioner	Adjustable				Intermittent operation ≤ 15 years

Classification of Air Conditioners - By Media (1)

- Air conditioners are classified into the following by cooling system:
  - Direct expansion air-cooled

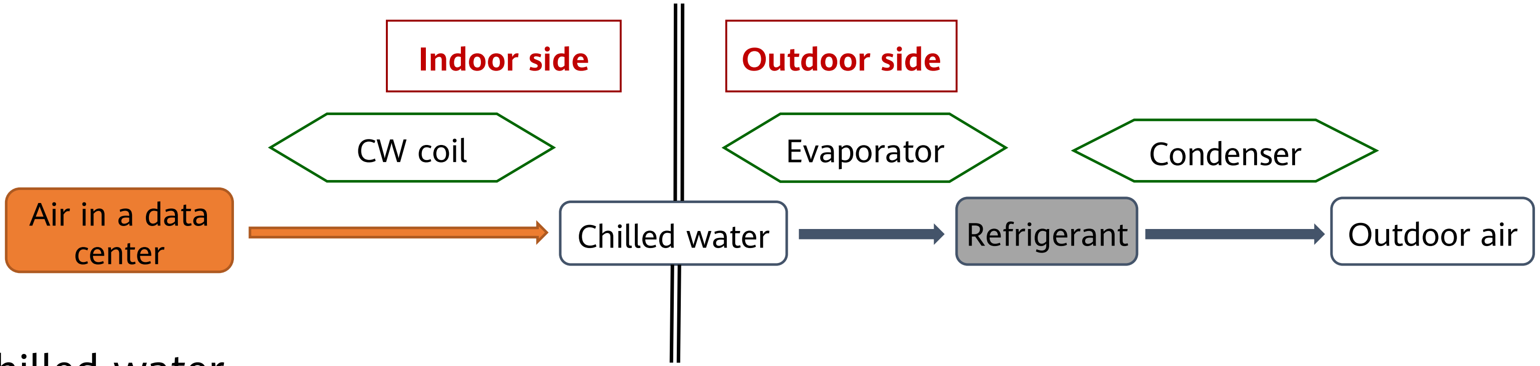


  - Direct expansion water-cooled

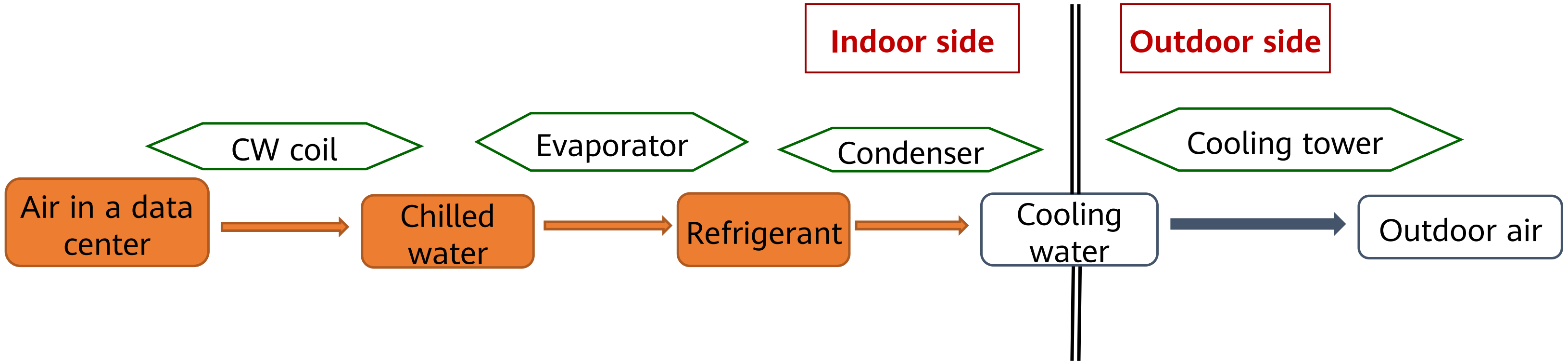


Classification of Air Conditioners - By Media (2)

- Air conditioners are classified into the following by cooling system:
  - Air-cooled chilled water



  - Water-cooled chilled water



Classification of Air Conditioners - By Other Criteria

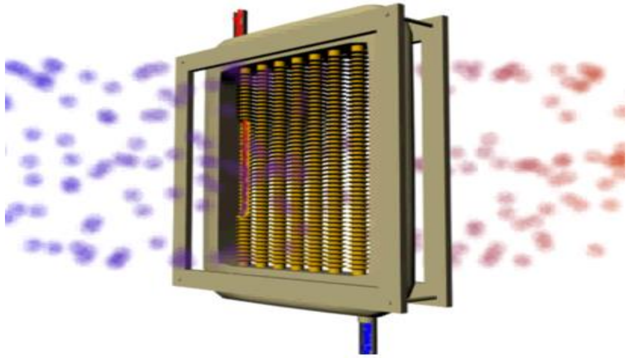
By the concentration degree of air conditioning devices	By the refrigeration architecture	By the method of adjusting the system air volume
• Centralized air conditioning system • Semi-centralized air conditioning system • Distributed air conditioning system	• In-room air conditioner • In-row air conditioner • In-cabinet air conditioner	• Constant-air-volume air conditioning system • Variable-air-volume air conditioning system

Contents

Classification of Devices That Process Air Heat and Humidity

- Direct-contact processing device
  - The medium that exchanges heat and humidity with air is in direct contact with air. Specifically, a direct-contact processing device lets air flow on the surface of the medium or sprays the medium into air. Common direct-contact processing devices include water chambers and humidifiers.
- Indirect-contact processing device
  - The medium that exchanges heat and humidity with air is not in direct contact with air. The exchange of heat and humidity between the air and the medium is carried out using the metal surface of the device. Common indirect-contact processing devices include surface coolers, air heaters, evaporators, and condensers.

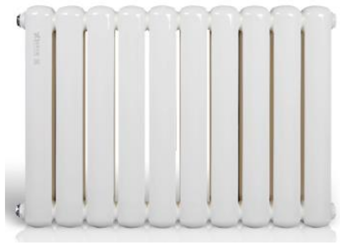
Direct contact (humidifier)



Indirect contact (surface heat exchanger)

Surface Heat Exchanger

- Surface heat exchangers include air heaters and air coolers.



Light pipe air heater

Finned tube air heater

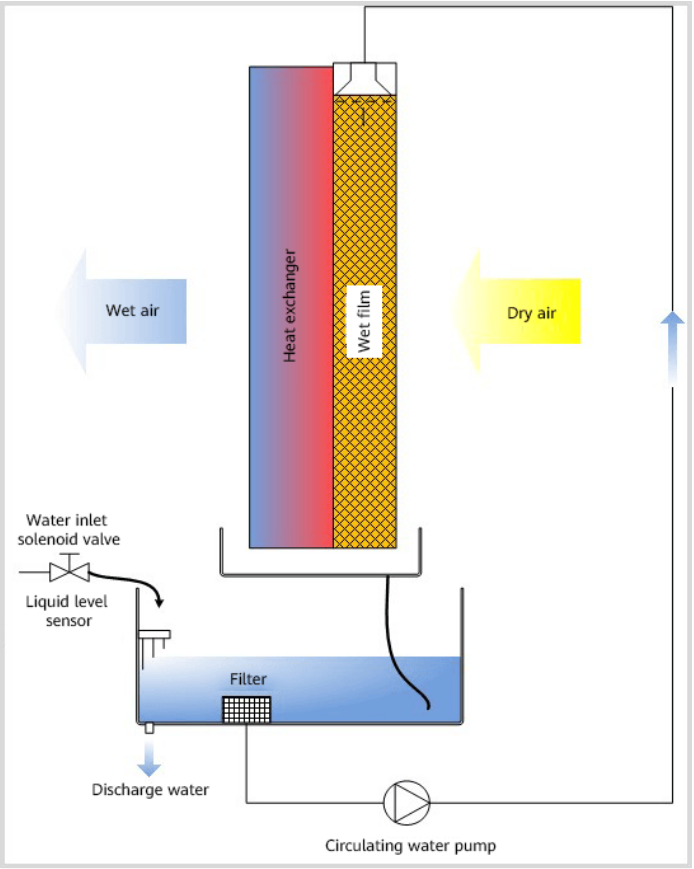
Electric heater

Finned tube air cooler

Finned tube air cooler

Humidifier (1)

- Wet film humidifier
  - When water in the tank is conveyed to the sprinkler on the top of a humidifier, the sprinkler sprinkles the top part of the wet film with water evenly. The water permeates through all layers in the wet film and is absorbed by the wet film. Then an even water film is formed. When dry air passes through the wet film, the dry air has a large area of contact with the wet film surface so that a large amount of water evaporates. A lot of water molecules are blown with air into the space that requires humidification to increase its air humidity.

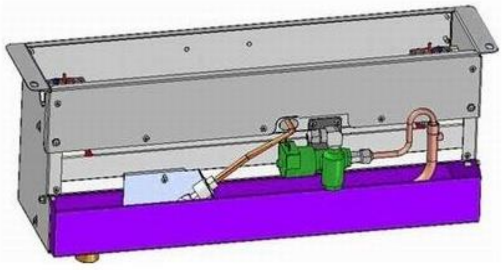


Humidifying Devices (2)

- Electrode humidifier
  - The electrodes of an electrode humidifier form a loop with water in a humidifier cylinder. The electrode humidifier heats the water until the water boils and generates steam. The amount of moisture generated by a humidifier is controlled by adjusting the level of water in the humidifier cylinder in use. The electrode humidifier is safe and reliable. It does not work without water. It controls precision through output power and is free from the impact of scaling. The electrode humidifier features large humidification amount and low acquisition cost. Electrode humidifiers are generally used in in-row precision air conditioners.

Electrode humidifier

- Infrared humidifier
  - An infrared humidifier uses extreme infrared rays to make water vibrate, so that the water obtains heat and then evaporates. An electrode humidifier has high requirements for the water quality, because scale generated in the humidifier cylinder may block the solenoid valve and affect the humidification efficiency. An infrared humidifier does not have this weakness. In addition, an infrared humidifier saves energy. Infrared humidifiers are generally used in in-room precision air conditioners.



Infrared humidifier

Humidifying Devices (3)

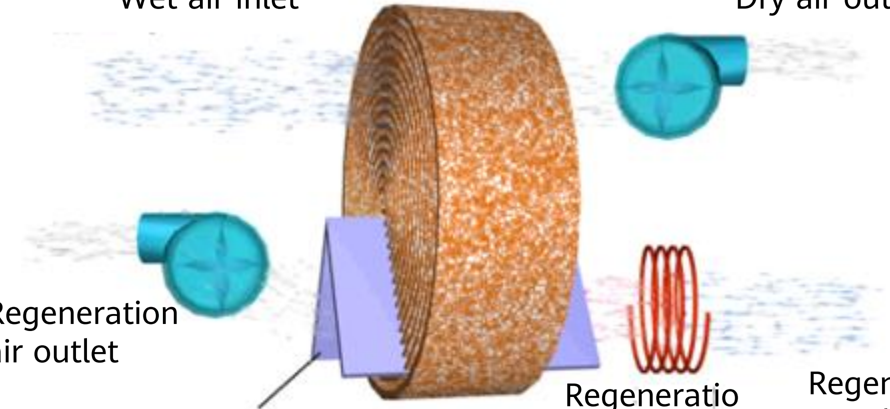
- Other humidifiers

High-pressure micro-mist humidifier

Dry steam humidifier

Dehumidifying Devices

Refrigeration dehumidifier

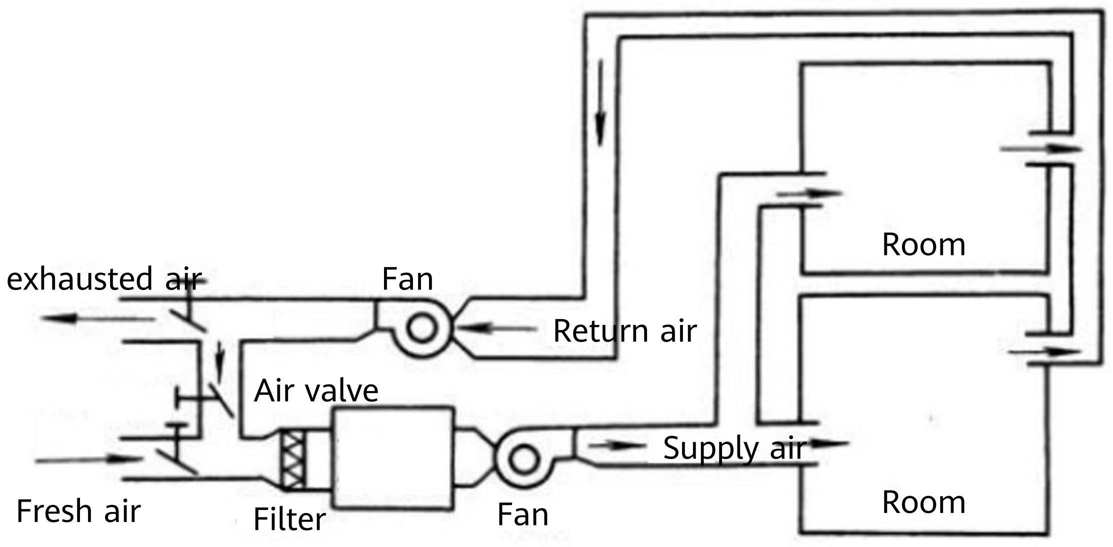


Rotary dehumidifier

Contents

Functions of Air System

- Functions of air system: An air system properly organizes the flowing of indoor air, with the goal of ensuring that the temperature, humidity, speed, and cleanliness of the air in indoor work areas better meet requirements of the production process and human body comfort. The air system of an air conditioning system primarily consists of fans, ducts, air vents, and air valves.



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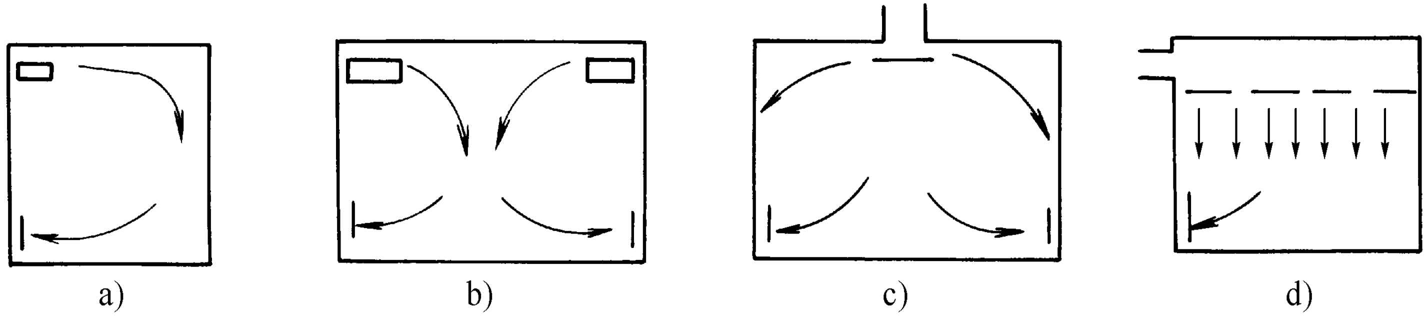
Airflow Forms (1)

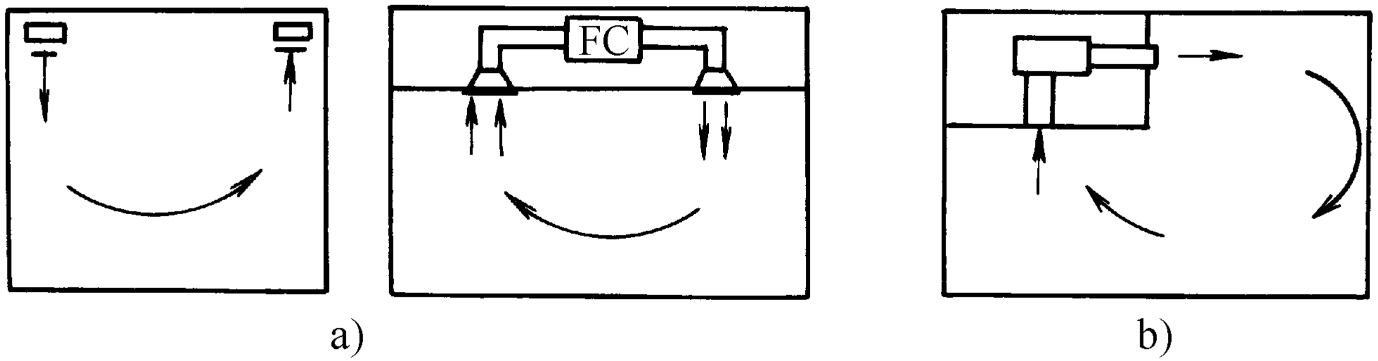
- Supplying air from the top of room (up supply) and returning air from the bottom of room (down return).
  - Air supply vents are located at the top of an air-conditioned room, and air return vents are located at the bottom of the room. The airflow enters the room from the top and leaves the room from the bottom.
  - This airflow form applies to industrial air conditioners that require a constant temperature and cleanliness, and also applies to comfort air conditioners that primarily supply hot air and are installed in rooms with a large floor height.



Airflow organization forms of up supply and down return

Airflow Forms (2)

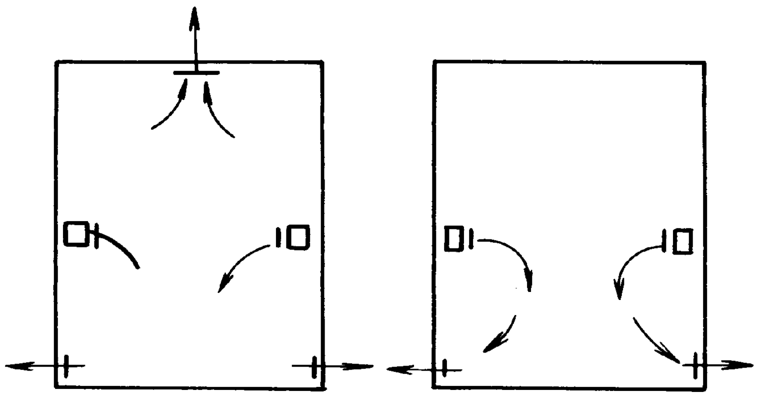
- Supplying and returning air both from the top of room (up supply and up return).
  - When both air supply/return ducts and air supply/return vents are located at the top of an air-conditioned room, the airflow enters the room from the top and leaves the room also from the top.
  - This airflow organization form applies to comfort air conditioners that are primarily used to reduce temperature and are installed in rooms with a small floor height, and also applies to rooms where air return vents cannot be provided at the bottom.



Airflow organization forms of up supply and up return

Airflow Forms (3)

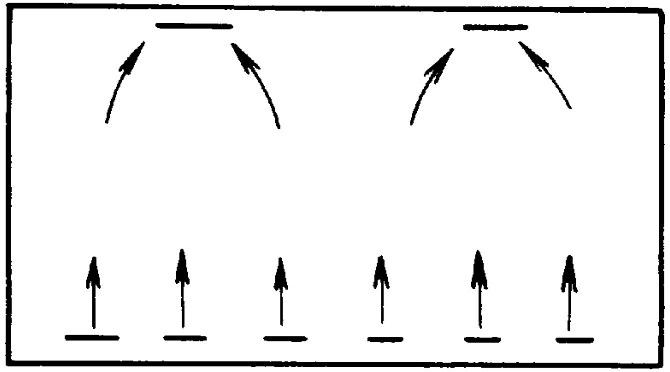
- Supplying air from the middle of side walls of room (central supply).
  - Air supply vents are located in the middle of side walls of an air-conditioned room, and air return vents are located at the bottom of the room. The airflow enters the room from the middle of side walls and leaves the room from the bottom.
  - For some tall air-conditioned rooms, if the actual work areas are in the lower parts of the rooms, you do not need to control the entire space, and you only need to control the lower parts of the rooms.



Airflow organization forms of central supply

Airflow Forms (4)

- Supplying air from the bottom of room and returning air from the top of room (down supply and up return).
  - Air supply vents are located at the bottom of an air-conditioned room, and air return vents are located at the top of the room. The airflow enters the room from the bottom and leaves the room from the top.
  - This airflow organization form applies to industrial air conditioners that need to take away a large amount of excess heat in the lower part of an air-conditioned room, and also applies to comfort air conditioners that are installed in crowded public buildings with a large floor height, for example, a theater.



Airflow organization forms of down supply and up return

Introduction to Air Vents (1)

- Louver
  - Louvers are the most widely used air vents in air conditioning projects. Louvers can be installed on walls of air-conditioned rooms or sides of exposed ducts. Besides, louvers can be installed on ceilings of air-conditioned rooms or bottoms of exposed ducts.
  - Common louver types: single-layer louver and double-layer louver.

Single-layer louver

Double-layer louver

Introduction to Air Vents (2)

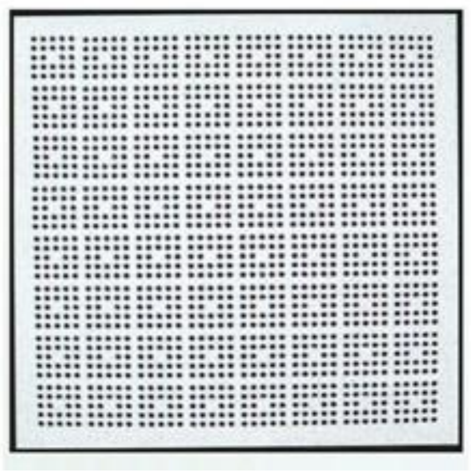
- Air Diffuser
  - Air diffuser is usually installed on the ceiling of an air-conditioned room or the bottom of an exposed. Air diffuser has a nice shape, easily matches the room decoration, and is one of the most widely used air supply vents.
  - Common types: down air supply type and horizontal air supply type.

Round diffuser

Square diffuser

Introduction to Air Vents (3)

- Vented floor
  - Vented floor is generally installed on raised floors in data centers and used as downward air supply vents.
  - Common types: mechanical type and electric type.



Mechanical vented floor

Electric vented floor

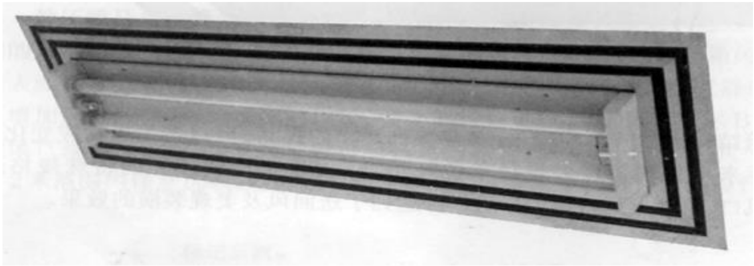
Introduction to Air Vents (4)

- Other air vents

Nozzle

Swirl vent

Striped vent



Lamp air supply diffuser

Contents

Cooling Capacity, EER and COP

- **Cooling capacity:**
  - Heat absorbed by the refrigerant on the low-pressure side in the evaporator in unit time when the air conditioner is refrigerating or the sum of heat removed from the enclosed space, room or area in unit time. The common unit is W or kcal/h.
  - 1 cal is the energy needed for making the temperature of 1g water rise by one Celsius degree. In international unit, energy is expressed by using joule. 1 cal = 4.184 J.
  - Refrigeration ton: Refrigeration ton indicates the cooling capacity needed for freezing 1 ton of 0℃ saturated water into 0℃ ice within 24 hours；
    - 1 US refrigeration ton =3024 kcal/h = 3.517 KW.
- **Consumed power:**
  - Consumed power for refrigeration: total power consumed when an air conditioner is refrigerating(unit: W).
  - Consumed power for heating: total power consumed when an air conditioner is heating (unit: W), including power consumed by the electric heater supplementing the heat pump.
- **Energy efficiency ratio (EER):**
  - Ratio of cooling capacity to input power under rated and specified conditions when an air conditioner is refrigerating. The value is expressed by using W/W.

Refrigerant and Circulated Air Volume

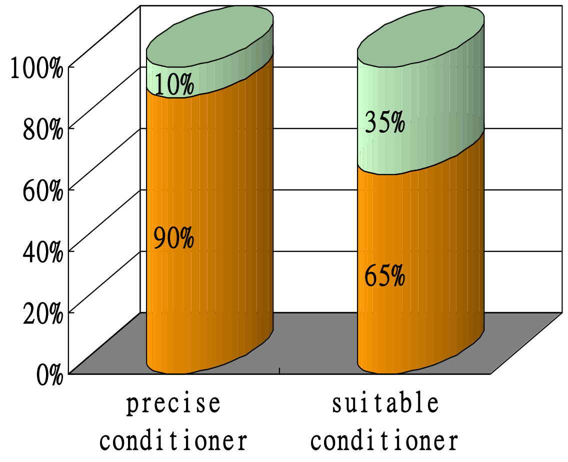
- **Refrigerant:**
  - Refrigerant is also called refrigerating medium. It is an operating substance that circulates continuously in the refrigerating system by changing its state to realize refrigeration. Refrigerant absorbs heat of cooled medium (water or air) in the evaporator and evaporates and then transfers heat to surrounding air or water in the condenser and condenses;
  - Common refrigerant: R22 (HCFC-22), R407C (HCFC-32/123/134a), and R410A (HCFC-32/123). R22 will create a greenhouse effect and damage the ozone layer and R407C and R410a will create a greenhouse effect;
  - Types of refrigerant oil: R22, R407C, and R410A.
- **Circulated air volume:**
  - Air volume sent to the enclosed space, room or area under rated refrigerating conditions. Unit: m^3/h;
  - In a room, the air velocity has a great effect on human comfortableness. The air velocity in ordinary working areas is 0.4 m/s.

Sensible Heat Ratio

- **Sensible heat ratio =** sensible heat/total heat = sensible heat/(sensible heat + latent heat)
  - **Sensible heat** refers to heat that can be sensed. It can cause temperature change of a substance but does not change the state of the substance;
  - **Latent heat** changes the state of a substance but does not change the temperature when heat is absorbed or released;
    - **Latent heat of fusion** refers to the heat absorbed or released when a substance changes from solid state to liquid state or from liquid state to solid state;
    - **Latent heat of vaporization** refers to the heat needed when a substance changes from liquid state to gas state;
    - **Latent heat of liquid** refers to the heat released when a substance changes from gas state to liquid state.

<u>Example of latent heat</u>: 335 J of energy is absorbed when 0°C ice melts into 0°C water.

<u>Example of sensible heat</u>: 4.186 J of energy is absorbed when 0°C water is heated and becomes 1°C water.



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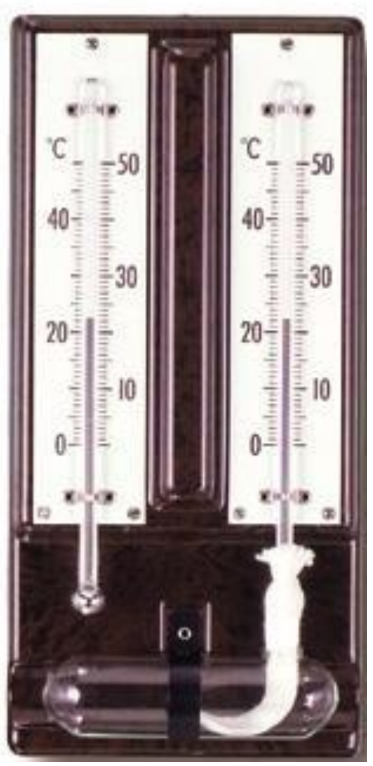
Temperature

- **Temperature:**
  - Dry bulb temperature: temperature measured by using the thermometer not wrapped with wet gauze, as shown in the figure on the left.
  - Wet bulb temperature: temperature measured by using the thermometer wrapped with wet gauze, as shown in the figure on the right.
  - In general, the air is unsaturated and can absorb moisture. In this case, water on the wet gauze absorbs heat and evaporates. Therefore, the wet bulb temperature is generally lower than the dry bulb temperature. The lower the relative humidity of air is, the more water on wet gauze will evaporate. In this case, the wet bulb temperature is much lower than the dry bulb temperature. When the air is saturated, the two are the same.
- **Centigrade temperature (°C):**
  - Under 1 atmospheric pressure, the freezing point of water is 0°C and the boiling point is 100°C.
- **Fahrenheit temperature (°F): °F=°Cx1.8+32; °C=(°F - 32)x5/9**
- **Absolute temperature (K): K=273+°C**



Humidity

- **Humidity: amount of steam in the air**
  - The most suitable humidity is 40% to 55% in the computer room.
  - Too low humidity will easily generate static electricity; too high humidity will easily generate condensate water and cause short circuit of electric equipment.

Humidity	Definition	Meaning
Relative Humidity	Ratio of the actual amount of steam in the air to the maximum amount of steam that can be accommodated in the air under the same temperature and same pressure. It is expressed by using %.	Drying degree of air. The smaller the percentage is, the drier the air is.
Moisture content	Amount of steam in each kilogram of air (g)	Water volume in unit mass of air

Dew Point

- **Dew point: temperature when the air becomes saturated.**
  - Under certain atmospheric pressure and steam content, when the air becomes saturated and continuous cooling will form dew, the temperature at this time is dew point.
  - In the air conditioning system, when the surface temperature of the evaporator or surface cooler is lower than the dew point of the air, steam in the air will condense, so as to achieve the objective of dehumidification.
  - In a general computer room (24°C, 50%), the dew point is 13.2°C. Below this temperature, the surface of objects will form dew.
  - The table below lists dew points in common computer room environments.

Dry Bulb Temperature (°C)	Relative Humidity	Dew Point (°C)
24	50%	13.2
24	45%	13.1
24	55%	14.6
23	50%	12.4
23	45%	10.6
23	55%	13.7
22	50%	11.3
22	45%	11.1
22	55%	12.7

Cleanliness

- **Cleanliness:** content of dust (including microbes) in clean air.
  - Code for Design of Data Centers raises the following requirement for dust concentration in computer rooms: under static or dynamic conditions, the number of dust particles greater than or equal to 0.5um is smaller than 17,600,000 in each cubic meter of air.
  - When the air conditioning system in the computer room adopts a cycle generating unit, a primary efficiency or medium efficiency filter should be equipped. A fresh air system should be equipped with a primary efficiency or medium efficiency filter and a sub-high efficiency filter is preferred.
- **Comparison table of filter levels:**

Filter efficiency compare table about China USA and Europe											
China GB/T14295	Roughing				Medium efficiency			High efficiency			
USA ASHRAE	C1	C2,3,4	L5 L6	L7	L8	M9 M10	M11	M12	M13	M14	
Europe CEN	G1	G2	G3	G4		F5	F6		F7	F8	
Europe EUROVENT	EU1	EU2	EU3	EU4		EU5	EU6		EU7	EU8	

Quiz

1. (Single)Which of the following devices is a direct-contact processing device?
    A. Humidifier
    B. Evaporator
    C. Electric heater
    D. Condenser
2. (Short Answer Question)What categories can air conditioning systems be classified into by media?

Summary

- Working Principles of Air Conditioning System
- Classification of Air Conditioning System
- Air Handling Equipment
- Air Conditioning Air System
- Common Air Conditioner Terms

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise：http://support.huawei.com/enterprise/
  - Online Learning：http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Basic Knowledge of Precision Air Conditioners in Data Centers

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Foreword

- The slides describe the basic knowledge of precision air conditioners in data centers, as well as the technical principles and main components of the air-cooled precision air conditioner, chilled water precision air conditioner, and indirect evaporative cooling system.

Objectives

On completion of this course, you will be able to:

- Understand the features of data center air conditioners and the differences between data center air conditioners and household air conditioners;
- Understand the basic principles and main components of the air-cooled precision air conditioner;
- Understand the basic principles and main components of the chilled water precision air conditioner;
- Understand the basic principles and main components of the indirect evaporative cooling system;
- Understand the product architecture of Huawei precision air conditioners.

Contents

Why Do We Use Air Conditioners?

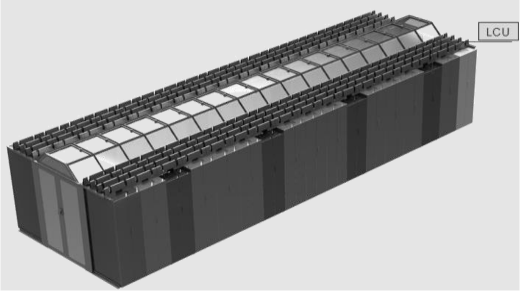
- If there are no specialized air conditioners for the computer room:
  - Unable to maintain constant temperature - greatly reduce service life of electronic components.
  - Partial superheat - sudden shutdown of equipment.
  - Too high humidity in computer room - generate condensate water.
  - Too low humidity in computer room - generate damaging static electricity.
  - Not clean enough - main equipment damage and communication data error.
- **ANSI/TIA-942-2-2010 " Telecommunications Infrastructure Standard for Data Centers "**

Space	Environmental requirements
Computer rooms, entrance rooms, access provider spaces, and service providers spaces in data centers	• Temperature: 18 – 27°C (64 – 81°F) dry bulb ▫ high altitude: reduce maximum dry-bulb temperature 1°C for every 300m (1.8°F for every 1000 ft) above 1800 m (5900 ft) altitude • Maximum Relative Humidity (RH): 60% • Maximum dew point: 15 °C (59 °F) • Minimum dew point (lower moisture limit): 5.5 °C (42°F) [1] • Maximum rate of temperature change: 5 °C (9 °F) per hour
Notes: 1. Dewpoint of 5.5 °C - corresponds to approximately 44% RH at 18 °C (64 °F) and 25% RH at 27 °C (81 °F).	

Why Do We Use Precision Air Conditioner?

- Data center air conditioner
  - Used in data centers to cool IT equipment.
- Advantages:
  - High energy efficiency: COP>3.0
  - High sensible heat ratio: > 0.9
  - High air volume
  - Cooling throughout the year
  - High precision control over temperature and humidity
  - Long service life: > 10 years

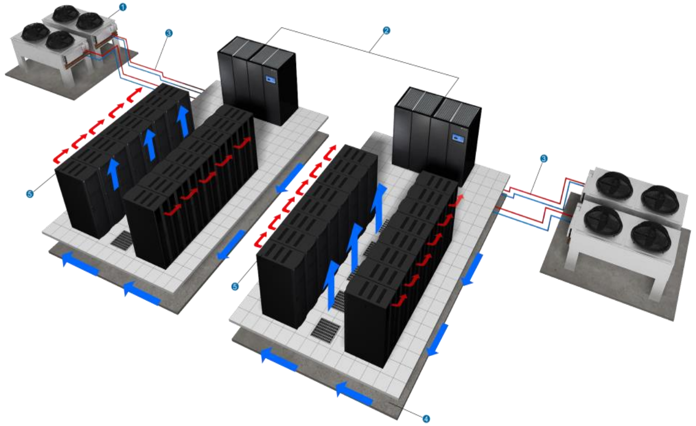
Application Scenarios

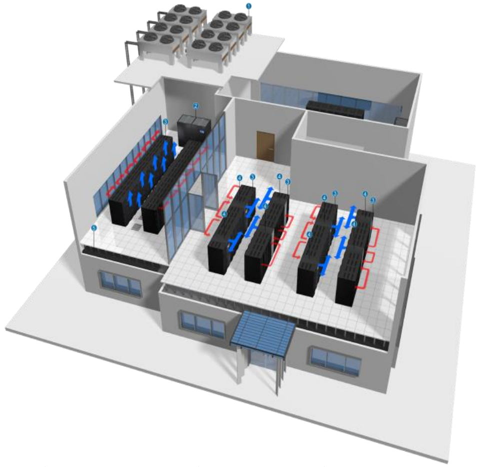


Modular data center

Application scenario

Container data center



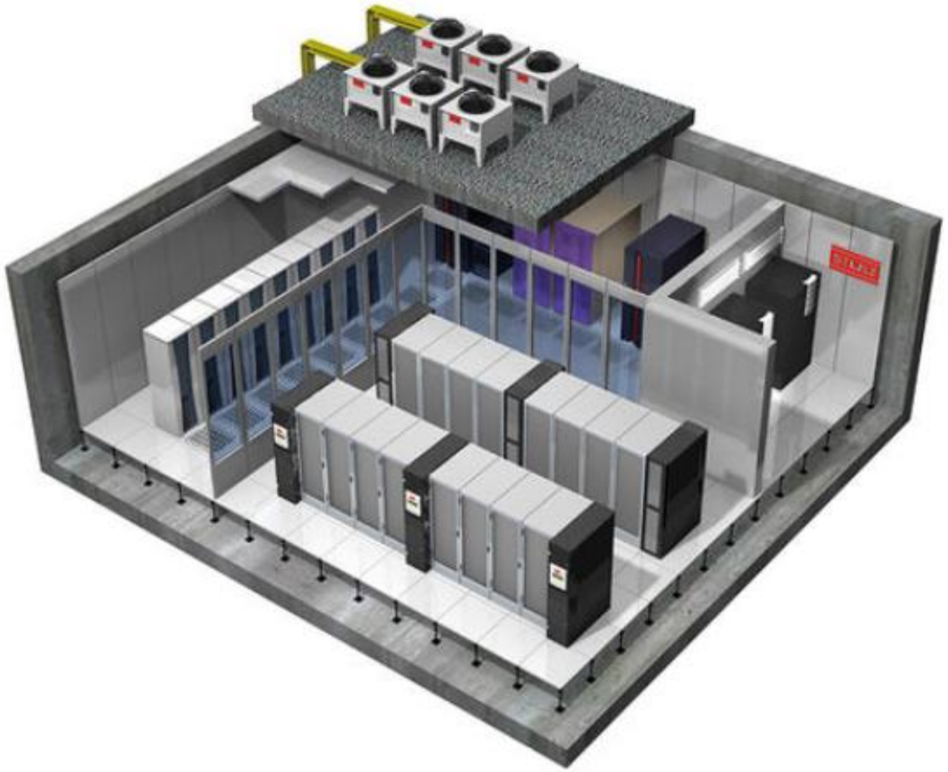


Medium or large data center

Contents

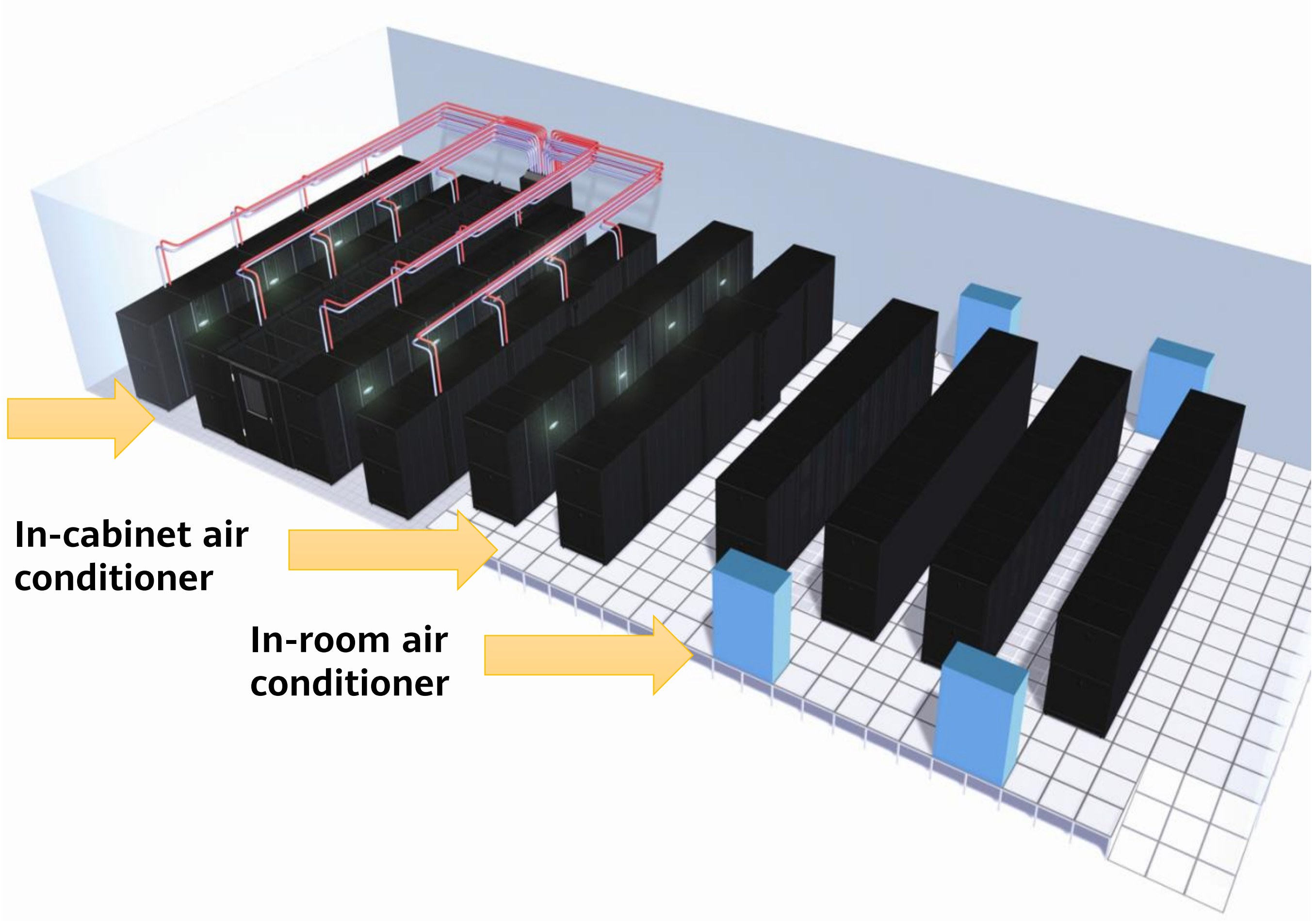
Classification (1)

- The mainstream cooling modes for data centers include mechanical cooling and free cooling.
  - Mechanical cooling is implemented by the compressor operation of a cooling device. Direct expansion and water-cooled air conditioners are mainly used for mechanical cooling.
  - Free cooling is implemented by free cooling sources to cool data centers. Direct fresh air cooling and indirect evaporative cooling are two major modes.
- With the development of technology and energy-saving requirements, many new cooling methods are emerging, such as refrigerant pump cooling, fan wall cooling, heat pipe air conditioning, and liquid cooling.
- This course mainly describes **air-cooled precision air conditioners, chilled water precision air conditioners, and indirect evaporative cooling air conditioners** that are widely used in data centers, and briefly introduces other technologies such as refrigerant pumps.



Classification (2)

- Classified by indoor unit layout



In-row air conditioner

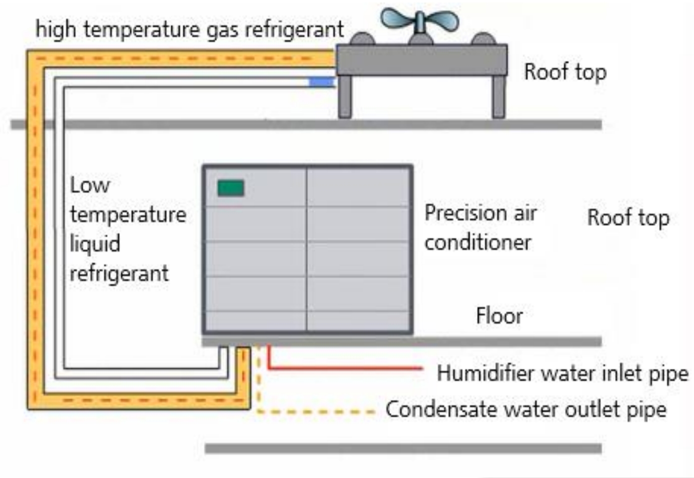
In-cabinet air conditioner

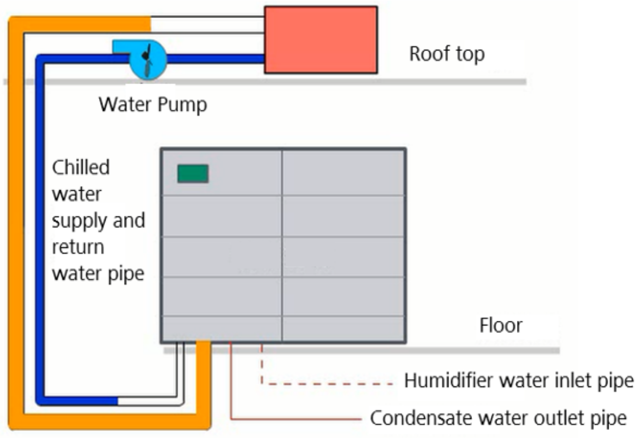
In-room air conditioner

Classification (3)

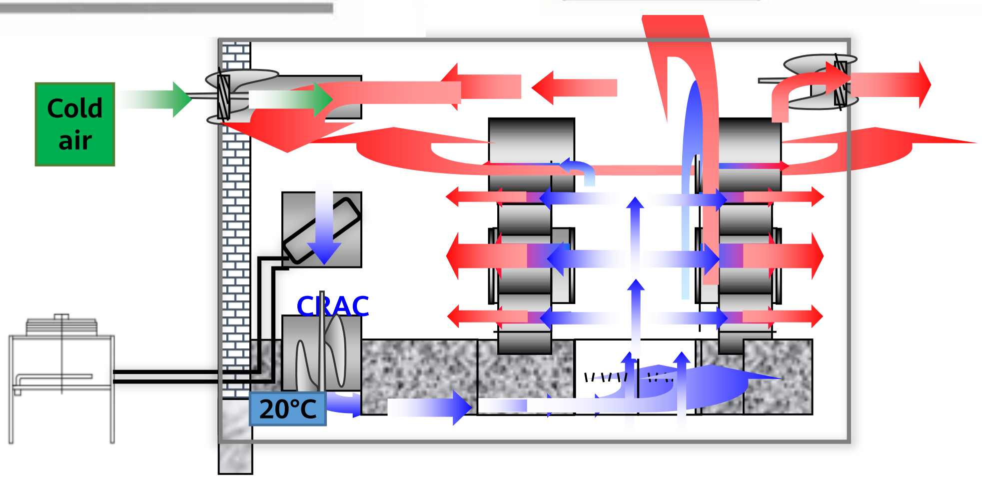
- Classified by cooling mode

Air-cooled air conditioner





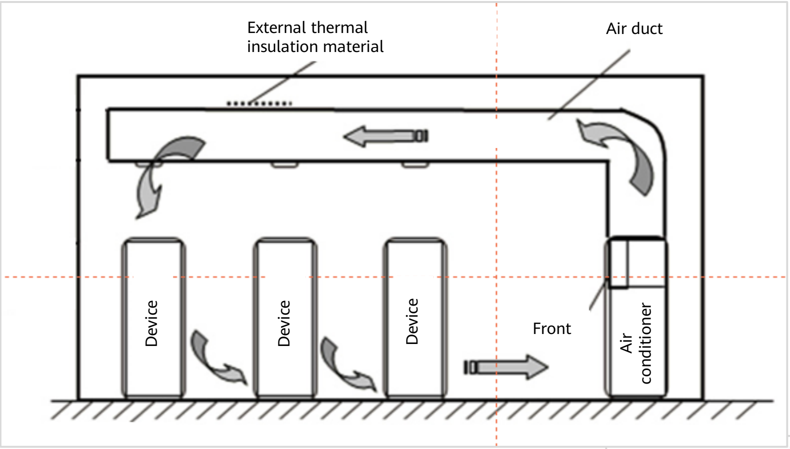
Chilled water air conditioner



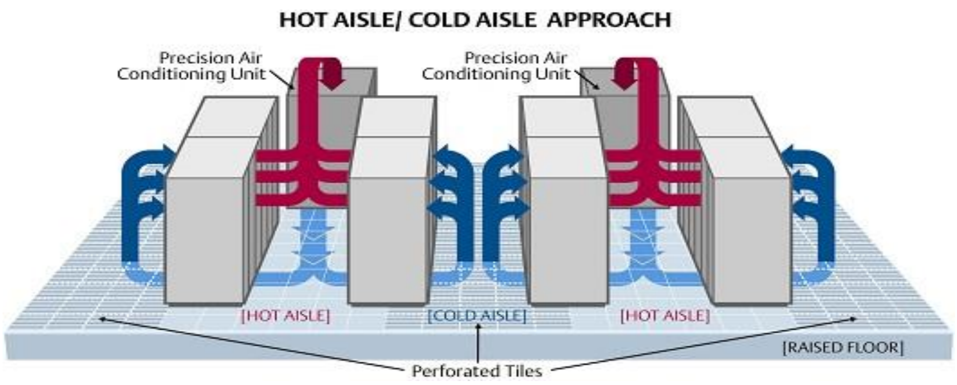
Free cooling air conditioner

Classification (4)

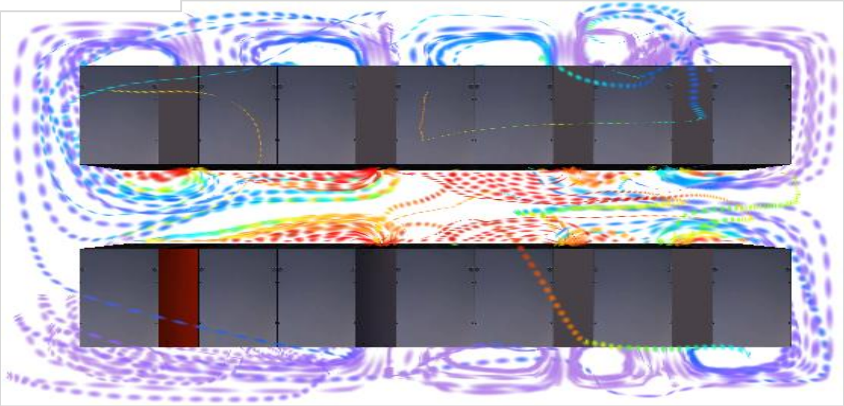
- Classified by airflow organization



Upflow air conditioner



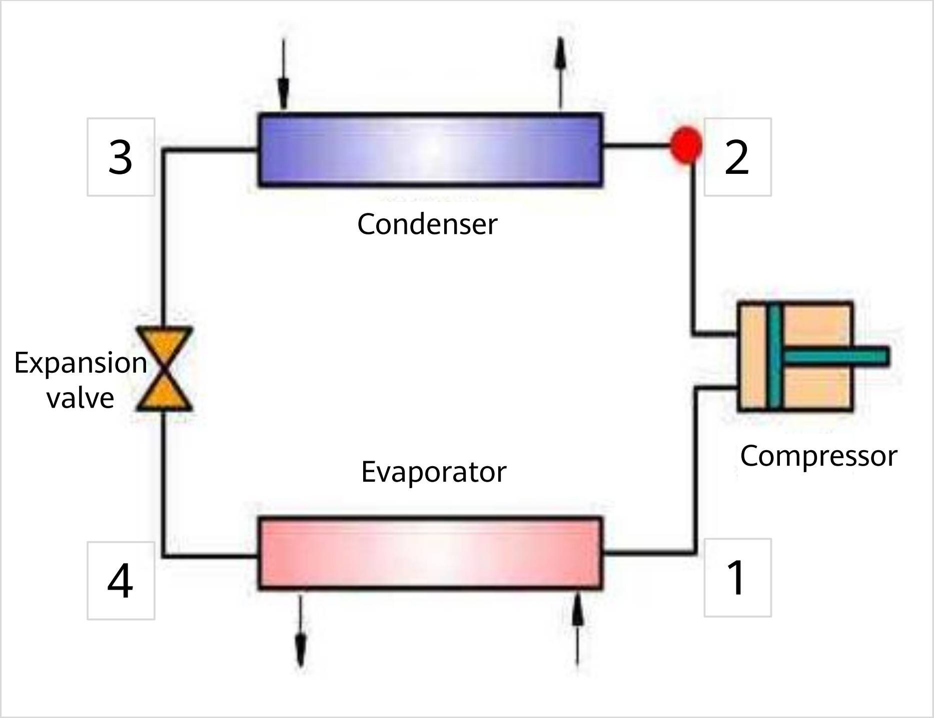
Downflow air conditioner



Air conditioner with horizontal airflow

Contents

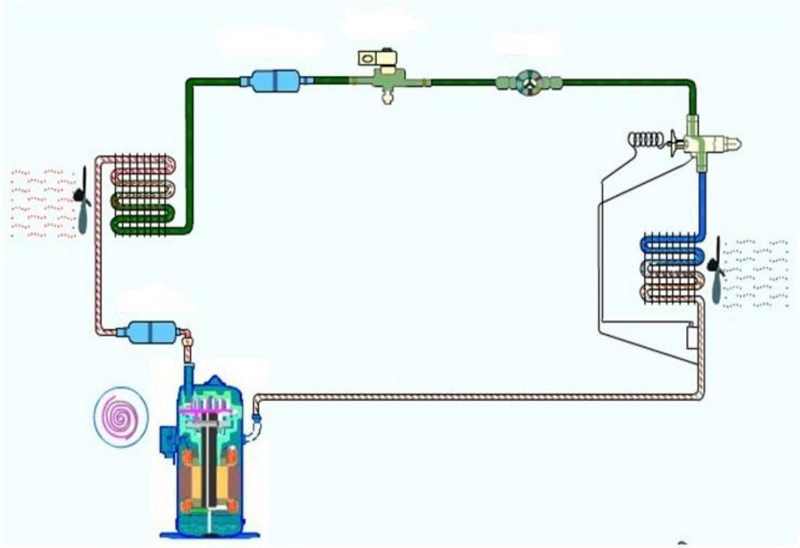
Basic Principles (1)



- 1——2: The low-temperature and low-pressure vapor is compressed into high-temperature and high-pressure vapor by the compressor.
- 2——3: The heat of the high-temperature and high-pressure vapor is released by the condenser to form medium-temperature and high-pressure liquid.
- 3——4: The saturated liquid passes through the expansion valve to form a low-temperature and low-pressure gas-liquid mixture.
- 4——1: The gas-liquid mixture absorbs heat through the evaporator to form low-temperature and low-pressure vapor.

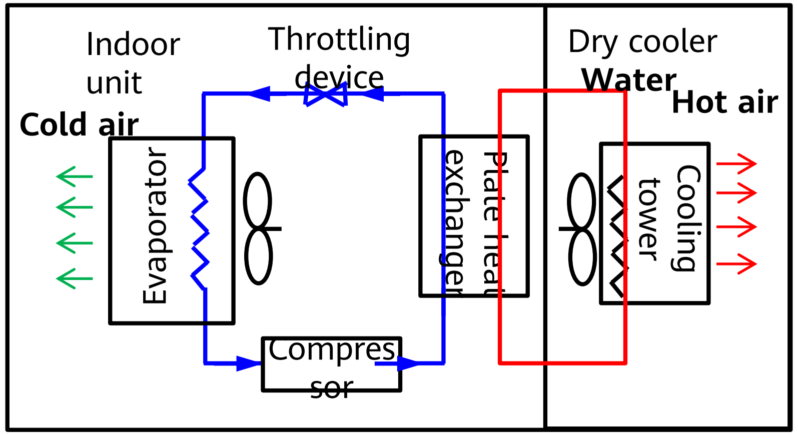
Basic Principles (2)

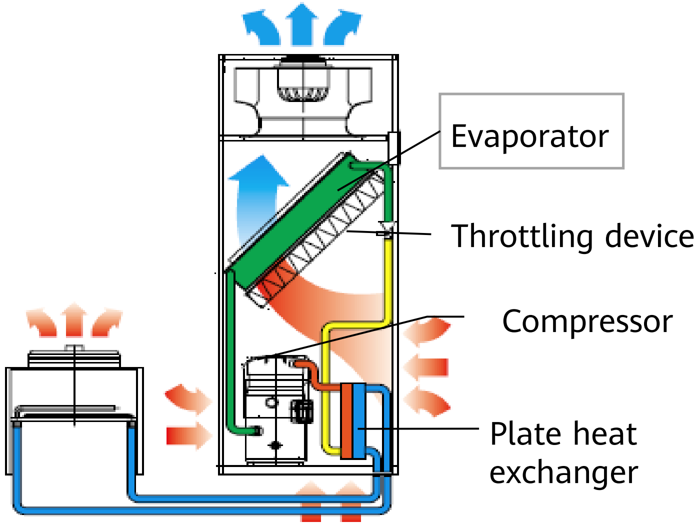
- Direct expansion air-cooled
  - Device refrigerant: refrigerants such as R410A, R407c, and R22;
  - Application scenarios: small and medium-sized data centers without 24 h chilled water source (with the cooling capacity less than 500 kW);
  - Characteristics:
    - Simple structure, easy and quick installation, and low cost;
    - Relatively small, independent refrigeration cycle, and easy maintenance;
    - Suitable for areas where water is scarce and where a cooling water system is absent;
    - Relatively low cooling energy efficiency ratio;
    - Not supporting long-distance installation. (Because such installation results in heavy cooling loss).



Basic Principles (3)

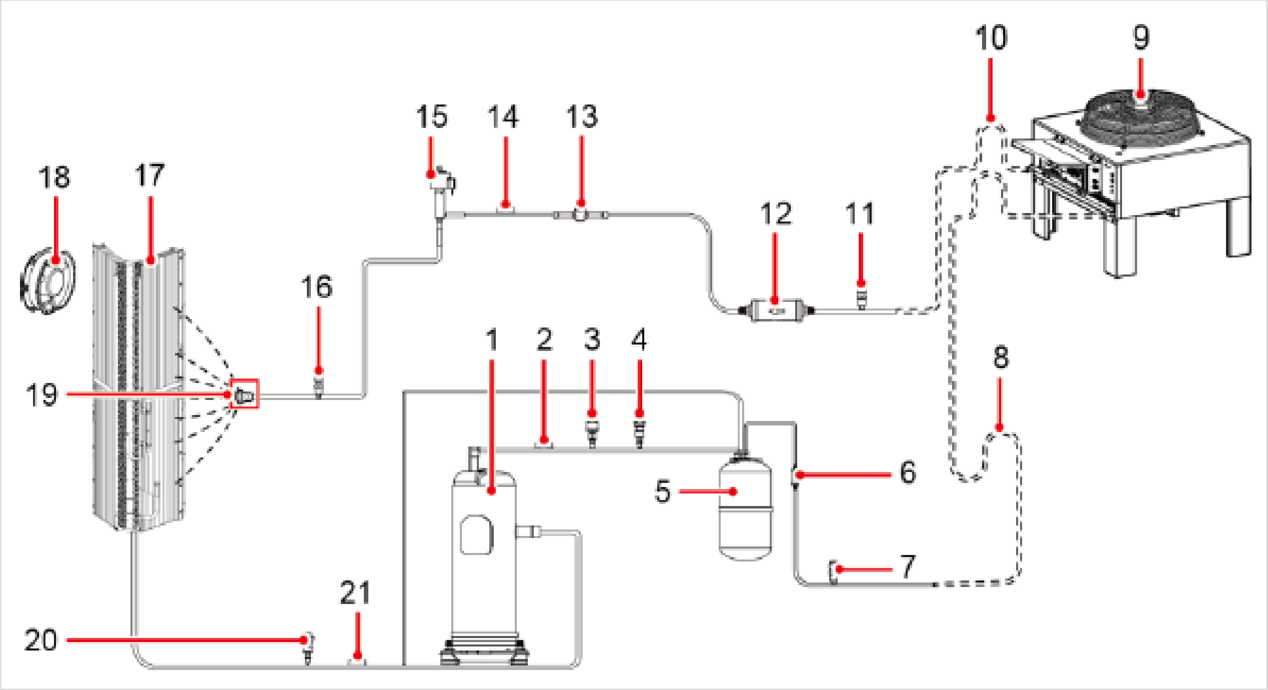
- Direct expansion water-cooled
  - Device refrigerant: refrigerants such as R410A, R407c, and R22;
  - Application scenarios: areas with abundant water sources;
  - Characteristics:
    - Convenient and quick installation; (because refrigerants have been filled in factories);
    - Supporting long-distance installation;
    - A mixed solution of water and ethylene glycol generally required;
    - More suitable for large-scale systems with a cooling tower.





Contents

Components of a Huawei Air-Cooled Air Conditioner



No.	Name
1	Compressor
2	Discharge temperature sensor
3	High pressure switch
4	High pressure sensor
5	Oil separator
6	One-way valve
7	Exhaust pipe needle valve
8	Oil trap
9	Outdoor unit
10	Inverted U-shaped trap

No.	Name
11	Liquid pipe needle valve
12	Filter dryer
13	Sight glass
14	Liquid pipe temperature sensor
15	Electronic expansion valve (EEV)
16	Low pressure needle valve
17	Evaporator
18	Indoor fan
19	Liquid distributor
20	Low pressure sensor
21	Suction temperature sensor

Main Components (1)

- **Four main components of refrigerating system**
  - Compressor: The compressor is the core of the refrigeration cycle and is a power unit for refrigerant to circulate inside the system.
  - Condenser: Under the effect of condensing medium, the condenser liquidizes the superheat saturated steam discharged by the compressor.
  - Expansion valve: used for throttling. It is a regulating device for circular flow of refrigerant.
  - Evaporator: The liquid refrigerant that is throttled absorbs heat and evaporates in the evaporator to cool down cooled materials, so as to achieve the objective of refrigeration.

Scroll compressor

Condenser

Electronic expansion valve

Evaporator

Main Components (2)

- **Common auxiliary parts of refrigerating system**
  - Oil-gas separator: It is used to separate the lubricant brought out due to exhaustion of the compressor and brings back the separated lubricant to the compressor.
  - Liquid storage tank: It is used to store excessive refrigerant in the system and guarantee that the refrigerant entering the expansion valve is liquid.
  - Filter dryer: It is used to absorb moisture and filters out impurities in the refrigerating system.
  - Sight glass: It is used to check whether water exists in the refrigerating system and observe the state of refrigerant.
  - Solenoid valve: It is used prevent slugging due to migration of refrigerant when the air conditioning unit is powered off.
  - Fan: Accelerating the air flow and improving the heat transfer capability of the heat exchanger.

Fan

Oil-gas separator

Liquid storage tank

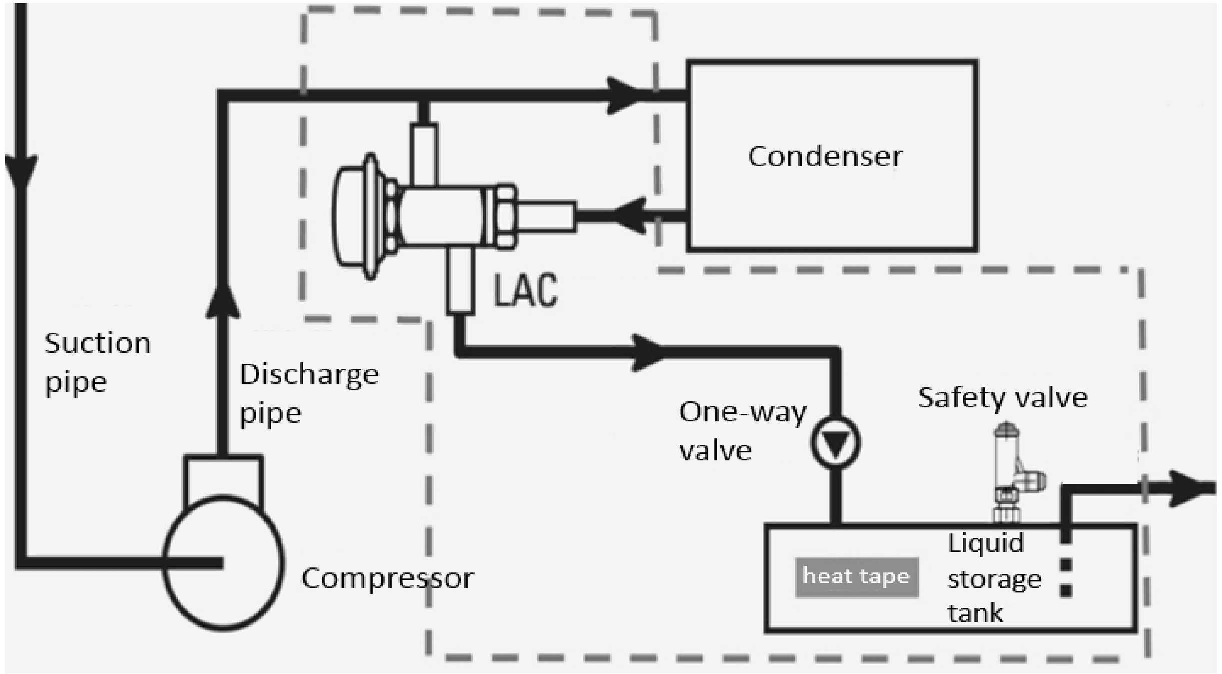
Filter dryer

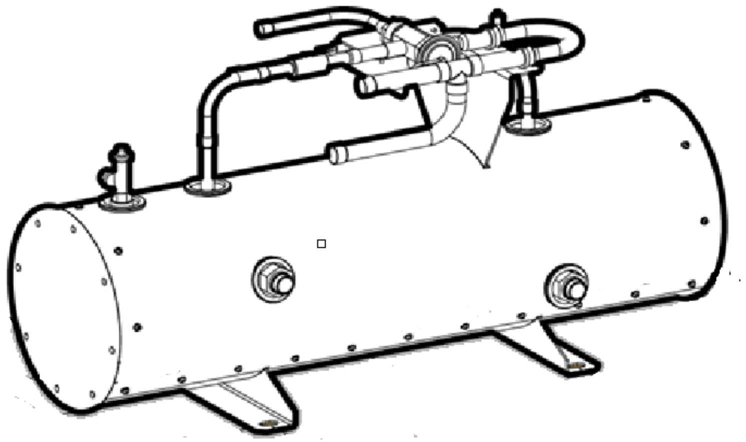
Sight glass

Solenoid valve

Main Components (3)

- Low temperature components - If we use air conditioner in lower temperature environments, we require a low temperature components to improve the continuous low pressure caused by low temperature starting. By adding low temperature components, the air conditioner can operate normally.

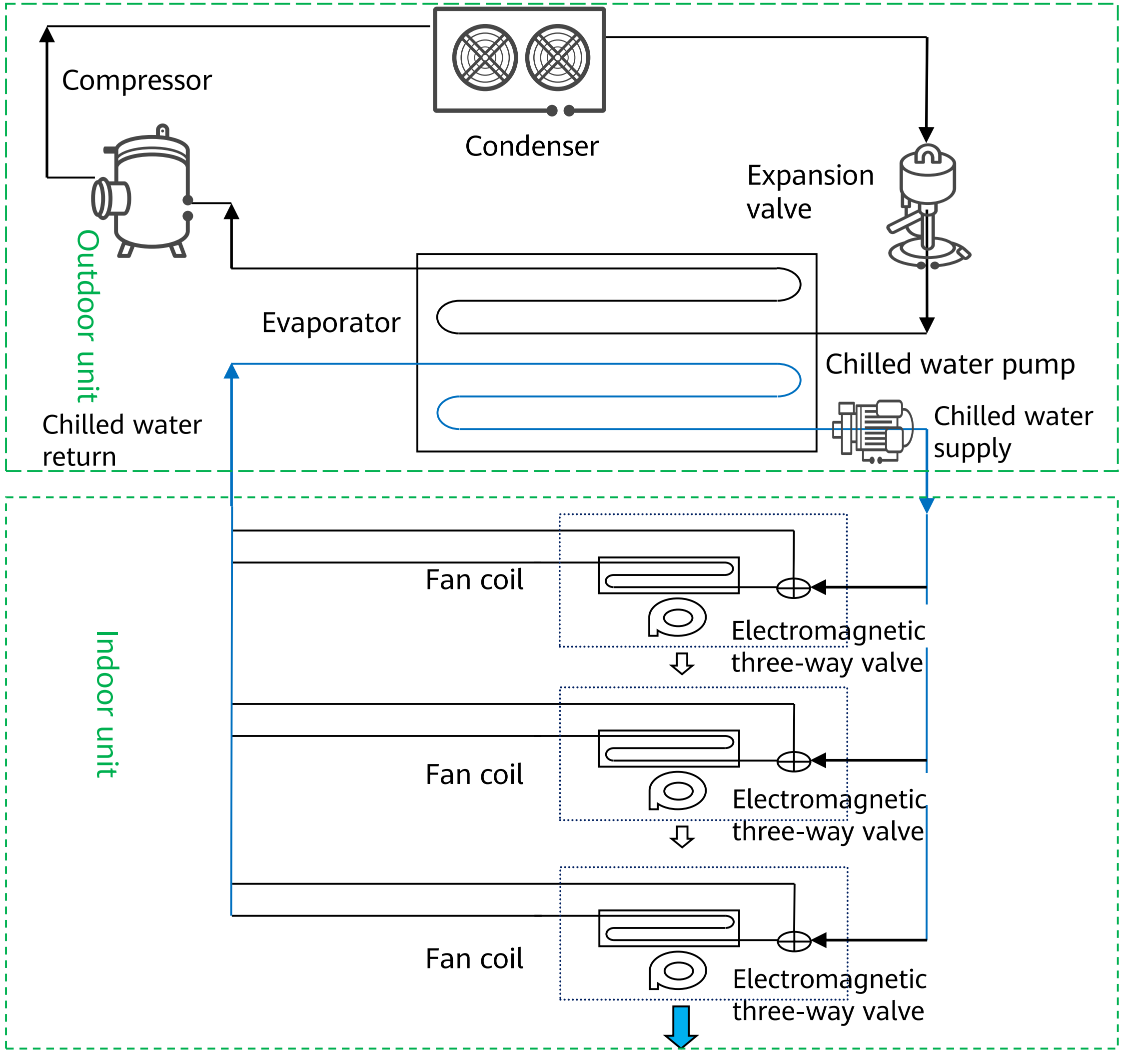


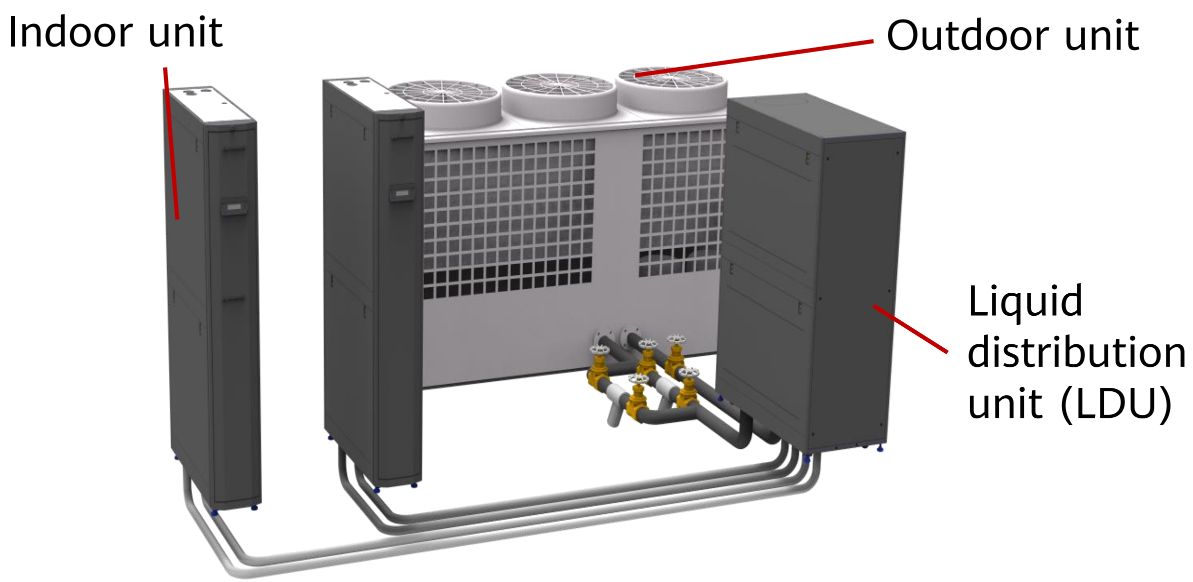


HUAWEI

Contents

Basic Principles (1)



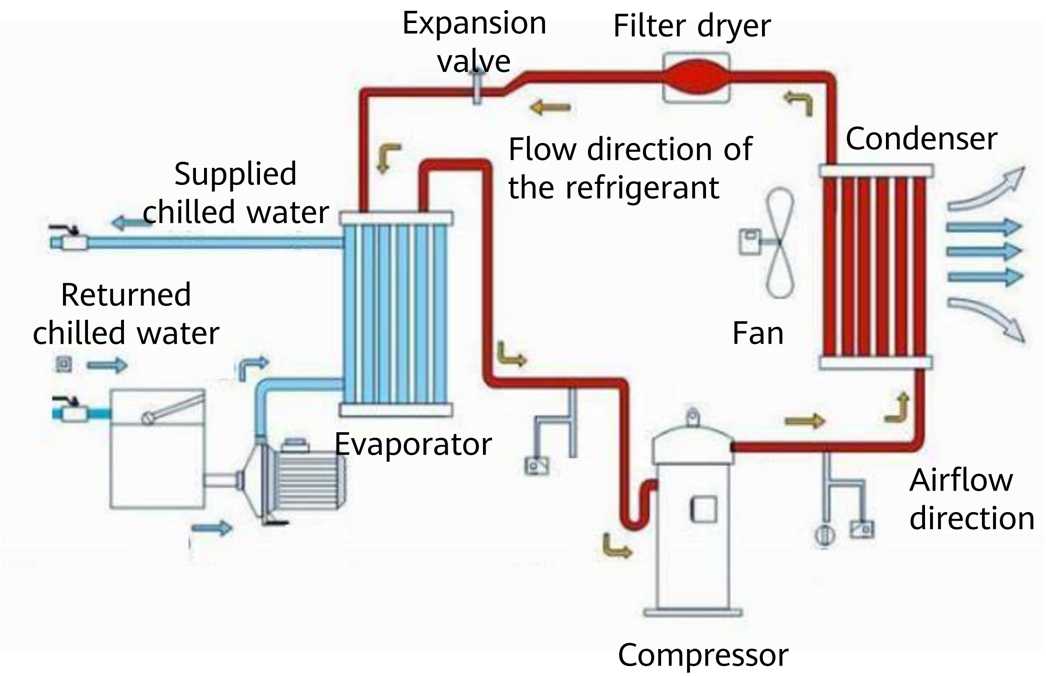


- The chiller uses the vapor-compression refrigeration principle to produce low-temperature water (called chilled water), and distributes the low-temperature water to the indoor unit (fan coil). The hot air in the room flows through the surface of the fan coil to reduce the temperature.

- After heat absorption, the temperature of the chilled water increases and the water flows back to the chiller. The preceding process is repeated.

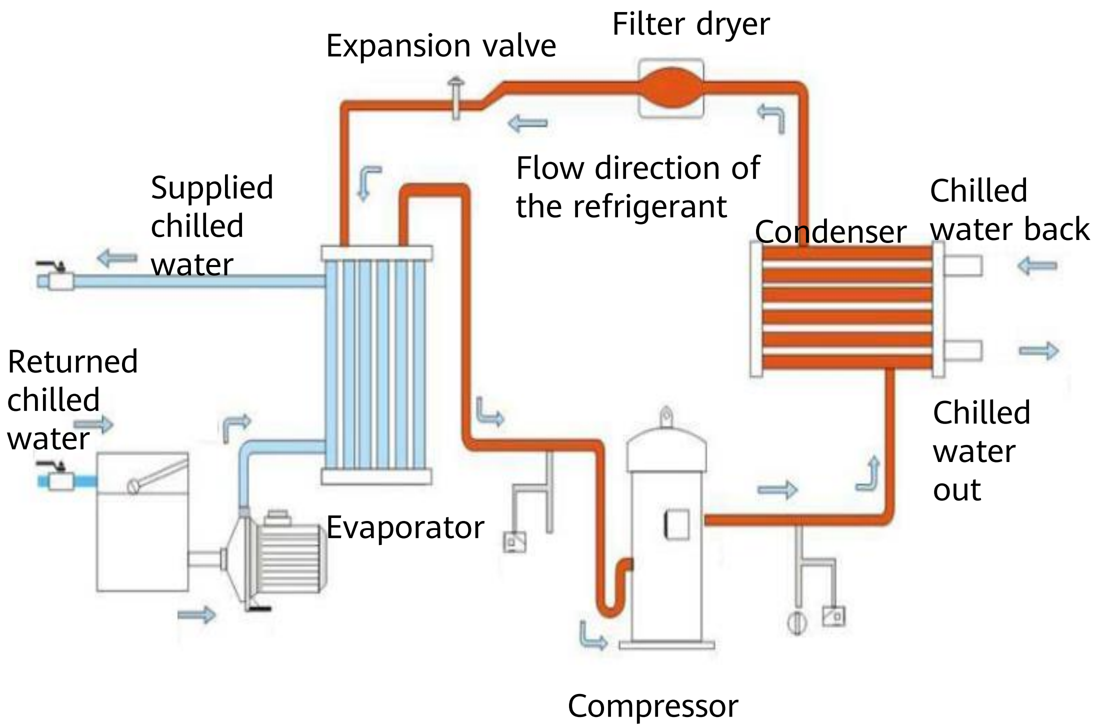
Basic Principles (2)

- Air-cooled chilled water
  - Device refrigerant: chilled water
  - Application scenarios: large and medium data centers
  - Characteristics:
    - Not requiring a cooling tower, easy to install, easy to move, and suitable for occasions where water is scarce and where a water tower is absent;
    - Low-noise fan motor, excellent cooling and condensation effects, and stable throttling body;
    - High EER value, low noise, and stable operation.



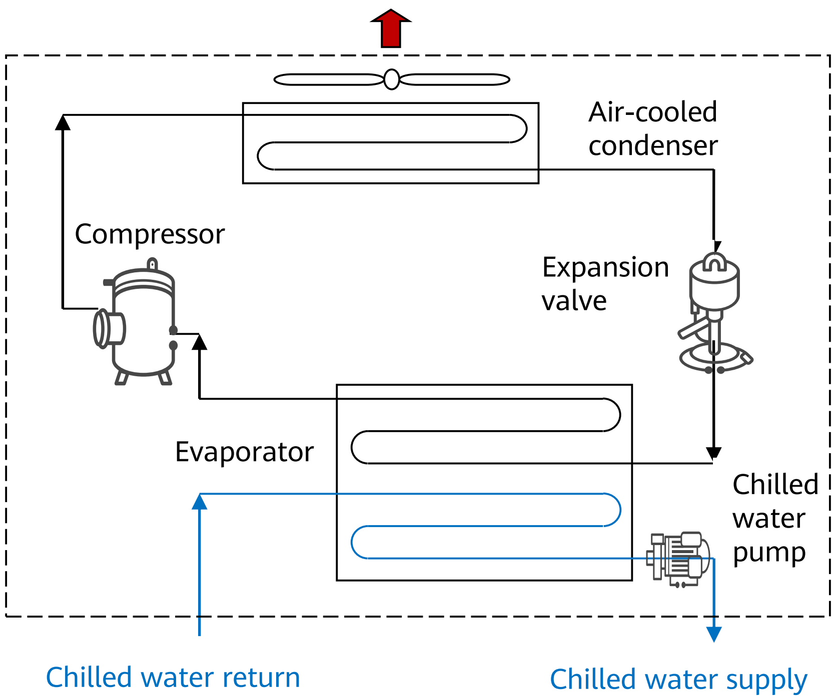
Basic Principles (3)

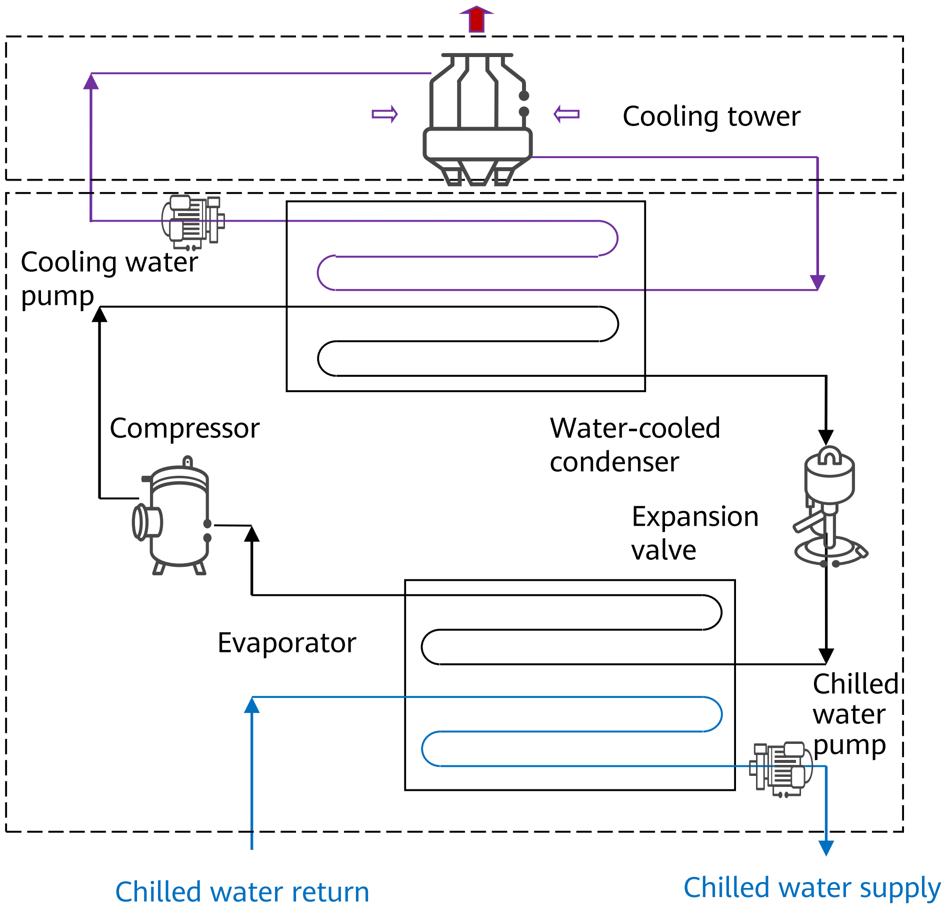
- Water-cooled chilled water
  - Device refrigerant: chilled water
  - Application scenarios: large and medium data centers
  - Characteristics:
    - Centralized cooling and high refrigeration efficiency;
    - Efficient heat transfer/exchanging device used, less cold loss, easy oil returning, and heat pipes not easily cracking;
    - Central air conditioning system used, and a need to consider the problem that chilled water cannot be provided in winter.



Basic Principles (4)

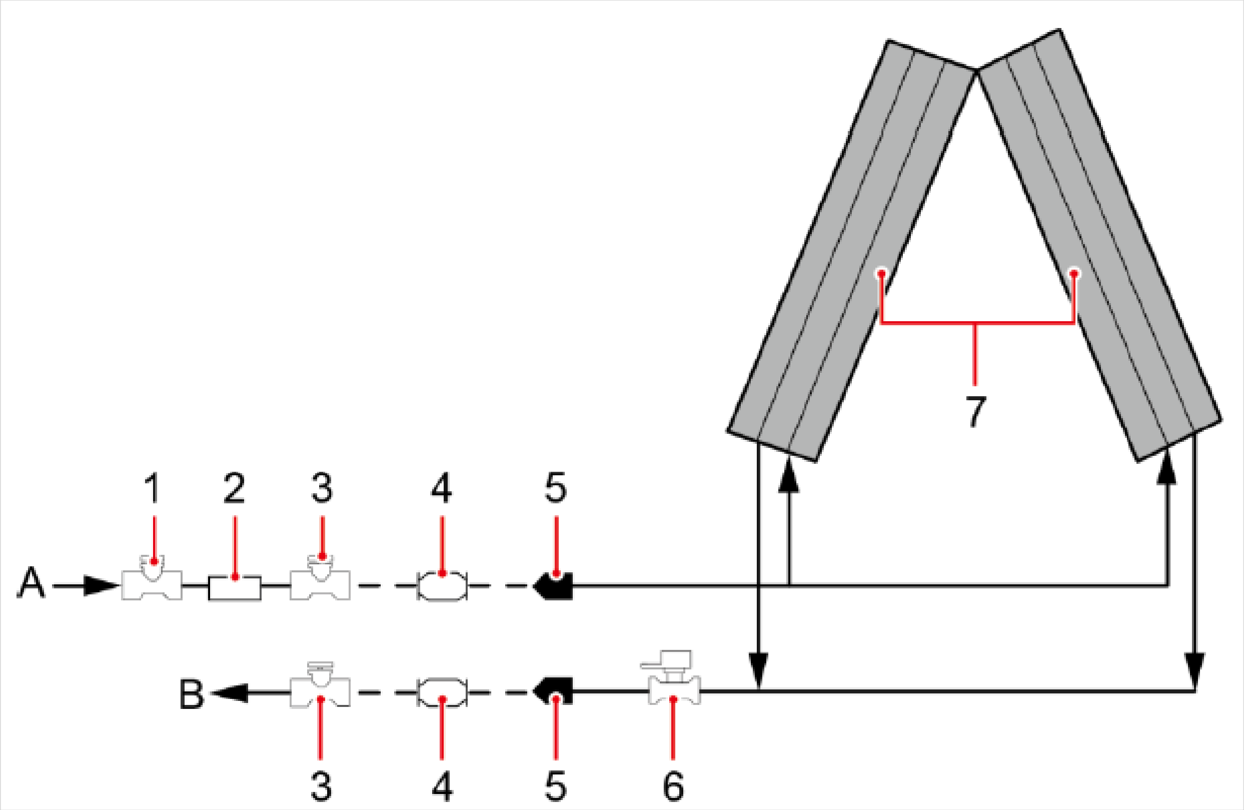
- Condenser types: air-cooled condenser and water-cooled condenser





Contents

Components of a Huawei Chilled Water Air Conditioner



No.	Name
A	Chilled water inlet
B	Chilled water outlet
1	Balance valve or isolation valve
2	Water strainer
3	Isolation valve
4	Soft connection
5	Chilled water inlet and outlet pipe connectors
6	Chilled water valve
7	Heat exchanger

Main Components (1)

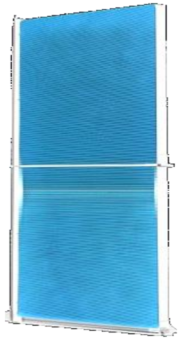
- Main components of refrigerating system
  - Two way valve - The water flow into the air conditioner is adjusted continuously according to the change of the thermal load, and the temperature is accurately controlled;
  - Fan - Accelerating the air flow and improving the heat transfer capability of the heat exchanger;
  - Surface air cooler - A component that controls the indoor temperature and humidity by exchanging heat between chilled water and indoor air.

Actuator

Valve body

Two way valve

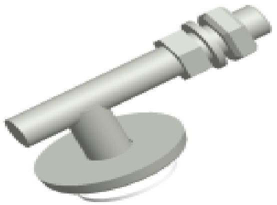
Fan



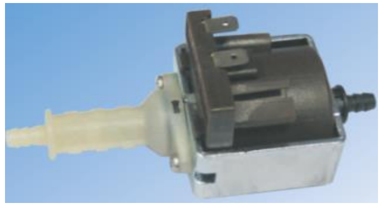
Surface air cooler

Main Components (2)

- Common auxiliary components
  - Power supply unit - Provide stable power supply to the fan;
  - Condensate water pump - Drain condensate water from the system;
  - Float - Used to control condensate water level.
- Other components
  - Water sensor
  - Temperature sensor
  - Air filter
  - Electric heater
  - Electrode humidifier



Float



Condensate water pump

Power supply unit

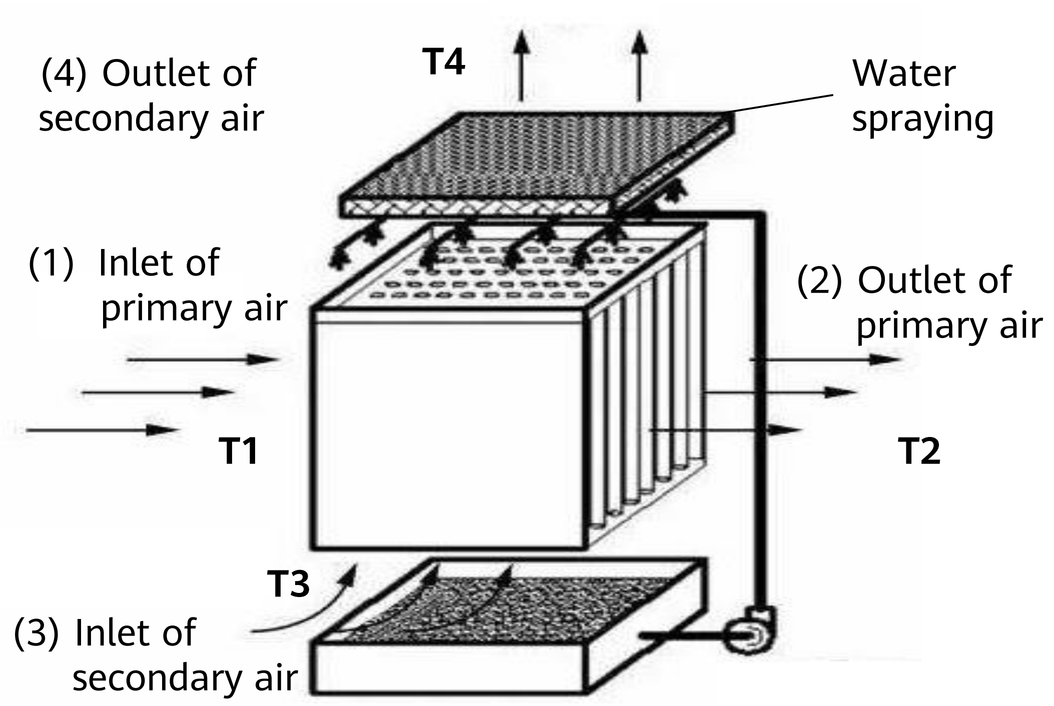
Contents

Basic Principles (1)

- Evaporative cooling principle:
  - In nature, liquids, such as water, absorb heat from the air during evaporation, causing the air temperature to drop. Water evaporates at any temperature and absorbs heat from the air, causing the air temperature to drop. Evaporative cooling is **an isenthalpic process of humidifying and cooling air**.
- Evaporative cooling phenomena:

Basic Principles (2)

- In the indirect evaporative cooling process, the cooled air and water obtained by (direct) evaporative cooling are transferred to the air to be processed through an indirect-contact air-to-air heat exchanger, so as to obtain air with temperature reduced but moisture content unchanged. This is an iso-humid process of cooling air.



Conceptual diagram of an indirect evaporative cooling system

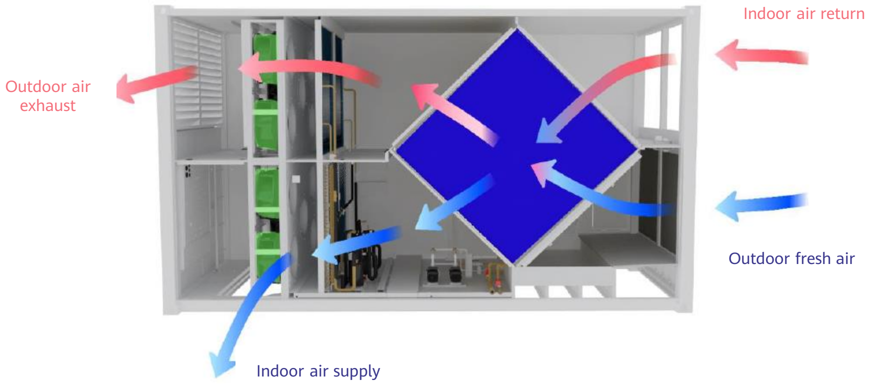
1—2: Iso-humid process of cooling, indirect cooling

3—4: Isenthalpic process of humidifying, direct evaporative cooling

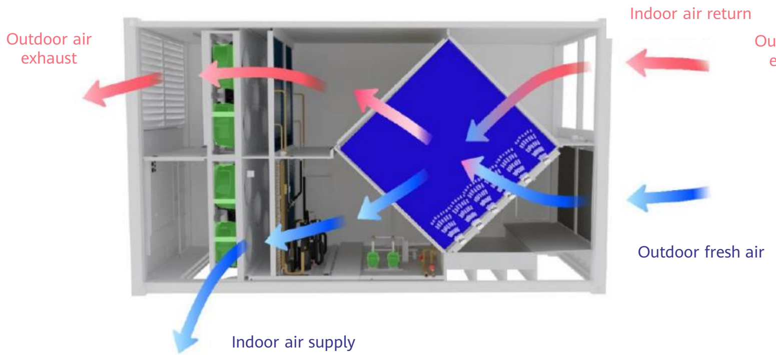
Basic Principles (3)

- Based on the outdoor fresh air temperature and humidity and IT load, an air conditioner works in three modes to implement on-demand cooling.

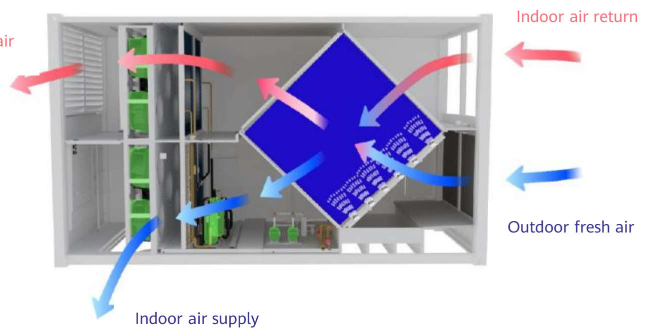
Working Mode	Outdoor Ambient Temperature (100% Load)	Fan	Water Pump	Compressor
Dry mode	Dry bulb temperature ≤ 16°C	ON	OFF	OFF
Wet mode	Dry bulb temperature > 16°C; wet bulb temperature ≤ 19°C	ON	ON	OFF
Hybrid cooling mode	Wet bulb temperature > 19°C	ON	ON	ON



Dry mode



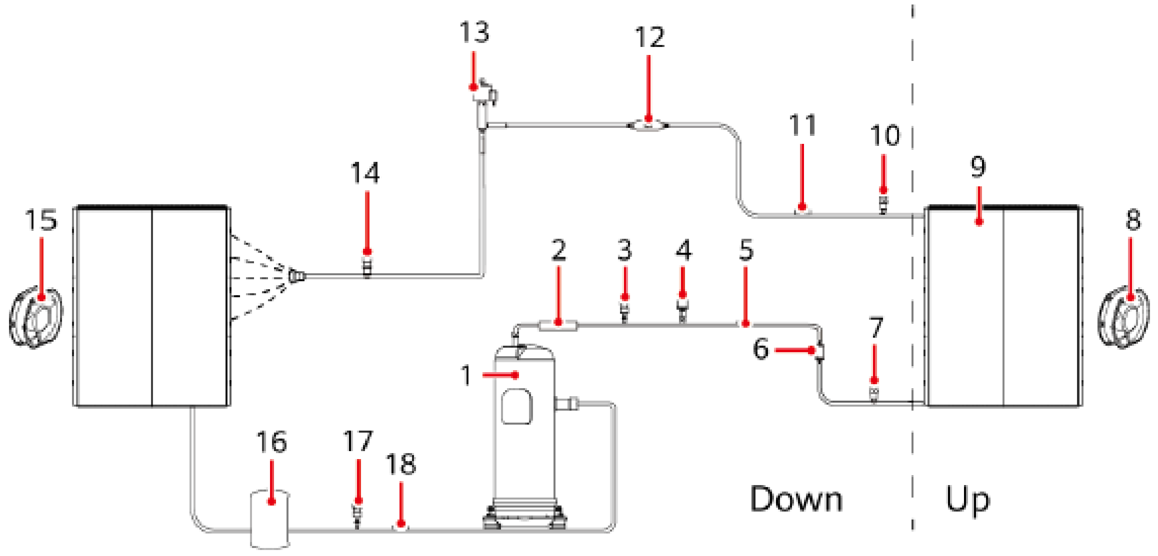
Wet mode



Hybrid cooling mode

Contents

Components of a Huawei Indirect Evaporative Cooling Air Conditioner



No.	Name
1	Compressor
2	Shock-absorbing corrugated pipe
3	High pressure sensor
4	High pressure switch
5	Discharge temperature sensor
6	One-way valve
7	Exhaust pipe needle valve
8	Exhaust fan
9	Heat exchanger

No.	Name
10	Liquid pipe needle valve
11	Liquid pipe temperature sensor
12	Strainer
13	EEV
14	Low pressure needle valve
15	Indoor fan
16	Gas-liquid separator
17	Low pressure sensor
18	Suction temperature sensor

Components

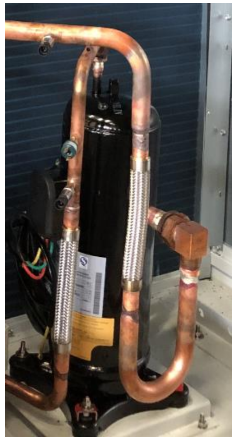
- Heat exchanger core: cross-flow heat exchanger, improving heat exchange efficiency
- Fan: accelerates air flow and improves the heat exchange capability.
- Nozzle: ensures the spray pressure and improves the spray effect.
- Water tank: stores water and provides spray water for a certain period of time.
- Shock-absorbing pipe: reduces pipe vibration to prevent pipe cracks during transportation and operation, improving the unit reliability.
- Differential pressure switch: detects the differential pressure between the front and rear of the internal circulation air filter to determine whether the air filter is dirty or blocked.


Heat exchanger core


Fan


Nozzle


Water tank

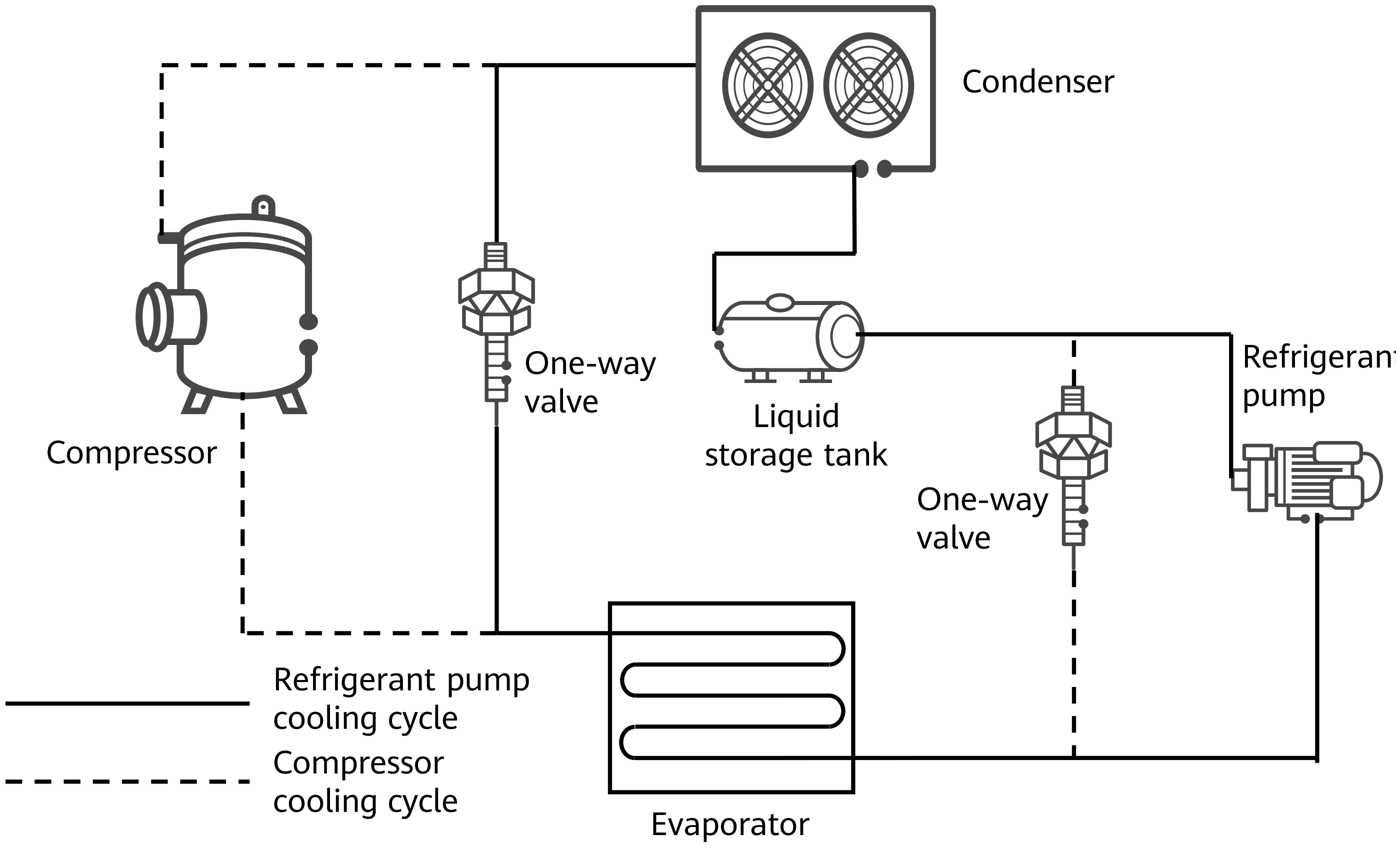

Shock-absorbing pipe


Differential pressure switch

Contents

Refrigerant Pump Cooling Technology

- When the outdoor temperature is higher than 20° C, the conventional mechanical cooling solution is adopted. The compressor works properly and the refrigerant pump does not work.
- When the outdoor temperature is lower than 10° C, the compressor stops and the refrigerant pump starts cooling.
- When the outdoor temperature is greater than or equal to 10° C and less than or equal to 20° C, the refrigerant pump and compressor start cooling at the same time, enabling the hybrid cooling mode to save energy.

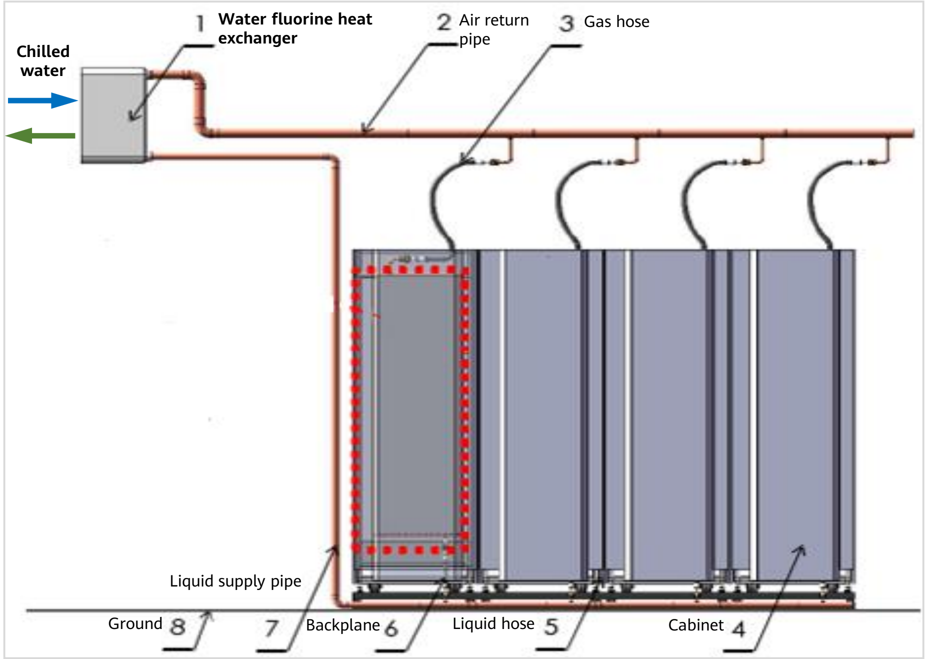


Fan Wall Cooling Technology

- The fan wall technology is an energy-saving technology that uses free cooling sources. Based on the indoor and outdoor temperature difference, the outdoor cold air is taken into the equipment room to absorb heat through the process of air intake, pre-processing, fan wall, air exhaust, and air return. In this way, partial or complete free cooling without mechanical cooling is implemented for the equipment room, which saves energy.
- The fan wall technology, with multiple small fans arranged in order, replaces a single large fan in a conventional air handler, so that airflow organization is more even and fan energy consumption is lower.

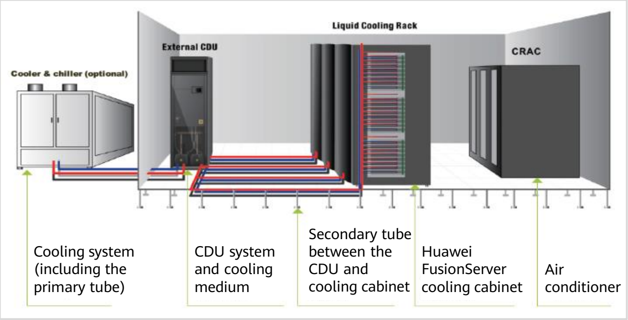
Backplane Heat Pipe Air Conditioner

- The cooling unit is distributed to the cabinet backplane in the internal area. Based on the heat pipe principle, the liquid working medium absorbs heat at the cabinet backplane in the indoor area and evaporates to gas, which rises to the outdoor condenser. After condensation, the gas working medium releases heat to the outdoor environment and becomes liquid, which flows back to the indoor environment under gravity. In this way, the indoor heat is transferred to the outdoor environment to complete the cooling cycle.



Liquid Cooling Technology

- Cold plate liquid cooling
  - An LDU is configured on the liquid cooling cabinet to provide water inlet and outlet pipes. The LDU is connected to the internal cold plate pipes in the liquid-cooled compute nodes to implement liquid cooling circulation in the compute nodes.
- Immersion liquid cooling
  - Specific coolant is used as the heat dissipation medium. Immerse IT equipment in the coolant to take away heat through coolant circulation.
- Spray liquid cooling
  - Insulated non-corrosive coolant is sprayed onto the surface of a heating device (or the extended surface in contact with the heating device) through the spray plate on the server box for heat exchange.



Contents

Huawei Precision Air Conditioner Series

NetCol5000-C

NetCol5000-C030
NetCol5000-C065

NetCol5000-A

NetCol5000-A011
NetCol5000-A020

NetCol5000-A025
NetCol5000-A035
NetCol5000-A042
NetCol5000-A050

- In-row precision air conditioner (11–65 kW)

NetCol8000-C

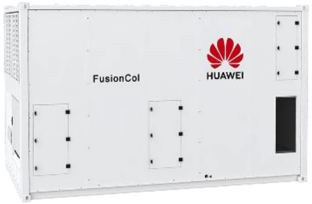
NetCol8000-C(070-260)
NetCol8000-C(070, 130, 190)
NetCol8000-C(050–150)

NetCol8000-A

NetCol8000-A(045, 090)
NetCol8000-A(050, 100)

- In-room precision air conditioner (45–260 kW)

NetCol8000-E



NetCol8000-E220

- Indirect evaporative cooling air conditioner (220 kW)

Huawei Outdoor Unit Series

- Main functions
  - The outdoor unit controls the fan speed based on the condensing pressure to implement variable frequency speed control.
  - The outdoor unit provides protection against overheating for fans.
  - The driver provides a screen manipulator for keys and nixie tubes to meet commissioning requirements.
  - Indoor and outdoor units are connected using signal cables. The outdoor unit is started or shut down as instructed by the indoor unit.

Single-fan NetCol500

NetCol500-A026
NetCol500-A032
NetCol500-A036
NetCol500-A038

Dual-fan NetCol500

NetCol500-A072
NetCol500-A088

Quiz

1. (Single)Which of the following is not one of the four major components of an air-cooled air conditioner?
   - A. Compressor
   - B. Evaporator
   - C. Fan
   - D. Condenser
2. (Multiple)Which of the following are the performance features of an air conditioner in an equipment room?
   - A. Small air volume and large enthalpy difference
   - B. Cooling throughout the year
   - C. High reliability
   - D. Various air supply modes

Quiz

3. (Single)When the indirect evaporative cooling system works in dry mode, there is an iso-humid process of cooling.

   A. True

   B. False

Summary

- Overview of Data Center Air Conditioners
- Air-Cooled Precision Air Conditioner
- Chilled Water Precision Air Conditioner
- Indirect Evaporative Cooling Air Conditioner
- Other Cooling Solutions for Equipment Rooms
- Introduction to Huawei Air Conditioners

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise：http://support.huawei.com/enterprise/
  - Online Learning：http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

HUAWEI

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

HUAWEI

Basic Knowledge of Monitoring Systems

Foreword

- This chapter describes basic knowledge about the monitoring system, including interfaces and common protocols of the monitoring system and data center infrastructure monitoring modes.

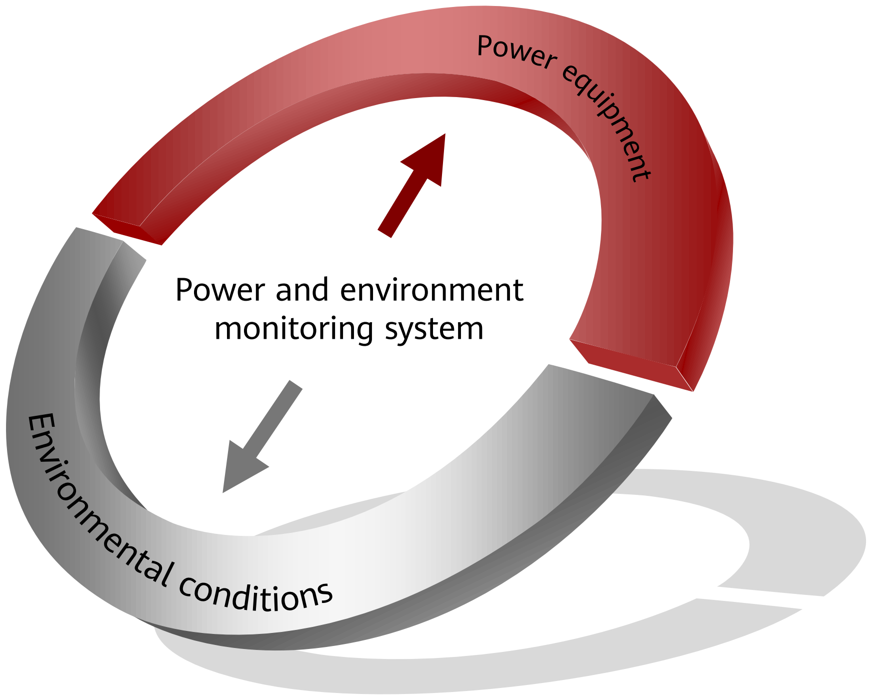
Objectives

Upon completion of this course, you will be able to:

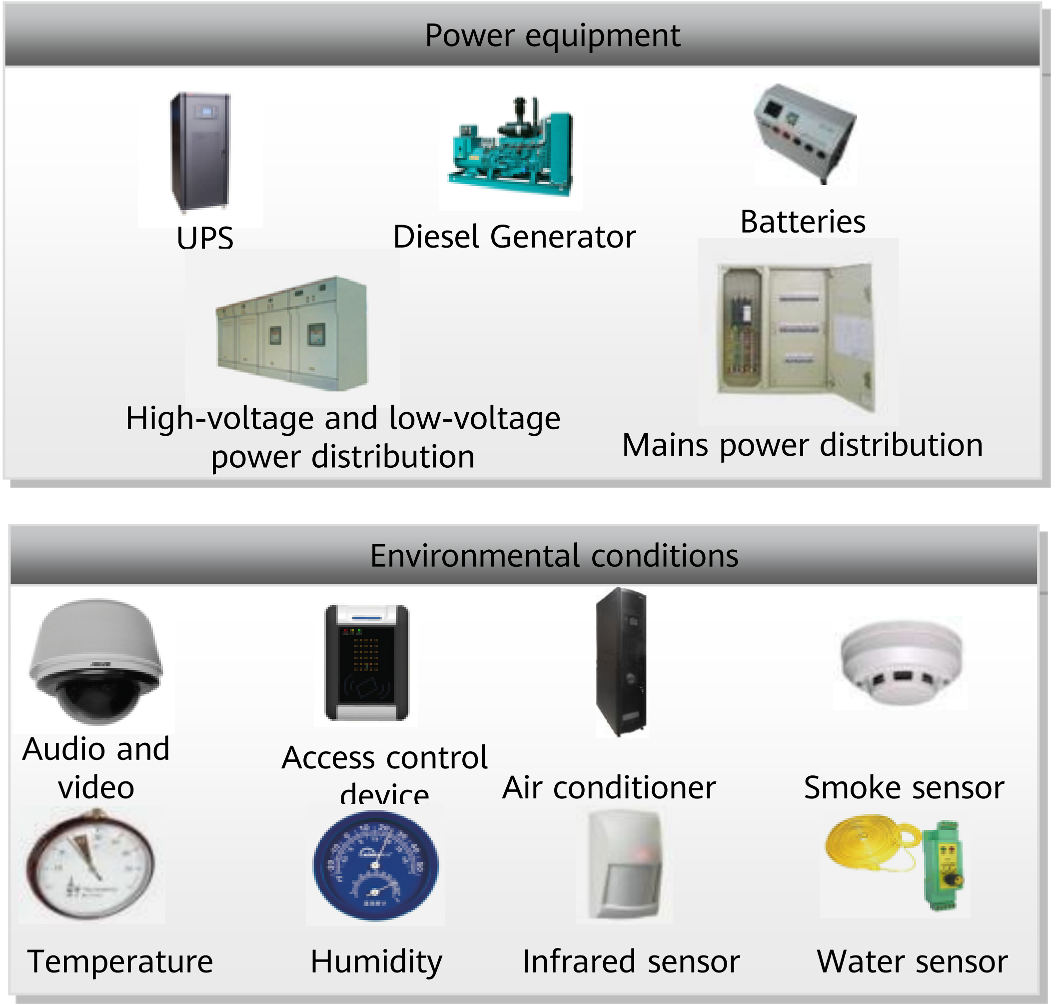
- Describe basic interfaces and communication protocols.
- Describe the overall architecture of the monitoring system.

Contents

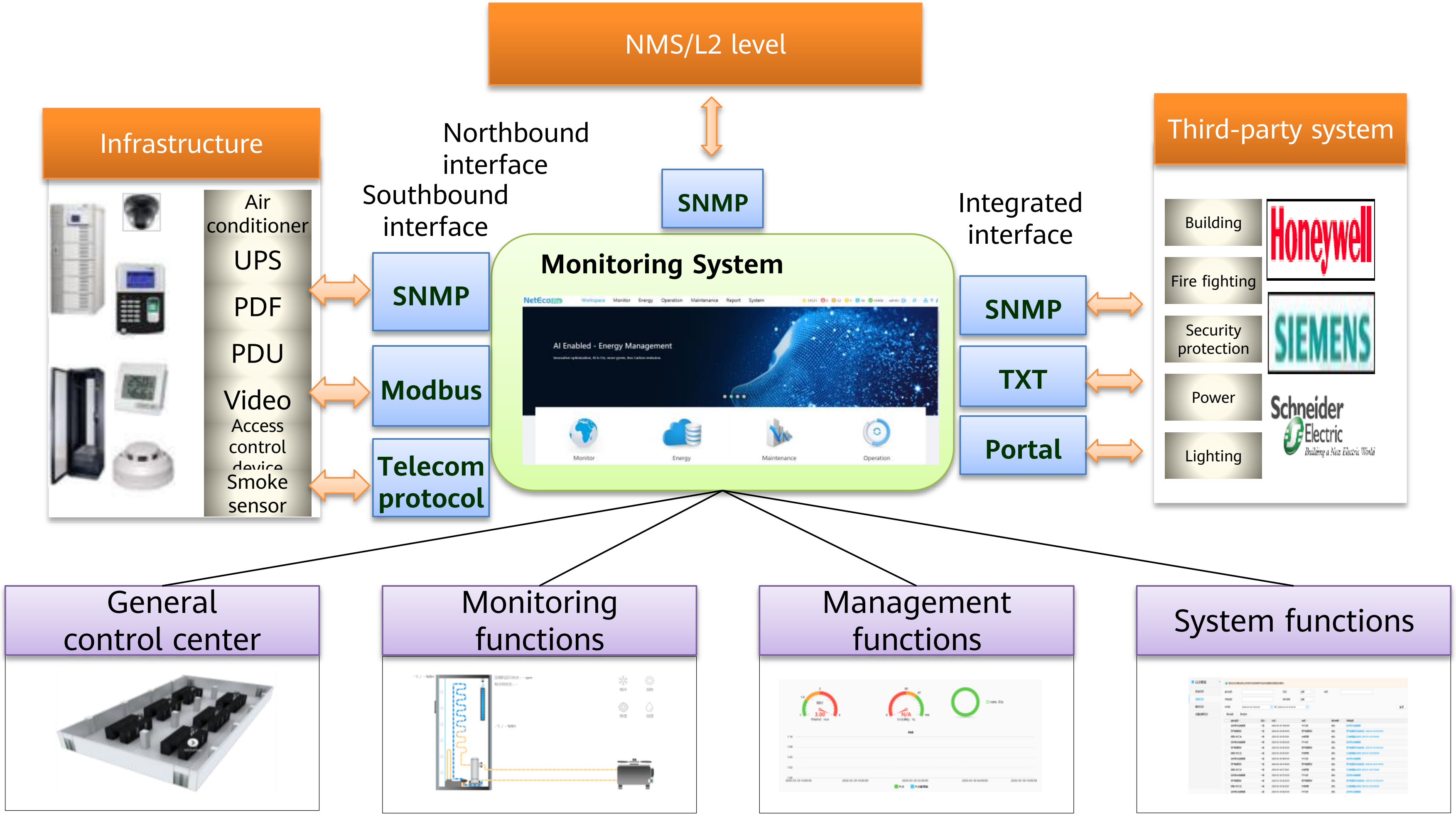
What is Power and Environment Monitoring System



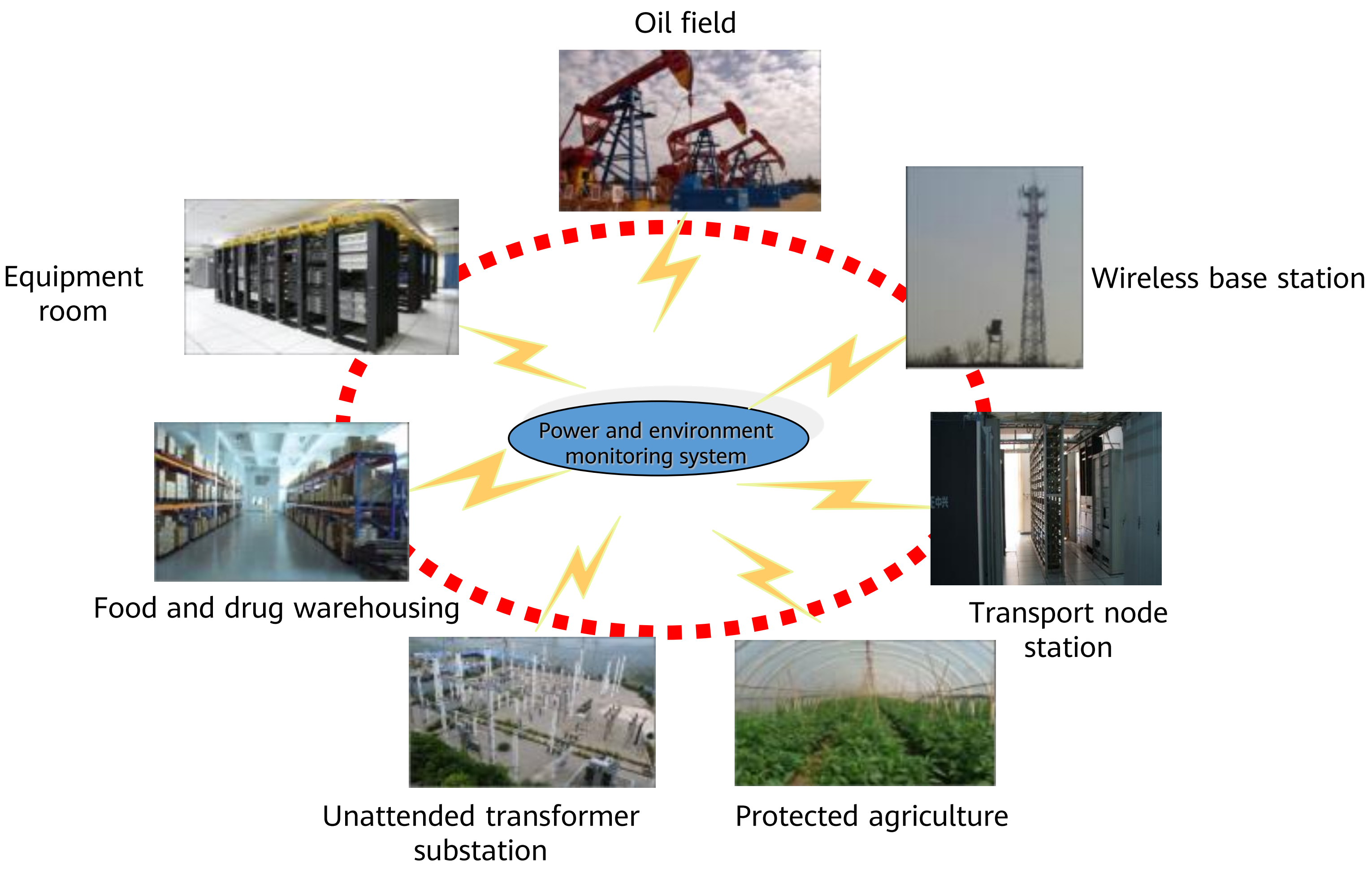
The power and environment monitoring system is the short name of the power and environment centralized monitoring system.



Overview of the Monitoring System



Application Scenarios of the Monitoring System

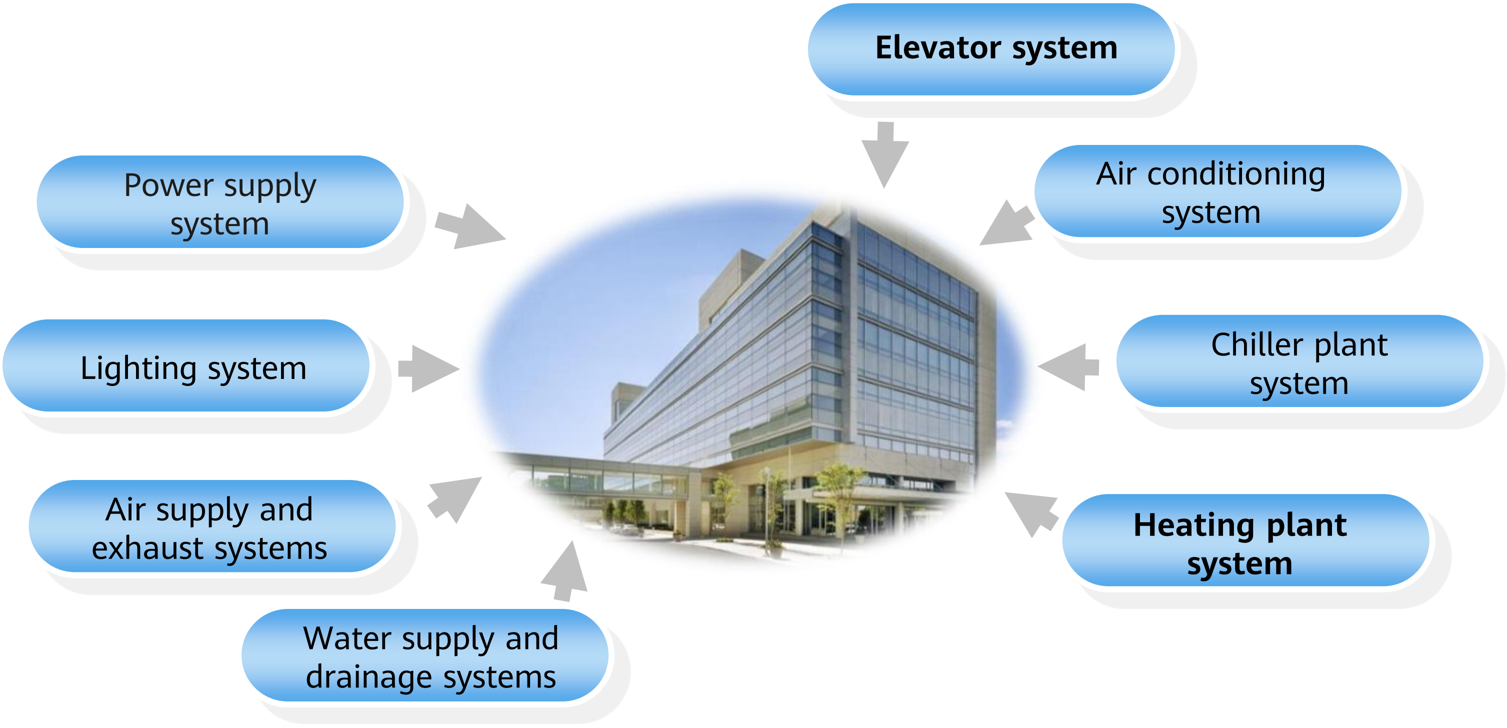


Development Trend

- With the development of technologies, data center staff want to reduce inspection times of on-duty staff, reduce the workload of data center maintenance and management staff, and improve system stability by monitoring system equipment and environment.
  - Unified monitoring: The monitoring system of equipment rooms is integrated with enterprise IT operation and maintenance (O&M) management systems (such as systems of service monitoring, server monitoring, and network monitoring) to form a complete management system.
  - AI energy conservation: drives data center energy efficiency diagnosis and optimization to continuously reduce energy consumption. It saves energy by monitoring and managing IT equipment chips and site environment.
  - Mobile inspection technology: Scheduled inspection of equipment rooms is one of the most important routine O&M tasks of a data center. Mobile inspection reduces the workload of staff and improves the accuracy of inspection data.
  - Fiber grating temperature measurement technology: An electrical equipment failure can cause insulation performance deterioration or even breakdown, damaging the equipment. Common measurement methods cannot accurately monitor the equipment operating temperature online. Fibers can overcome this difficulty and ensure equipment security.

Intelligent Building Monitoring System

- The main functions of the intelligent building monitoring system are integrated monitoring, linkage, and management of the systems under real-time monitoring system in a building.
- The intelligent building monitoring system focuses on the overall management of a building, and the power and environment monitoring system focuses on the management of in-house equipment.



Contents

Basic Concepts

- Interface: connection mode between two hardware devices.
- Protocol: a group of conventions that both parties involved in communication must observe, for example, how to establish a connection and how to identify each other. Both parties can communicate with each other only after they observe the conventions.
- For example, mouse and USB drive are devices that use USB ports. These devices must comply with USB port specifications before they can be used over USB ports.

Basic Concepts

- Common interface types
  - DB9, RJ45, and cord end terminal.
- Transmission modes
  - RS232, RS485, RS422, and FE.
- Protocol Type
  - SNMP, Modbus, telecom protocol, OPC, and other protocols.

Contents

Comparison of Common Protocols

Protocol Type	Feature	Transmission Mode	Category	Applicable Scope	Advantage	Disadvantage
Modbus	Field bus protocol, master/slave mode	Serial transmission, supporting loading of RS232/RS485/RS422	ModBus-RTU ModBus-ASC ModBus-TCP	Air conditioners, UPSs, ammeters, humidifiers, PDUs, and controllers	Standard and open, supporting multiple electrical interfaces; the frame format is simple and easy to use.	Master/slave mode, providing low efficiency
SNMP	Network management protocol	Used on TCP/IP networks in UDP mode.	SNMPV1.0 SNMPV2.0 SNMPV3.0	Air conditioners, UPSs, and PDUs	Complying with the OSI model, open protocol, and implementing management relying on network; the protocol is widely used; security is high.	The number of devices is large and the efficiency of query among much data is low; processing is complex.
Telecom protocol	Field bus protocol, master/slave mode	Serial transmission, supporting loading of RS232/RS485/RS422	Frontend intelligent monitoring equipment communication protocol for power supply, air conditioners, and integrated environment management system of telecommunication offices (sites)	Based station air conditioners and base station power supply	Open protocol, supporting multiple electrical interfaces	The format is complex and the protocol is not universal.

Comparison of Common Transmission Modes and Interfaces

Transmission Mode	Number of Pins	Electrical Characteristic	Transmission Mode	Transmission Distance	Transmission Rate	Advantage	Disadvantage
RS232	Standard 25-pin, common 3-pin	±15 V	Full duplex, single point	15 m	20 K	It is easy to obtain tools.	The distance is limited, networking is unavailable, and the transmission mode is susceptible to interference.
RS485	Standard 4-pin and 2-pin, common 2-pin	TTL (±2 to ±6)	Half duplex, master/slave	1200 m	10 M	2-pin interfaces are widely used, networking is convenient, and the anti-interference capability is provided.	The distance is large and resistance must be matched at a high rate.
RS422	Standard 4-pin	TTL (±2 to ±6)	Half duplex, master/slave	1200 m	10 M	The anti-interference capability is provided and networking is available.	The distance is large and resistance must be matched at a high rate. The number of slave nodes is 10, which is smaller than that of RS485. The number of cores is greater than that of RS485.
FE	Standard 8-pin	TTL	Full duplex, multi-master	100 m	10 M	The transmission rate is high, the efficiency is high, and flexible networking is provided.	The networking cost is high.

Common interface forms:

DB9

DB25

Crimp terminal

RJ45

RJ12

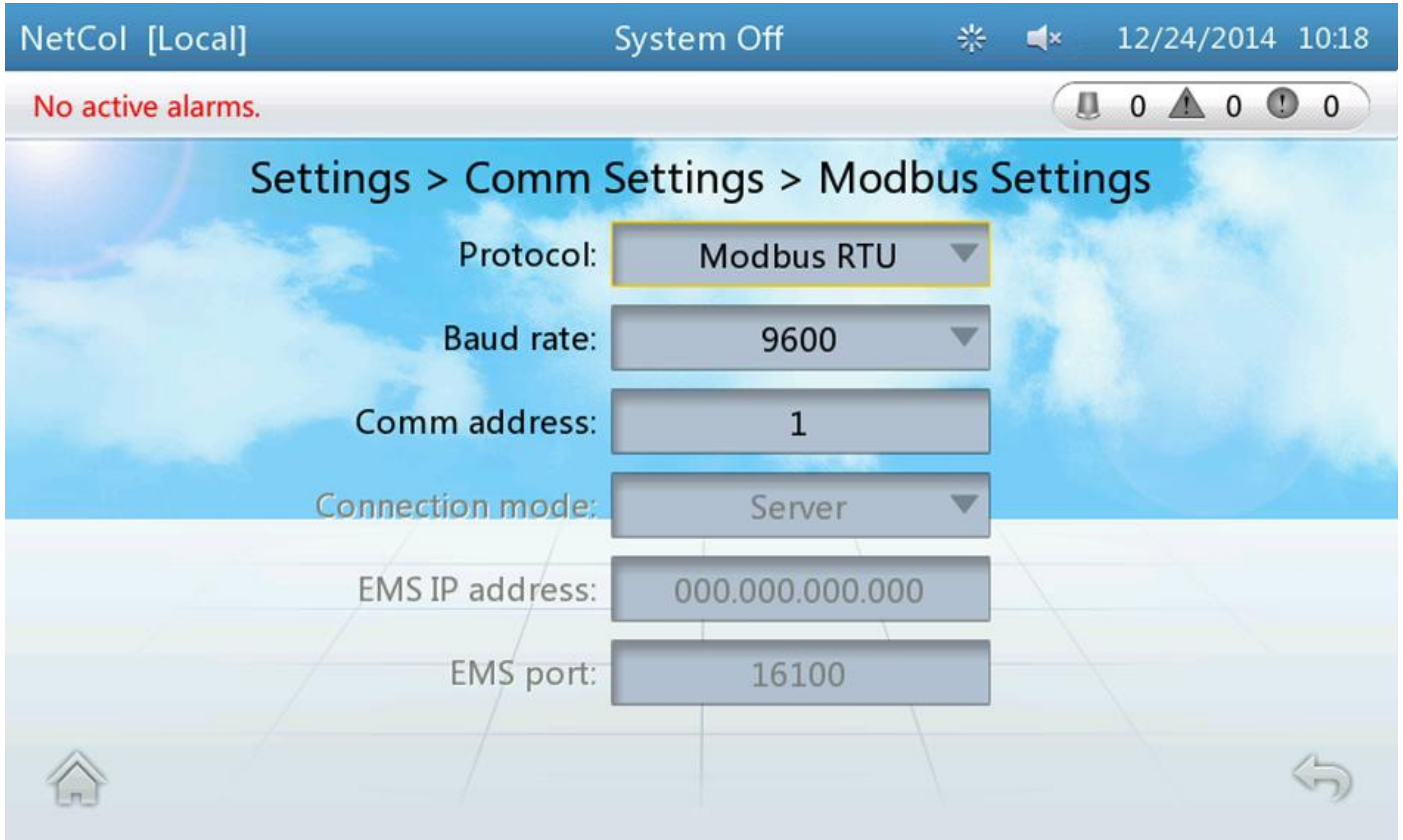
Contents

Parameter Settings - SNMP

- SNMP

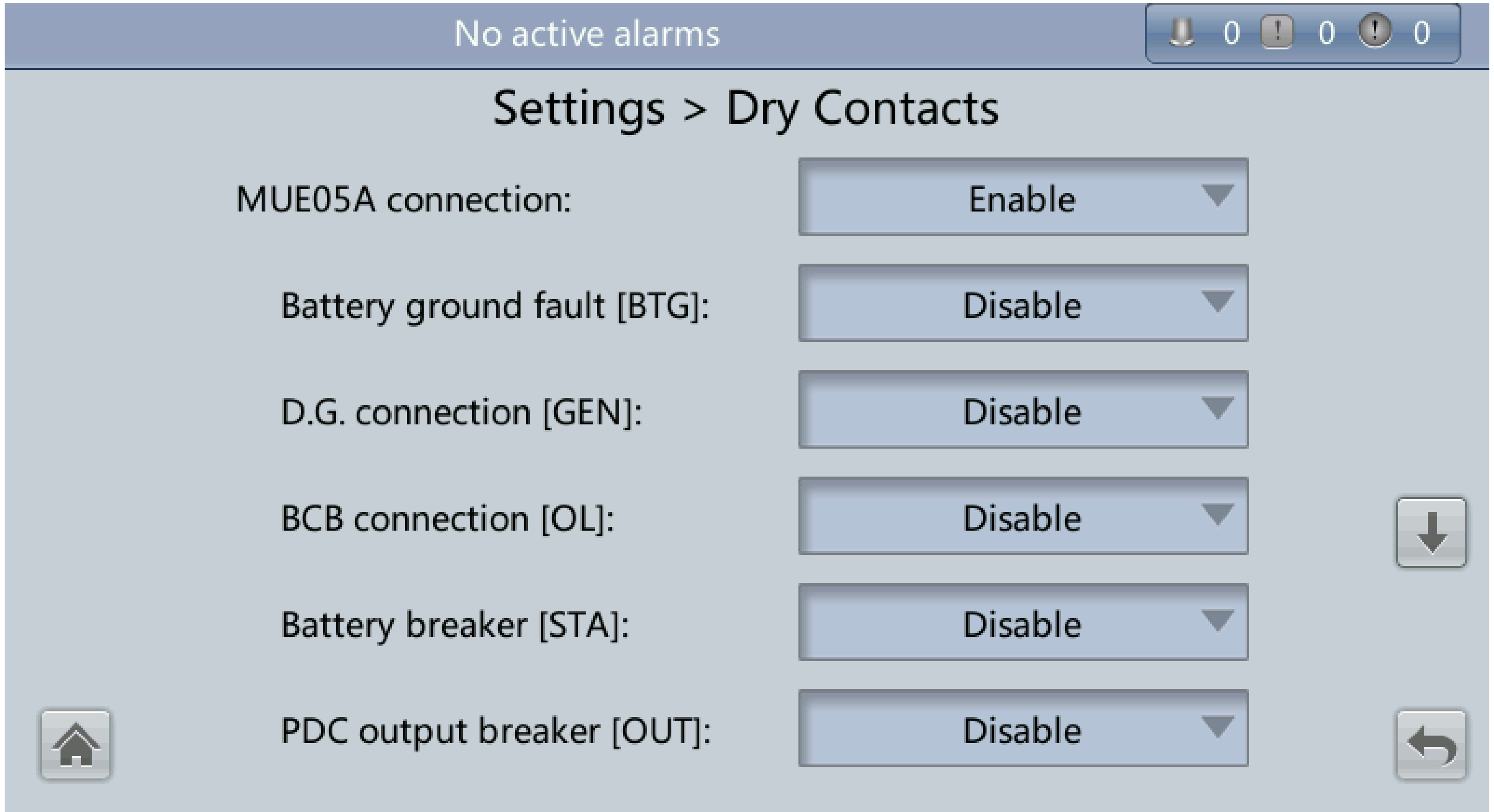
Parameter Settings - Modbus

- Modbus



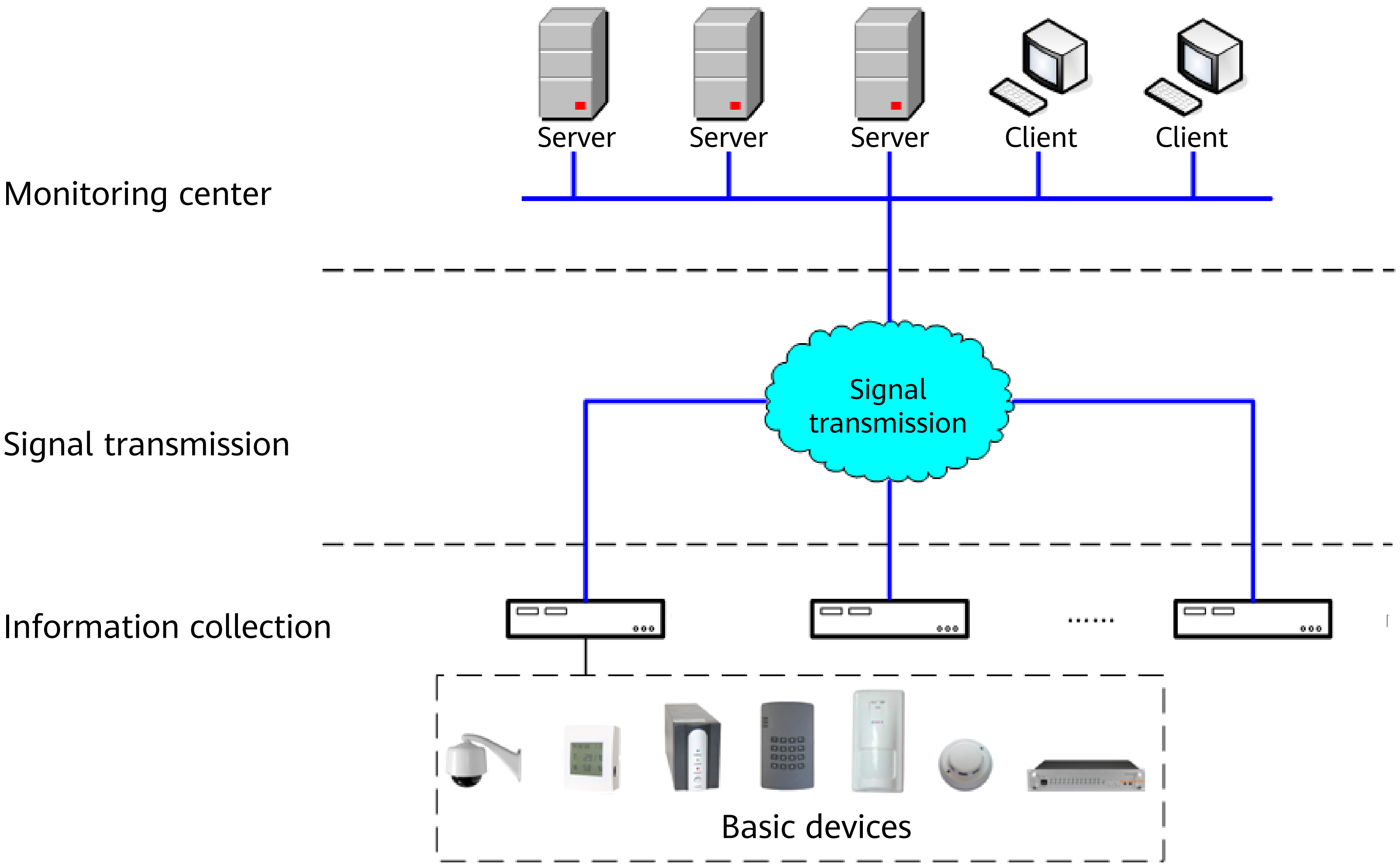
Parameter Settings - Dry Contact

- Dry contact

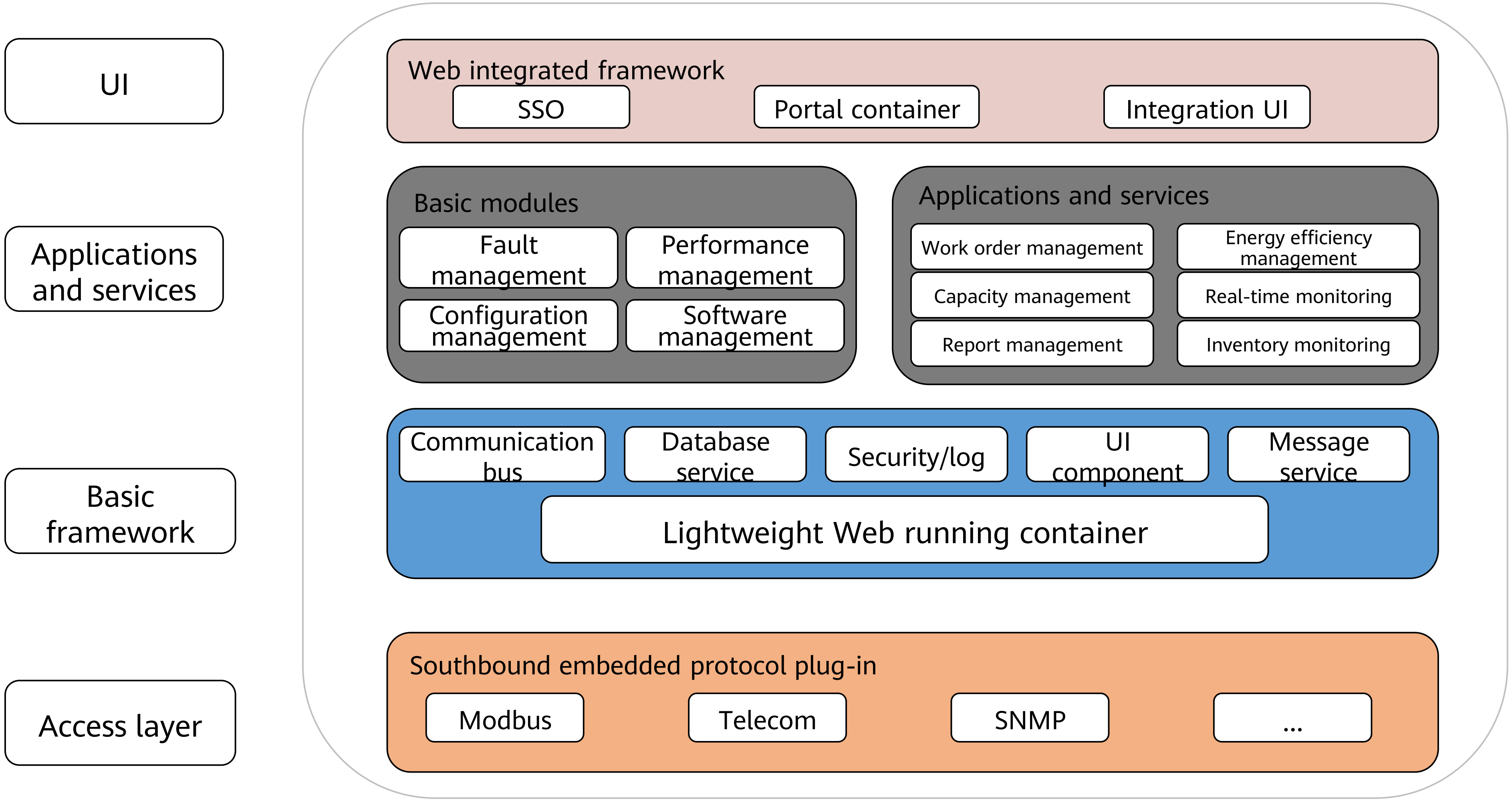


Contents

Composition of Hardware Devices



Software Architecture



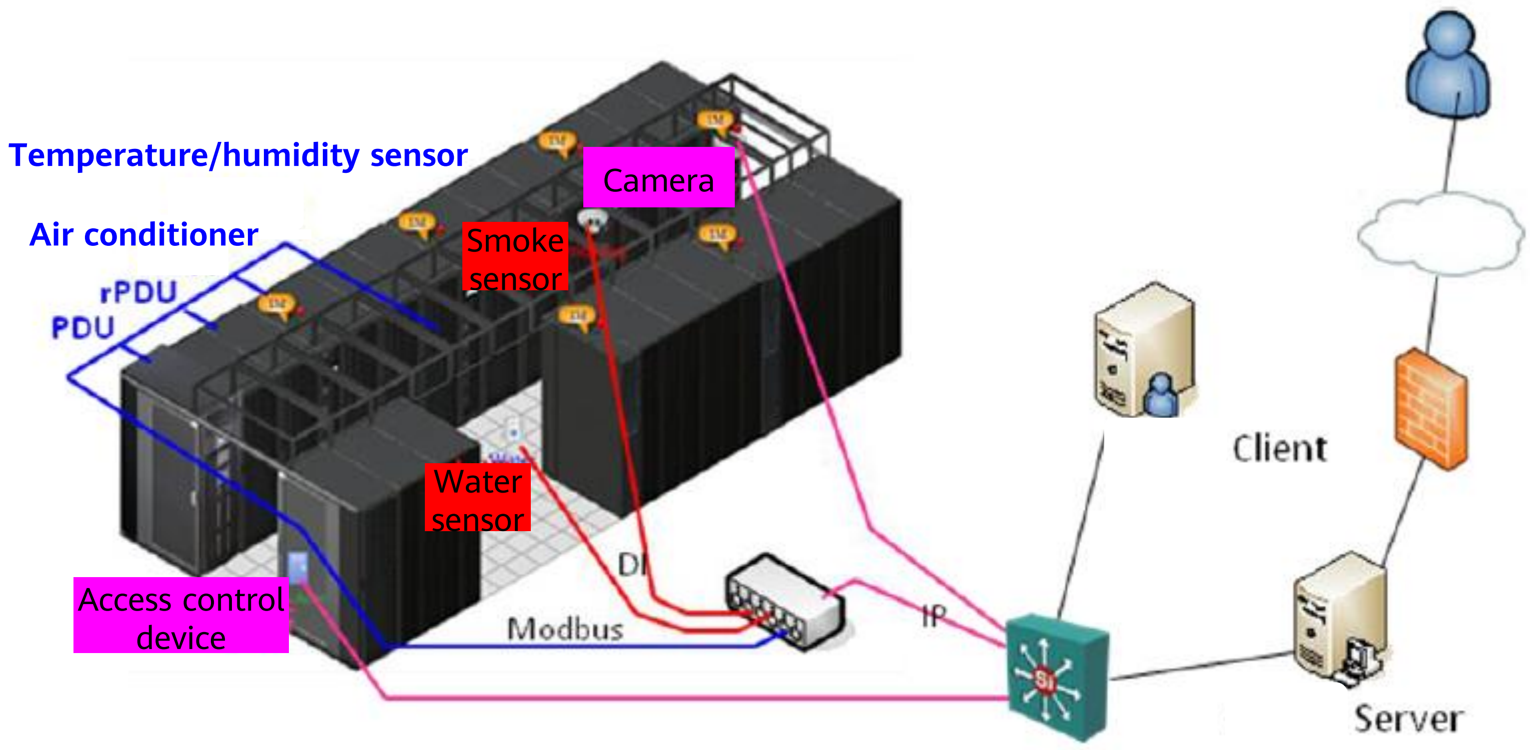
Contents

Data Center Application Scenario

- The monitoring system helps users quickly locate faults by monitoring infrastructure of the data center, supports centralized configuration and status monitoring for basic devices in the data center, and implements remote refined management for the data center.
- The monitoring system can be deployed in medium and large modular data centers, small modular data centers, and container data centers.

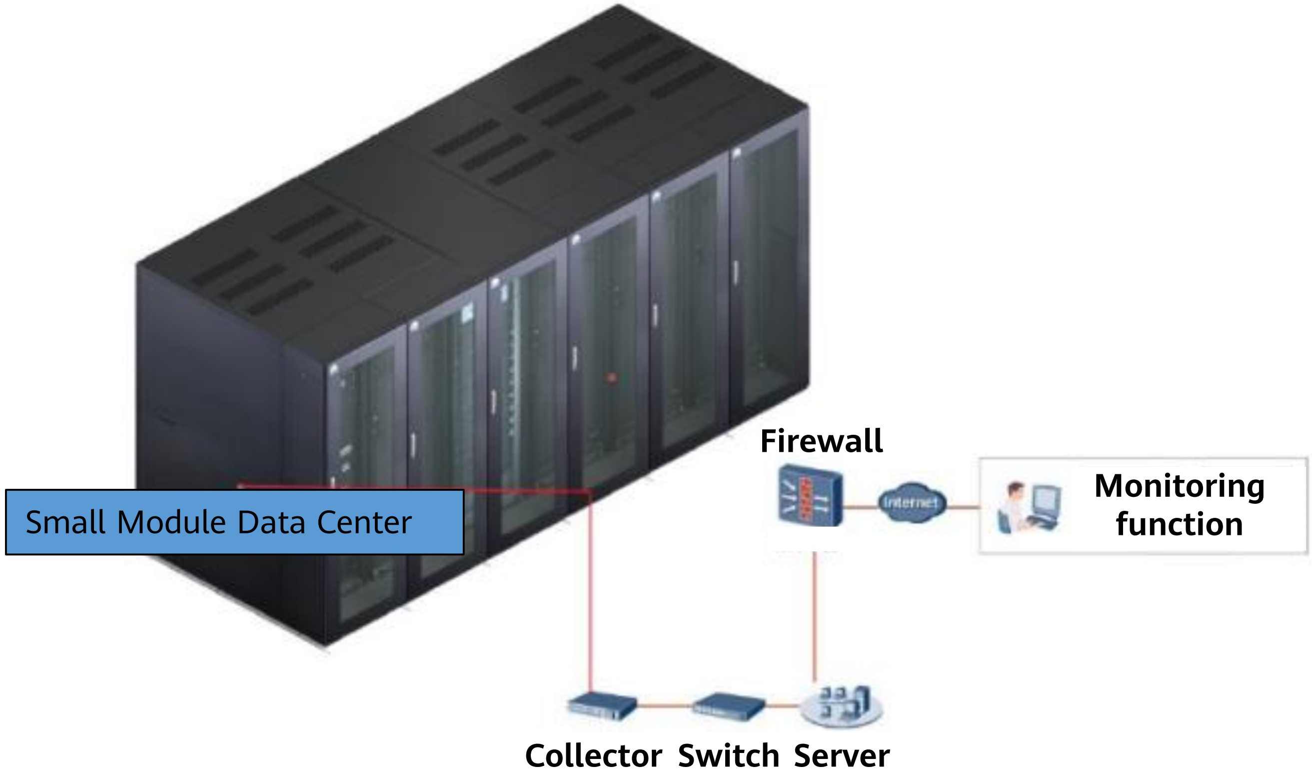
Medium and Large Modular Data Centers

- Medium and large modular data centers are a series of complete data center solutions. The solutions are applicable to quick deployment of medium and large data centers of operators and large corporate customers.

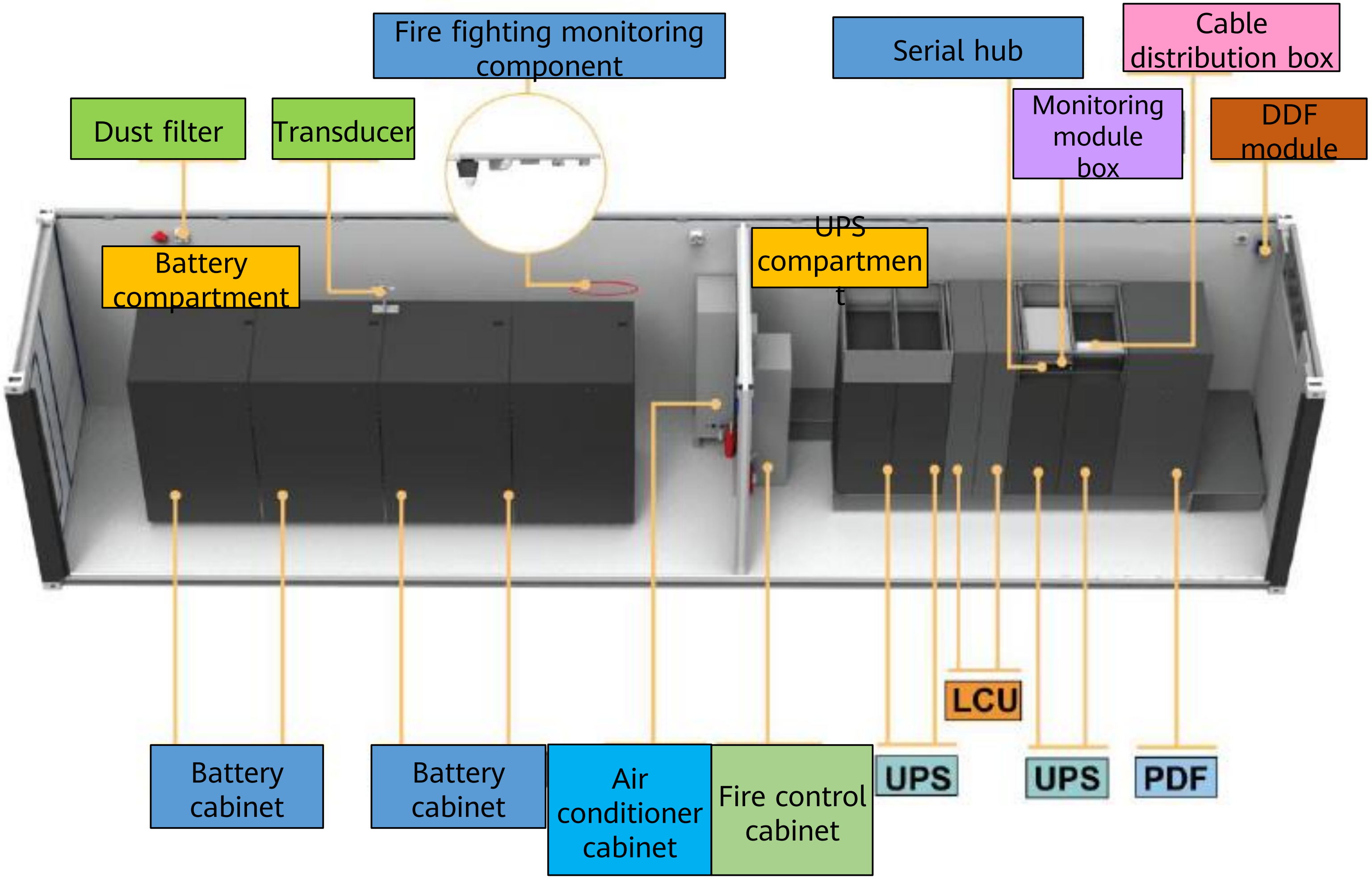


Small Modular Data Centers

- Small modular data centers are mainly used in cloud hosts in parks, branches of large enterprises, small and medium enterprises, e-government networks, education, healthcare, and data equipment rooms of financial branches.

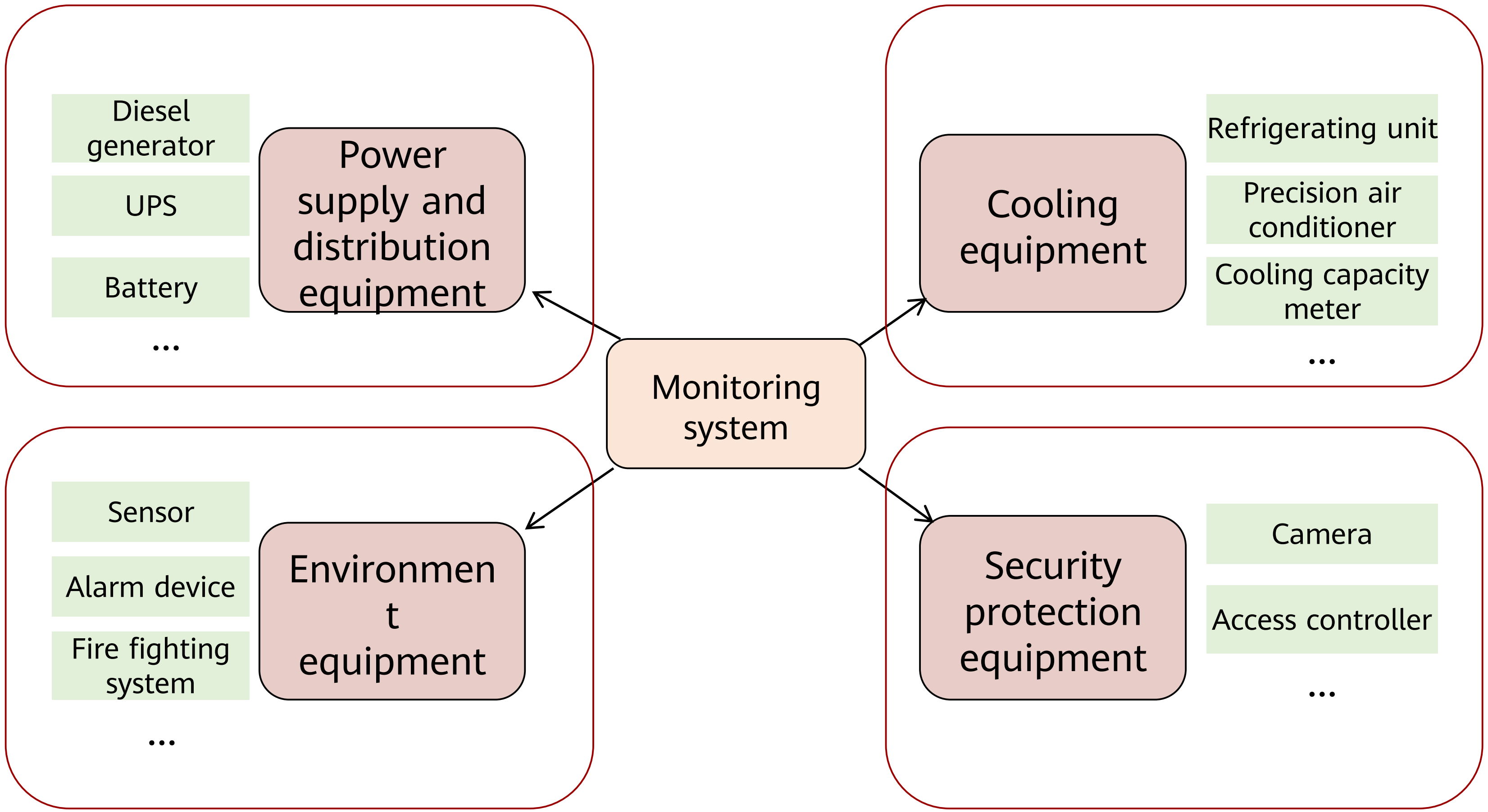


Container data center



Contents

Subsystem Monitoring



Subsystem Monitoring Implementation Mode (1)

Power supply and distribution equipment

<table>
<tr><th>Device Name</th><th>Object Monitored by NetEco</th><th>Monitoring Implementation Mode</th></tr>
<tr><td>Diesel generator</td><td rowspan="8">Operating status, operation parameters, alarms, and remote management;
operation parameters of remote management provided by protocols for various devices.</td><td rowspan="8">Based on different interfaces provided by the devices, the solution provides two network connection modes.
1. Devices supporting Modbus or Telcom protocol are connected to the serial server or monitoring system collector that provides transparent transmission capability over RS485.
2. Devices supporting SNMP are connected to the monitoring system over the FE interface.</td></tr>
<tr><td>ATS and STS</td></tr>
<tr><td>UPS</td></tr>
<tr><td>Battery and battery cabinet</td></tr>
<tr><td>UPS output cabinet</td></tr>
<tr><td>PDU</td></tr>
<tr><td>PDB</td></tr>
<tr><td>RPDU</td></tr>
</table>

Subsystem Monitoring Implementation Mode (2)

Refrigerating equipment

<table>
<tr><th>Device Name</th><th>Object Monitored by NetEco</th><th>Monitoring Implementation Mode</th></tr>
<tr><td>Refrigerating unit</td><td rowspan="5">Operating status, operation parameters, alarms, and remote management; operation parameters of remote management provided by protocols for various devices.</td><td rowspan="5">Based on different interfaces provided by the devices, the solution provides two network connection modes.
1. Devices supporting Modbus or Telcom protocol are connected to the serial server or collector that provides transparent transmission capability over RS485.
2. Devices supporting SNMP are connected to the monitoring system over the FE interface.</td></tr>
<tr><td>Precision air conditioner</td></tr>
<tr><td>Cooling capacity table</td></tr>
<tr><td>In-row air conditioner</td></tr>
<tr><td>Humidifier</td></tr>
</table>

Subsystem Monitoring Implementation Mode (3)

Environment equipment

Device Name	Object Monitored by NetEco	Monitoring Implementation Mode
Smoke sensor	Monitor the smoke concentration in an equipment room or module.	The smoke sensor is connected to the collector over the DI interface.
Temperature / humidity sensor	Monitor temperature and humidity in an equipment room or module.	The temperature and humidity sensor is connected to the collector over the RS485 interface.
Water sensor	Monitor liquid leakage in an equipment room or module.	The water sensor is connected to the collector over the DI interface.
Audible and visual alarm device	When an alarm is generated in an equipment room or module, the audible and visual alarm device in the equipment room or module produces sound or light, prompting the user to handle the alarm.	the collector over the skylight controller.

Subsystem Monitoring Implementation Mode (4)

Environment equipment

Device Name	Object Monitored by NetEco	Monitoring Implementation Mode
Hydrogen detection system	Monitor whether hydrogen exists in an equipment room or module and prevent safety accidents such as fire due to high concentration of hydrogen.	The hydrogen detection system is connected to the collector through dry contacts.
Fire fighting system	Control fire extinguishing equipment in an equipment room to put out fire.	The fire fighting system is connected to the collector through dry contacts.

Subsystem Monitoring Implementation Mode (5)

Security protection equipment

Device Name	Object Monitored by NetEco	Monitoring Implementation Mode
Camera	Real-time situation in an equipment room or module.	Cameras of the standard configurations are directly connected to a switch over the FE interface and are supplied with power in POE mode to view video information in real time.
NVR	Configure and manage cameras.	The NVR is used to store HD images and provide large-scale storage medium to store videos on a long-term basis. The videos are stored in different files based on time segment.
Equipment room access controller	Control and manage card readers.	Equipment room access controllers are connected to the monitoring system over the FE interface.

Quiz

1. (Short Answer Question)What are differences between SNMP and Modbus?
2. (Short Answer Question)Which scenarios can the power and environment monitoring system be used in?

Summary

- Basic Interfaces and Communication Protocols
- Subsystem Monitoring of Data Centers
- Technical Indicators and Environment Standards

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise： http://support.huawei.com/enterprise/
  - Online Learning： http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

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每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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Functions and Features of Monitoring Systems

Foreword

- This slides describe the main features and functions of the monitoring system, including the general control center and monitoring function, management function, and system function.

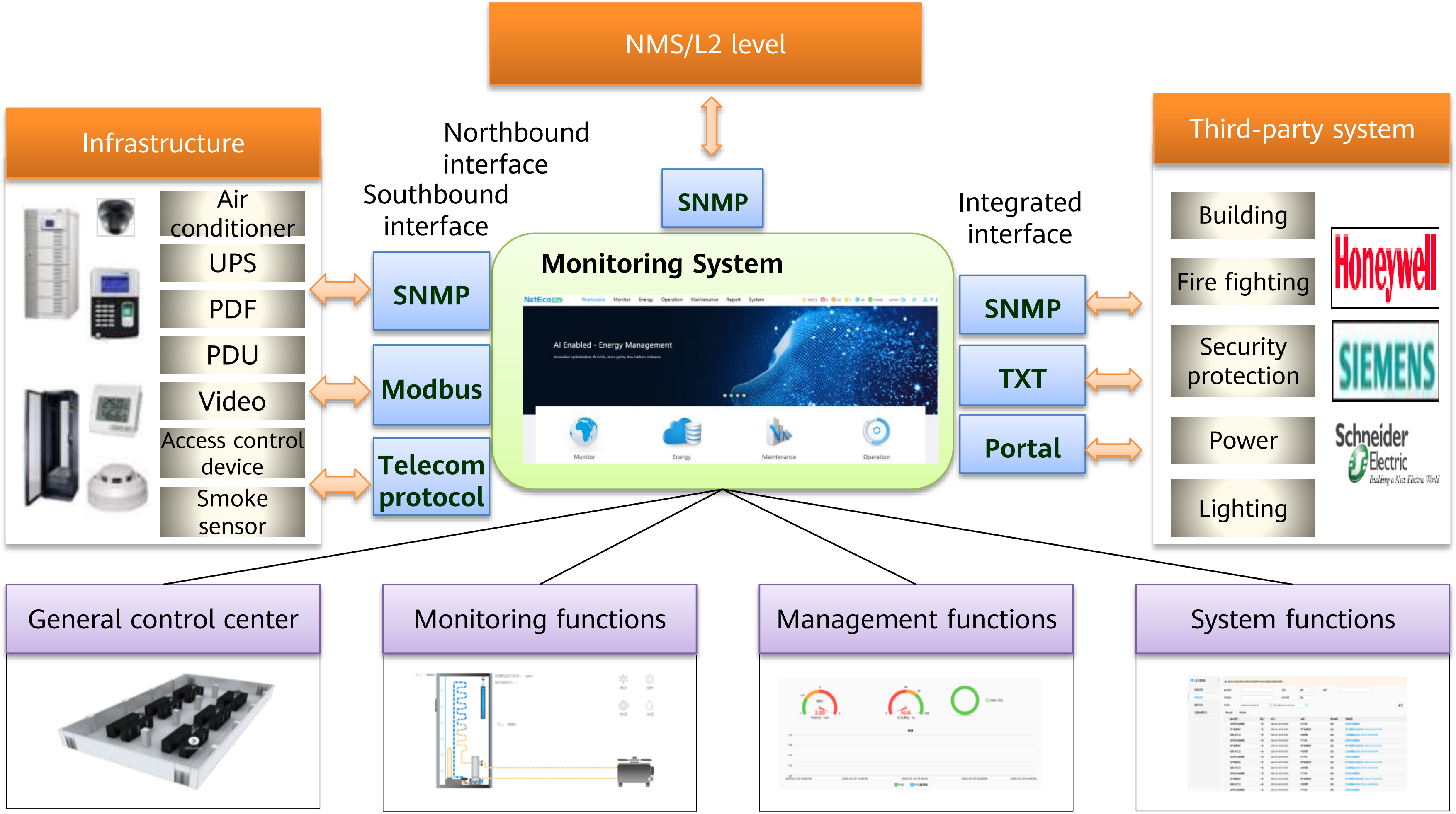
Objectives

Upon completion of this course, you will be able to:

- Describe the features and advantages of the monitoring system.
- Understand the main functions of the monitoring system.

Contents

Overview of the Monitoring System



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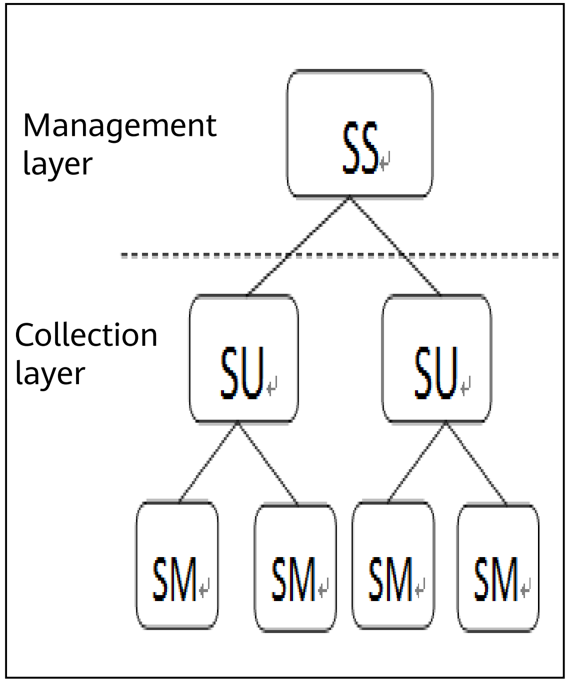
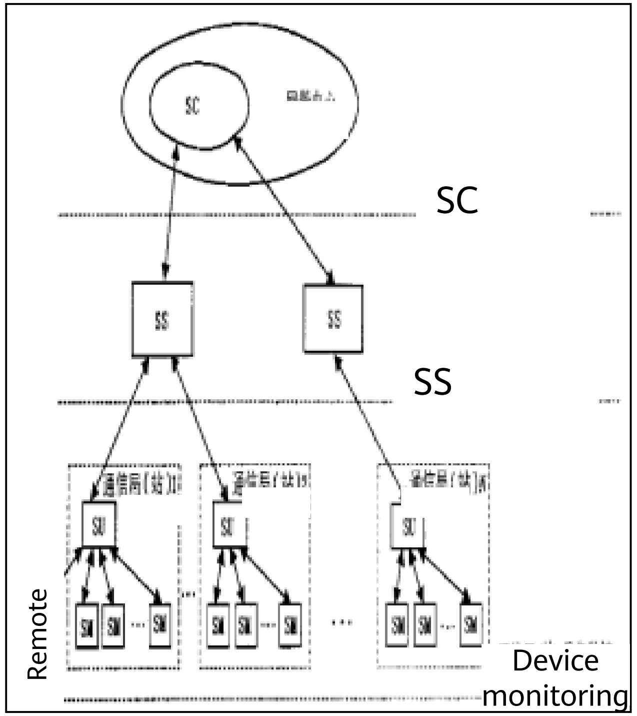
Hierarchical Deployment of the Monitoring System

- When multiple equipment rooms need to be monitored at the same time, hierarchical deployment is required.



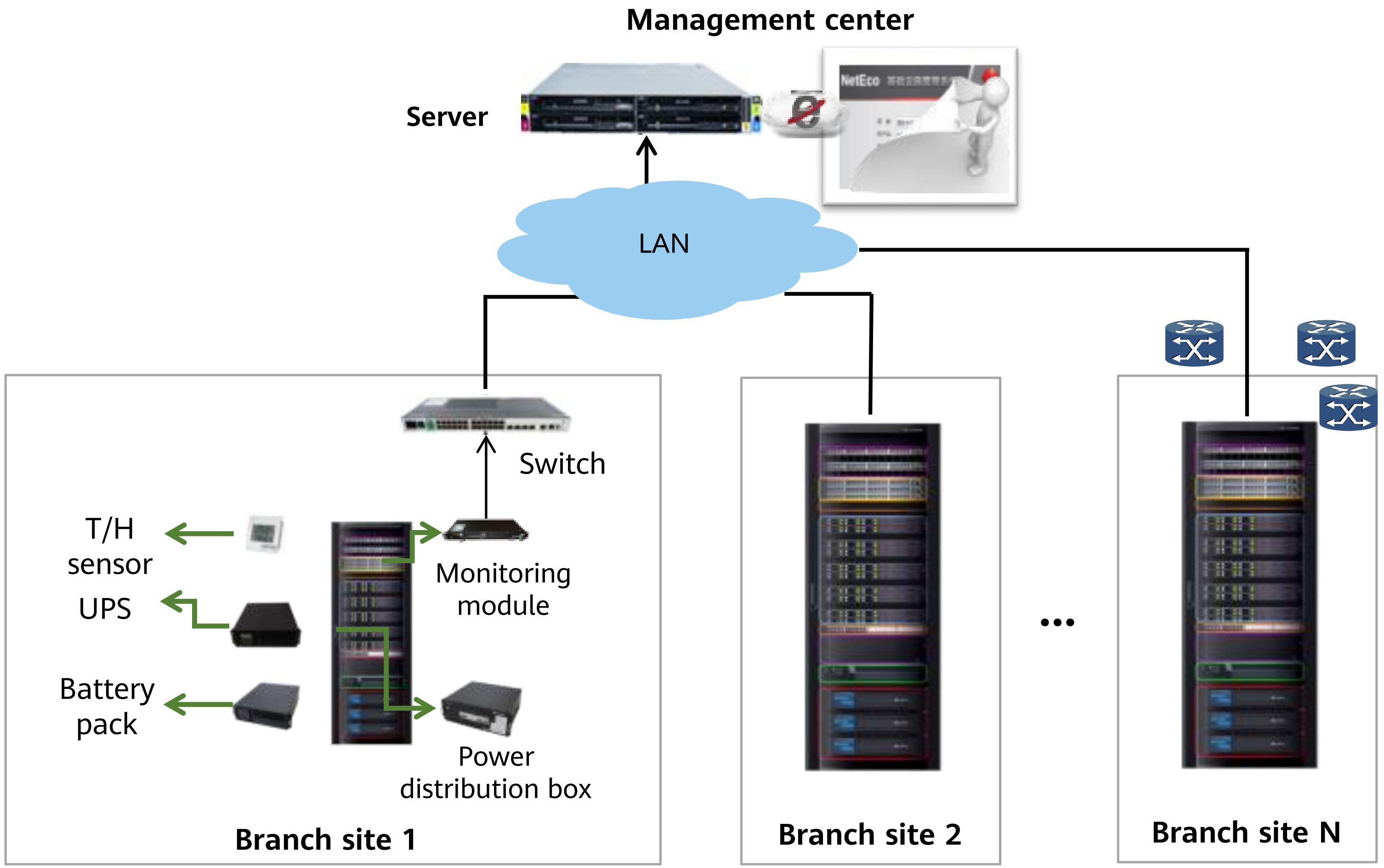
2-level architecture



Multi-level architecture

Abbreviation	Full Name
SC	Supervision Center
SS	Supervision Station
SU	Supervision Unit
SM	Supervision Module

Centralized Monitoring

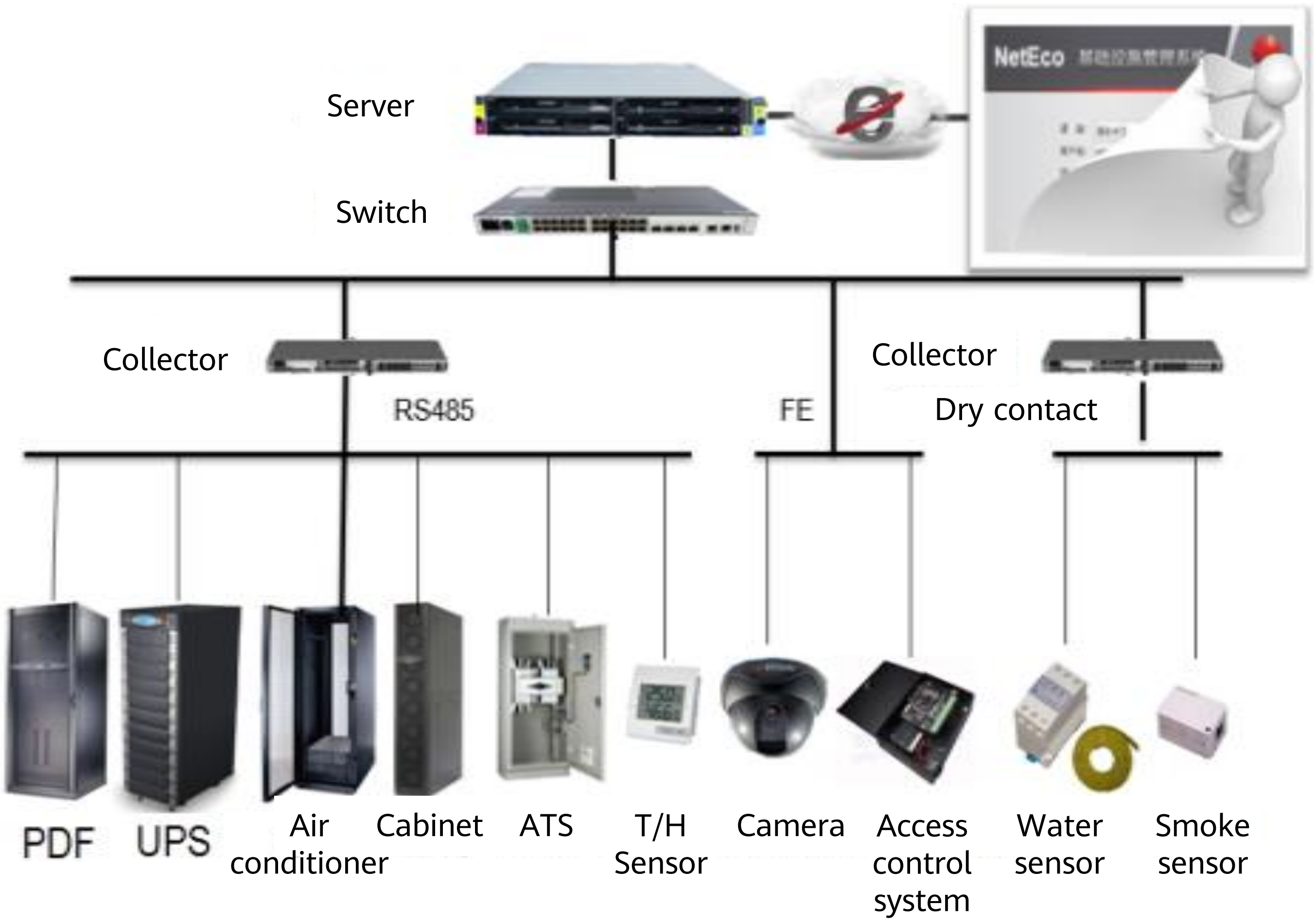


Centralized monitoring involves 2-level architecture and multi-level architecture.

Contents

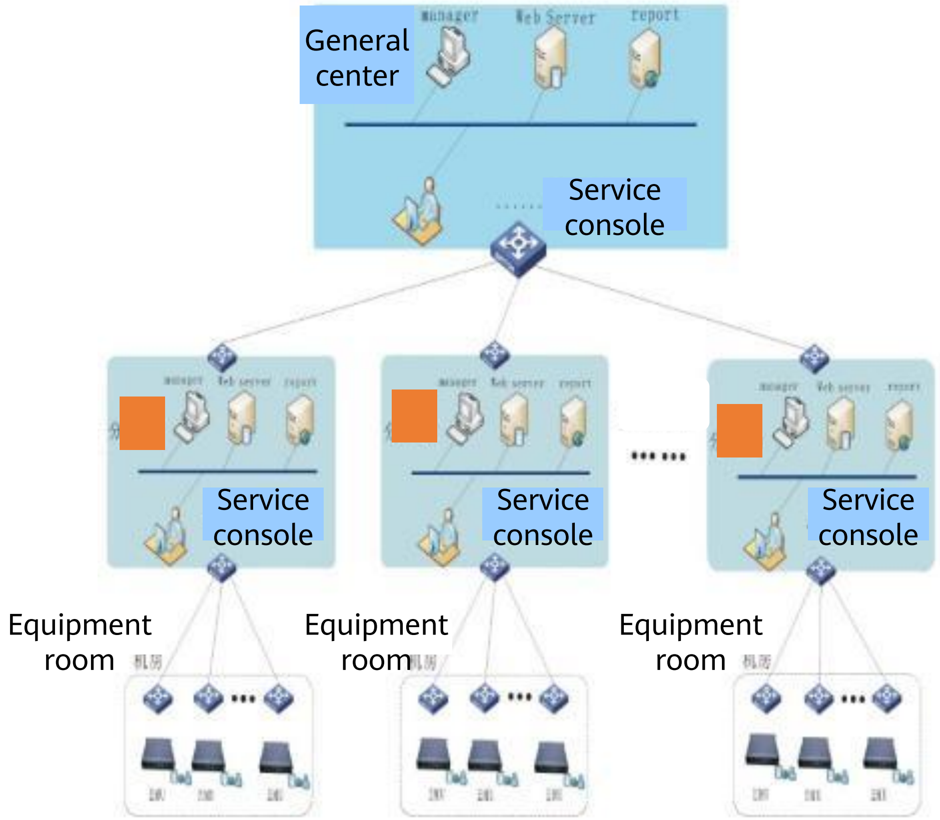
Double-Layer Architecture

- Two levels architecture: that is, management layer + data collection layer
- Only one monitoring station is provided.
- Multiple modules or equipment rooms are allowed.
- The levels of equipment rooms are not differentiated.
- This is the most common monitoring system mode.



Multi-Layer Architecture

- Typical 3-level architecture, that is, SC + SS + data collection layer
- Typical scenario in which the head office can directly manage branch equipment rooms.
- The monitoring management system of a branch center can be relatively independent and is an integral part of the SC.



Contents

Features of the Monitoring System (1)

- Flexible infrastructure management capability
  - Real-time device monitoring, ensuring device reliability and high utilization.
  - Real-time environment monitoring, ensuring environment consistency.
  - Robust security protection management, fully protecting security of devices and environments.
  - Accurate energy efficiency analysis, providing customizable and diversified energy consumption statistical and analysis methods.

Features of the Monitoring System (2)

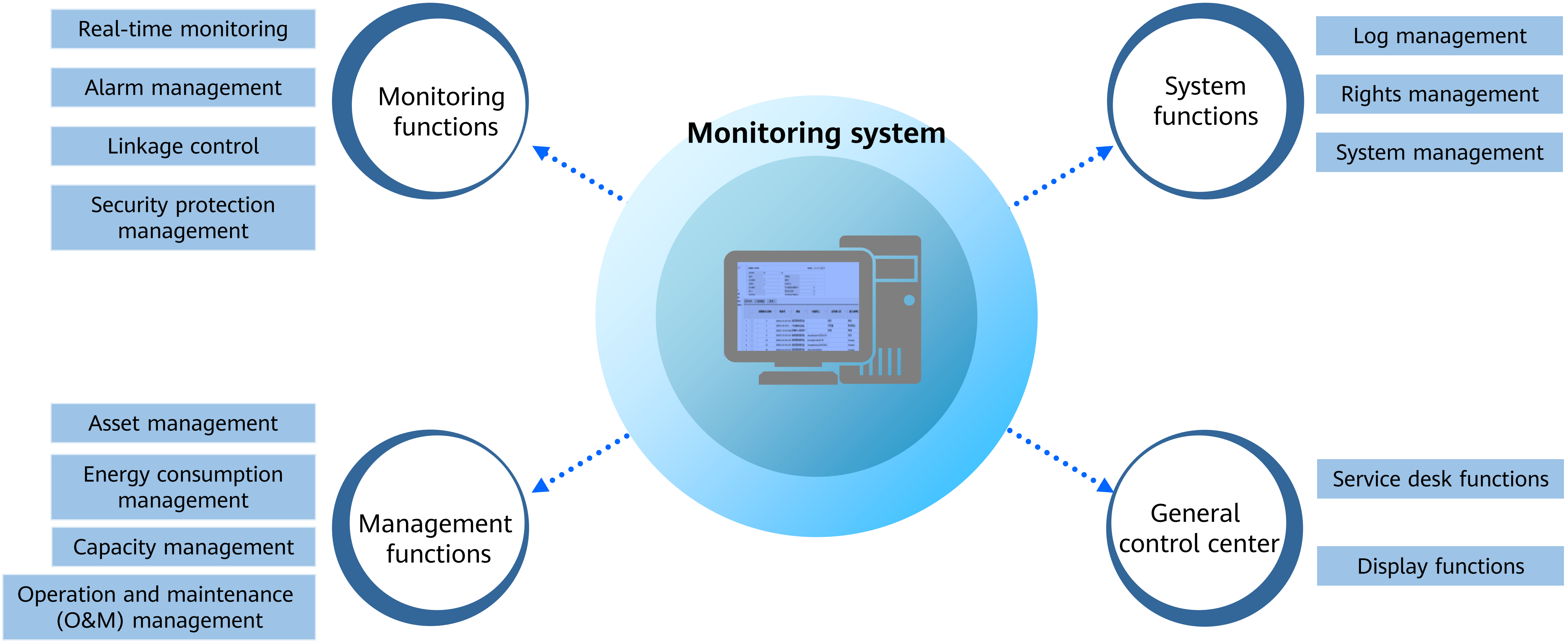
- Software and hardware layering
  - The monitoring hardware (collector) collects data of infrastructure and sends the data and alarms to the monitoring software.
  - The management software is divided into the data collection layer and the management and operation service layer.
- Modular design
  - Basic modules must be configured.
  - Advanced modules can be generally deployed as required or selectively deployed.

Features of the Monitoring System (3)

- Standard network management interface
  - The monitoring system can provide third-party NMSs with SNMP interfaces to meet information exchange with third-party systems. In addition, the monitoring system can provide a multi-protocol expansion mechanism to meet access of difference devices.
- Flexibly configured collector
  - Installation on a 19-inch cabinet is supported. The collector can be installed at the back of the cabinet to save space.
  - Front and rear installation using mounting ears is supported to meet installation requirements for different product configurations.
  - AI/DI expansion cards and serial expansion cards are supported.

Contents

Monitoring System Functions



Monitoring Functions — Real-time Monitoring

- The system allows users to view the running status of power supply and distribution equipment, air conditioners, security protection equipment, and fire protection equipment.

Real-time monitoring

Power supply and distribution	➢ Uninterruptible power system (UPS), generator sets, power distribution frames (PDFs), intelligent power distribution units (PDUs), and batteries
Air conditioning environment	➢ Precision air conditioners, fresh air units, and cooling towers
Security protection	➢ Video surveillance subsystem and access control subsystem
Fire protection	➢ Fire protection subsystem

Monitoring Functions — Alarm Management

- The monitoring system collects equipment information and generates warning and alarm information respectively before and after a condition is met according to preset alarm rules. Then, it displays and notifies the warning and alarm information to users.

Alarm management

- **Alarm settings**
  - Sets alarm rules in advance. When a monitored object meets conditions, an alarm is generated.
- **Alarm browsing**
  - Allows users to browse current alarms, historical alarms, and masked alarms, and view alarm details.
- **Alarm analysis**
  - Classifies alarms based on certain rules to facilitate user management.
- **Alarm handling**
  - Allows users to acknowledge, clear, export, and mask alarms.
- **Alarm notification**
  - Notifies users quickly by short messages, phone calls, emails, and sound and light.

Monitoring Functions — Linkage Control and Security Management

Monitoring functions

Linkage control

- Performs linkage control on non-core equipment based on predefined linkage policies to respond to data center O&M requirements.

Security protection management

Video management

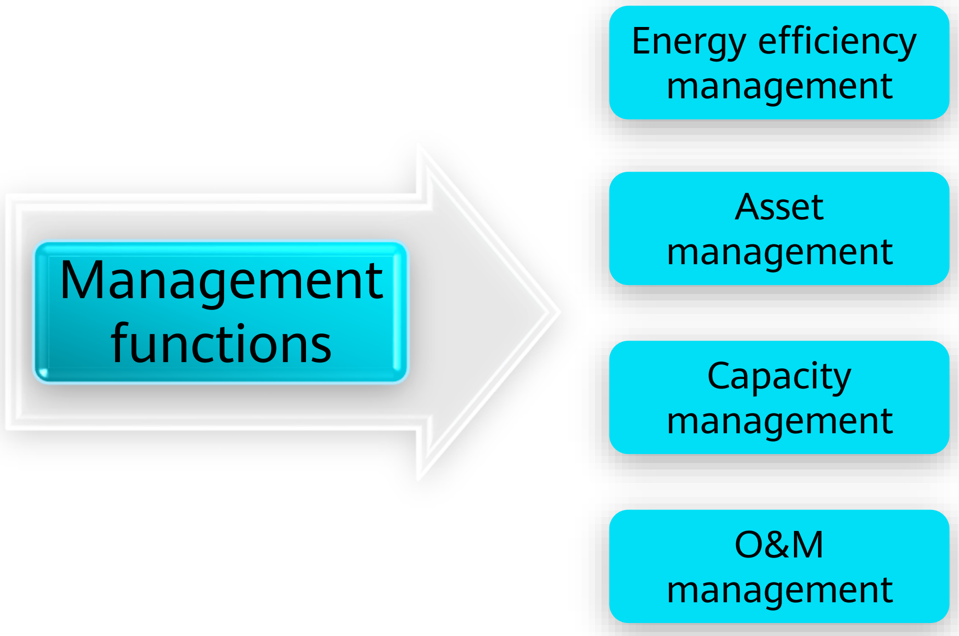
- Supports the video management system and allows users to view real-time videos and historical videos of a data center, performing visualized management of video cameras.

Access control management

- Allows users to create, configure, and manage access rights.
- Implements rights-based management for user groups.
- Monitors access control events.
- Processes, queries, and reports historical access control data.

Management Functions

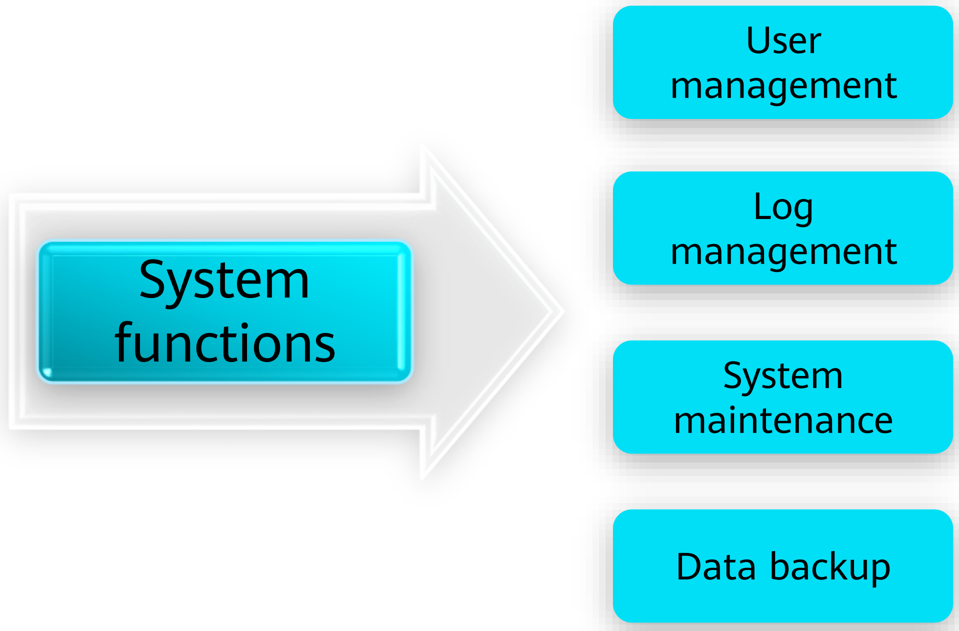
- The objective of data center operation management is to achieve high availability of the data center with low operation costs. To achieve this goal, the monitoring management system must have the following functions: energy efficiency management, asset management, capacity management, and O&M management.



- Calculates the power usage effectiveness (PUE) of a data center, implements visualized monitoring of the PUE, and displays the composition and changes of energy consumption.
- Uses electronic label technology to collect statistics on locations and quantities of power distribution equipment, air conditioners, and monitoring equipment in real time to improve asset stocktaking efficiency.
- Collects space, power, and cooling data of a data center, analyzes capacity changes, and uses the data as the basis for user capacity planning.
- Provides functions such as periodic maintenance, periodic inspection, and event (fault) management. The failure rate and duration can be reduced through accident prevention management and process-based management.

System Functions

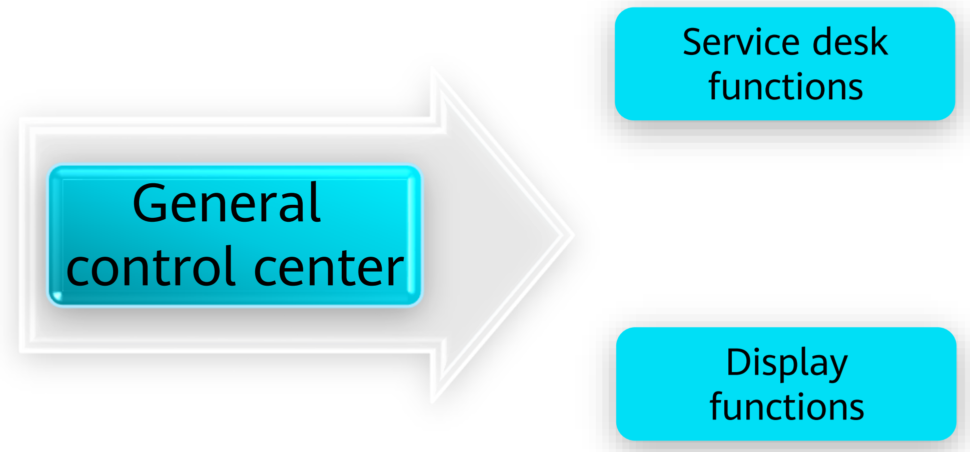
- The system provides common functions for each module of the monitoring management system, including user management, log management, system maintenance, and data backup.



- User management
  - Manages users in the system according to permission groups.
  - Multiple user authentication modes should be supported to ensure system security.
- Log management
  - Records all operations of the monitoring management system, traces accidents, and retrieves log information.
- System maintenance
  - Performs maintenance such as upgrading a system online.
- Data backup
  - Provides hot standby to back up and restore data of the monitoring system.

General Control Center (1)

- The general control center is an important entry for O&M management driver information. It provides the service desk and display functions and works with the O&M management system to ensure the availability of data centers.



- ➢ On-duty personnel in the general control center receive system exception information from users through the service desk, making up for the omission of abnormal runtime information caused by insufficient monitoring systems.
- ➢ After the on-duty personnel obtain exception information, they register and distribute service requests in the system, track the service process and quality, and review the issues to ensure that the O&M work is completed as required.
- ➢ Provides functions such as data center planning, large-screen display, 3D display, monitoring management reports, and web or mobile terminals to intuitively display the running status of a data center, improving the readability of system data.

General Control Center (2)

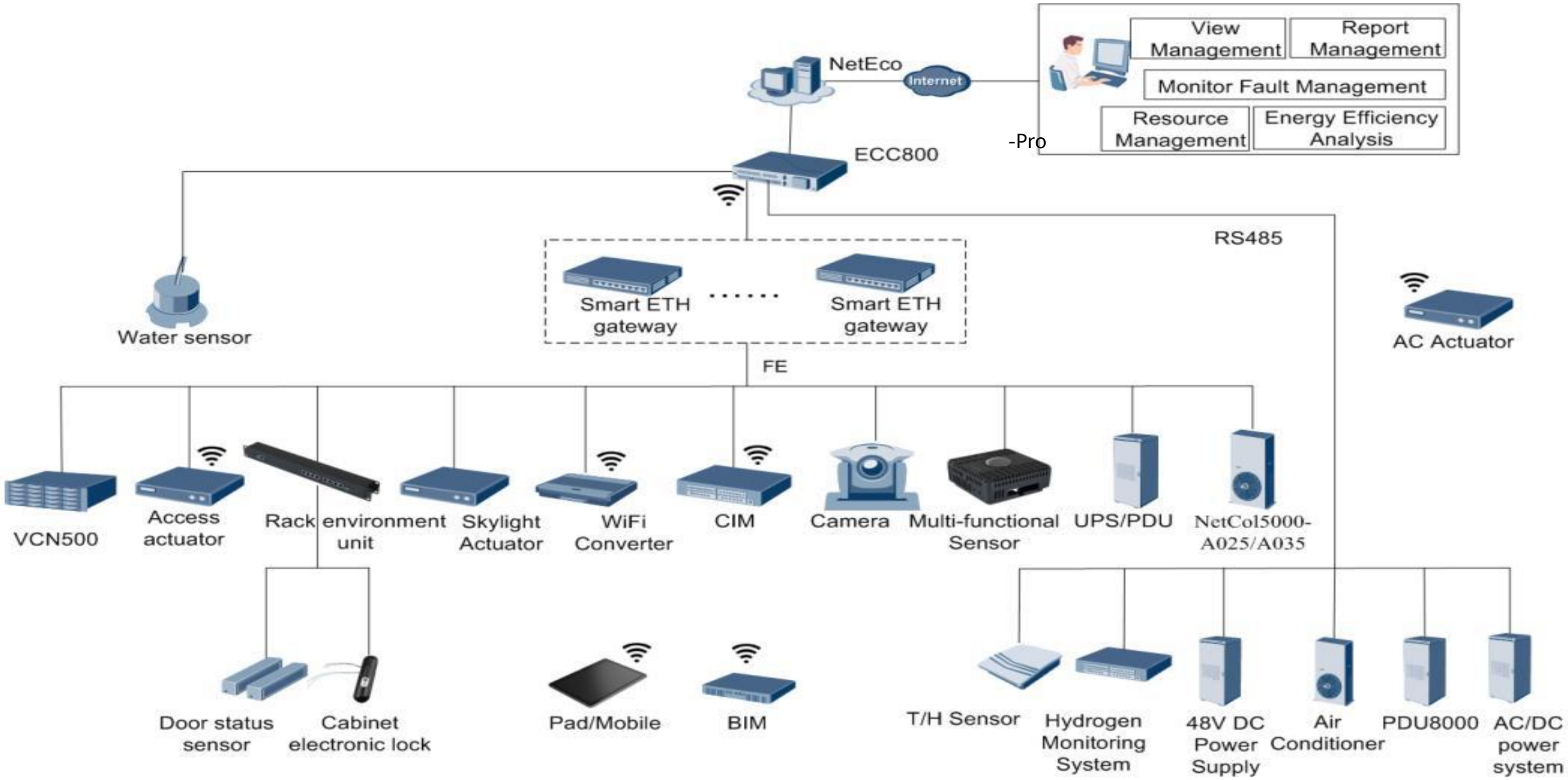
Display functions

Data center planning	➢ Users can use various graphical elements, such as curves, pipelines, and cabinets, to simulate the actual layout of a data center.
Large-screen display	➢ Displays monitoring views, alarms, energy efficiency analysis, capacity, and key battery information service segments on a large screen.
3D display	➢ Displays the data center panorama in a 3D view, showing equipment layout, alarm information, and running status to improve user experience of visualization.
Temperature map	➢ Displays the overall temperature distribution of a data center. Quickly eliminates hot spots in a data center to ensure normal operation of IT equipment, and accurately detects refrigerant leakage to prevent equipment failures and ensure security.
Report management	➢ Collects statistics on and analyzes historical device running data and alarm events, and displays them in charts. It provides intuitive and reliable basis for data center management and decision-making.
Web/Mobile terminals	➢ The monitoring system provides access management for web terminals and mobile terminal apps, which allows users to view alarms, performance, energy consumption, and resource data of a data center.

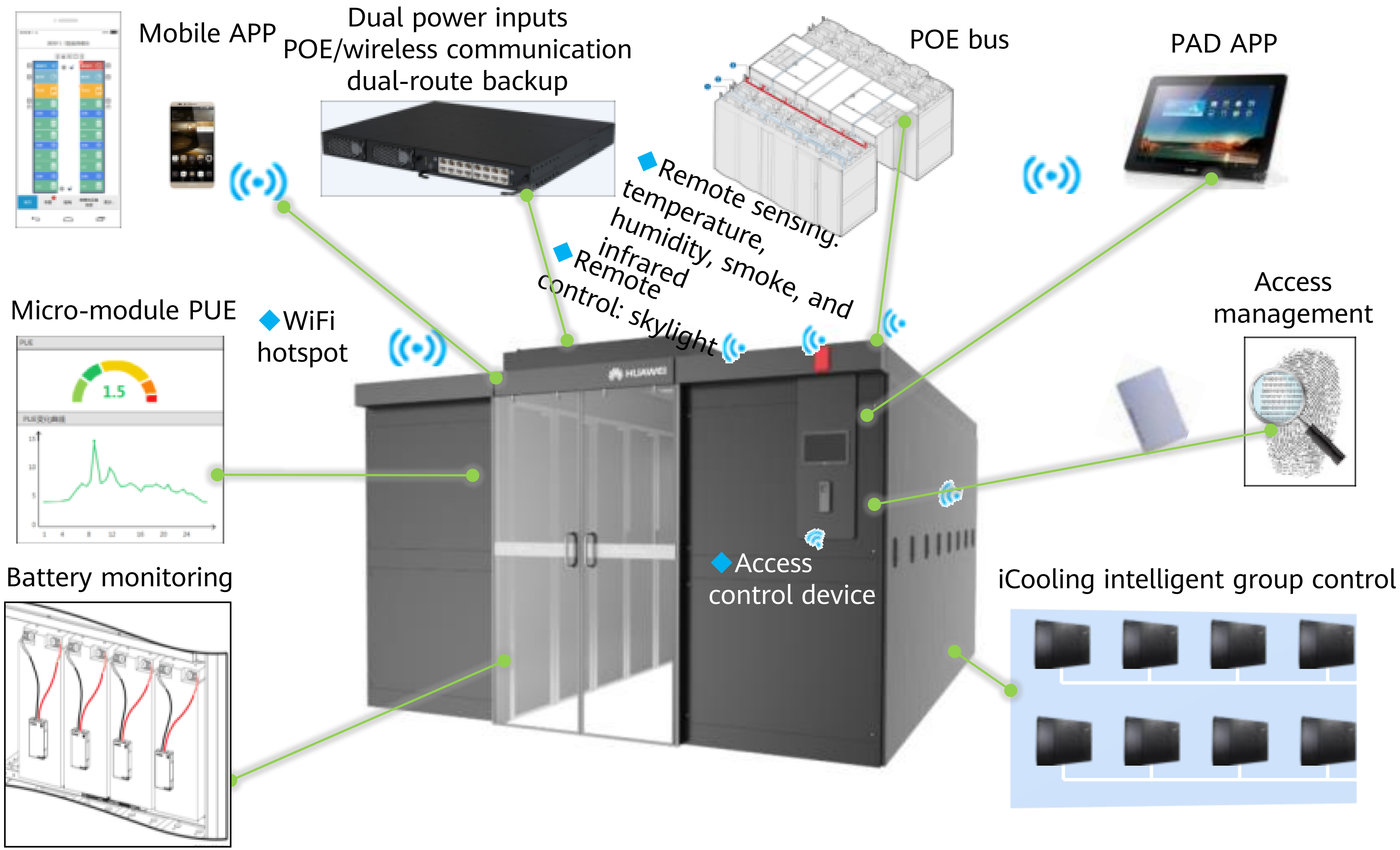
Contents

Huawei Monitoring Management System

- Huawei monitoring management system covers power monitoring, environment monitoring, and security monitoring, provides real-time status of devices inside micro-modules, alarm information, and configuration information for management, and provides visual interfaces.



Functions of Huawei Intelligent Monitoring System



Quiz

1. (Short Answer Question)What are the differences between 2-level architecture and multi-level architecture for centralized monitoring?
2. (Short Answer Question)What are the main functions of the monitoring system?

Summary

- Overview of the Monitoring System
- Introduction to Main Functions
- Introduction to Huawei Monitoring System

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise： http://support.huawei.com/enterprise/
  - Online Learning： http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

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每个组织，构建万物互联的智能世界。

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Introduction to Other Systems of Data Center Facility

Foreword

- In addition to the power distribution system, cooling system, and monitoring system, the data center facility has many other indispensable systems.

Objectives

On completion of this course, you will be able to:

- Understand systems of fire protection, fresh air, lightning protection and grounding, and integrated cabling in the data center infrastructure;
- Understand working principles and main components of these systems.

Contents

Fire Extinguishing System Overview (1)

- Functions:
  - Fire extinguishing system automatically detects the smoke or hot air produced when a fire happens in the fire detection area, generates audible and visual alarms, and controls the automatic fire extinguishing system. In addition, the fire extinguishing system is associated with the output contacts of other devices, to control emergency lighting, evacuation signs, emergency broadcast/communication, and fire extinguishing water supply/smoke control facilities. This enables automatic monitoring, alarms, and fire extinguishing.
- Classification:
  - Water fire extinguishing system: water is the most common extinguishing agent, because it is cheap and provides high extinguishing performance. Application scenarios: civil and industrial buildings.
  - Foam fire extinguishing system: the foam extinguishing agent is mixed with water based on a specific proportion, and generates extinguishing foam by using a foam generating device. Application scenarios: petrochemical enterprises, oil depots, underground engineering, various warehouses, large hangars and ships.

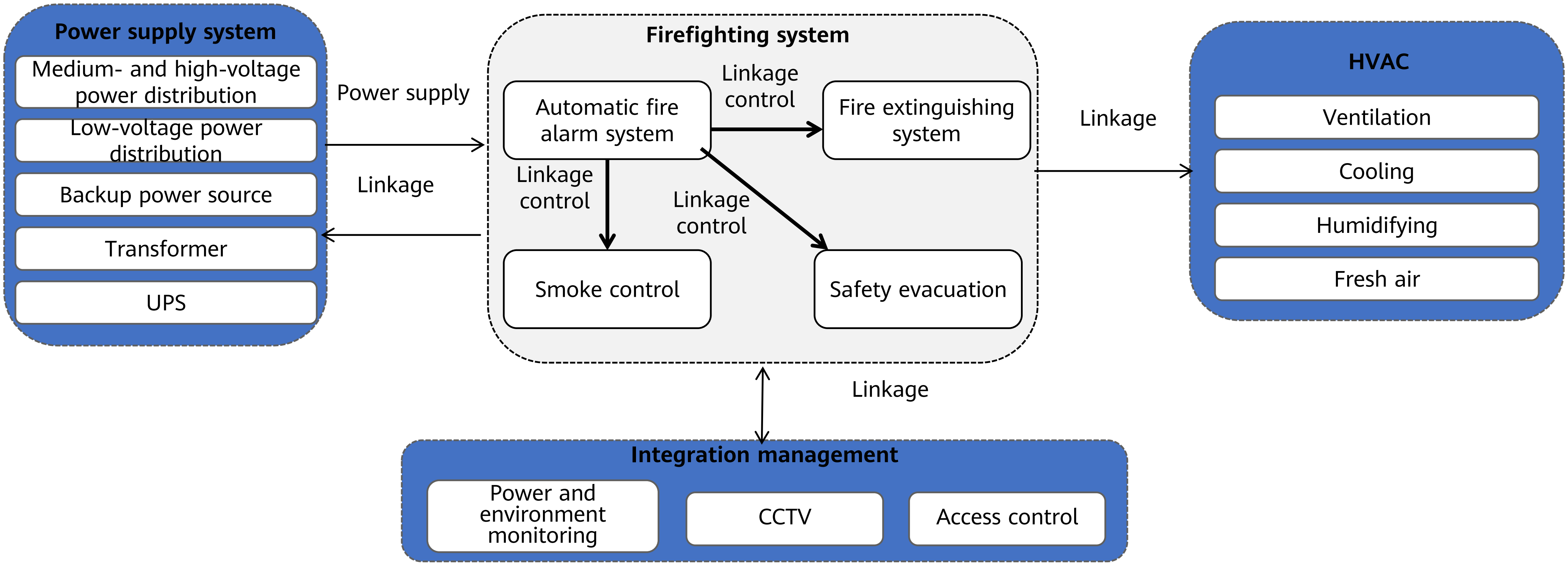
Fire Extinguishing System Overview (2)

- Classification:
  - Gas fire extinguishing system:
    - The extinguishing agent is stored in a pressure vessel in a liquid, liquefied gas, or gas state. During fire extinguishing, the extinguishing agent is sprayed in a gas (steam or mist) state.
    - The gas fire extinguishing system is mainly applied to places with valuable equipment or places where water fire extinguishing is not applicable. Such places and equipment include telecom equipment rooms, radio and television equipment, generator rooms, electrical equipment rooms, transformers, oil circuit breakers, motors, internal combustion engines, electric locomotives, library and archive buildings, scientific experiment buildings, valuable equipment rooms, large ships, and oil product factories.

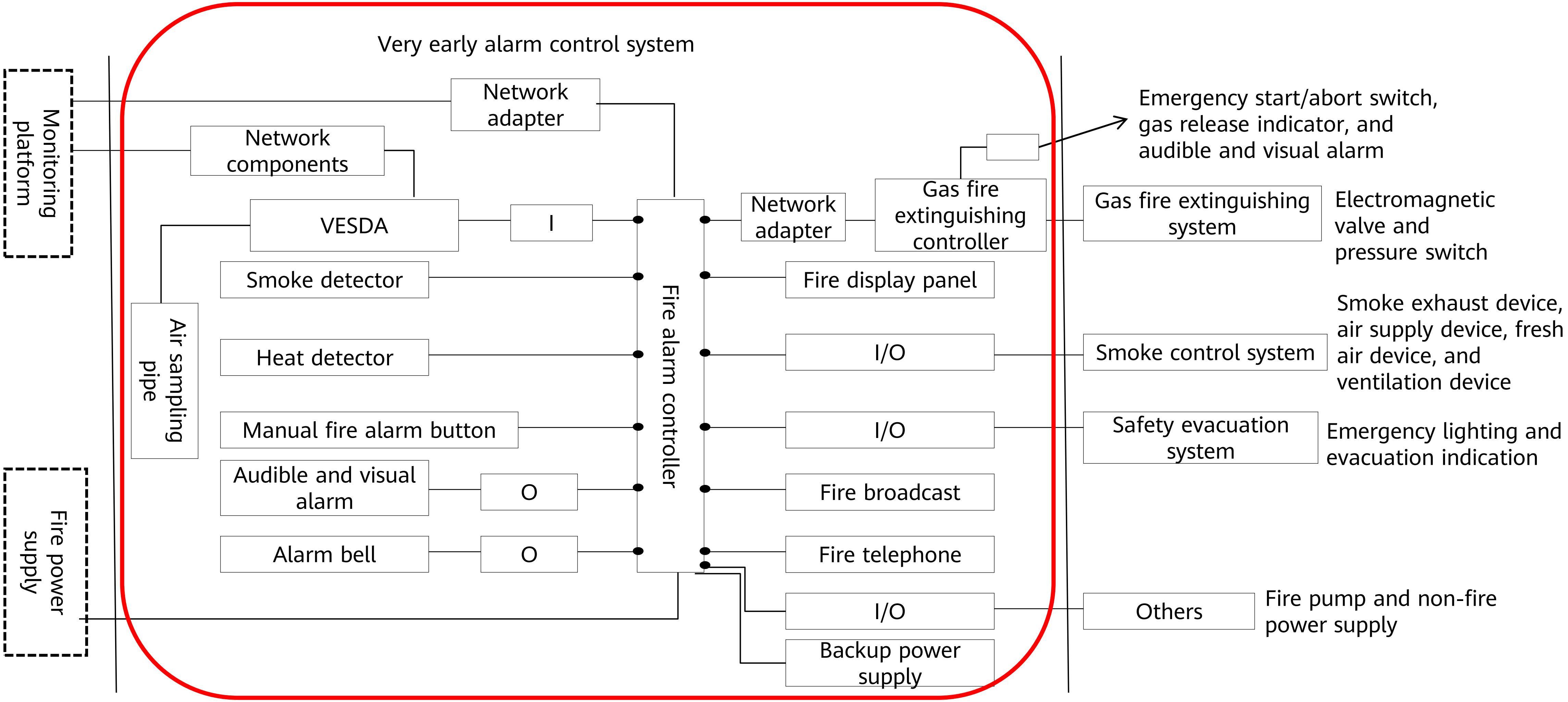
Structure of the Fire Extinguishing System (1)

- The fire extinguishing system consists of the automatic fire alarm system, gas fire extinguishing system, smoke control system, safety evacuation system.
  - Automatic fire alarm system: in the early stage of fire, the system converts the physical signals, such as smoke, heat, and flame produced by fire, to electrical signals through the fire detector, and transmits them to the fire alarm controller to trigger relevant linkages so that people may detect the fire and take effective measures in a timely manner.
  - Gas fire extinguishing system: The system stores extinguishant in the form of liquid, liquefied gas, or gas in a pressure vessel, and releases the extinguishant in the form of gas to extinguish a fire. The extinguishant diffuses evenly in a protected zone with a regulatory concentration sufficient to put out a fire from all directions.
  - Smoke control system: The system exhausts the large amount of smoke produced by fire and prevents the smoke diffusing out of the protected zone to ensure the smooth evacuation and sheltering of people in the building and create favorable conditions for firefighters to put out the fire.
  - Safety evacuation system: The system disconnects the non-firefighting power supplies in the case of fire and maintains proper lighting in the evacuation route and other necessary places to facilitate personnel evacuation and accident handling.

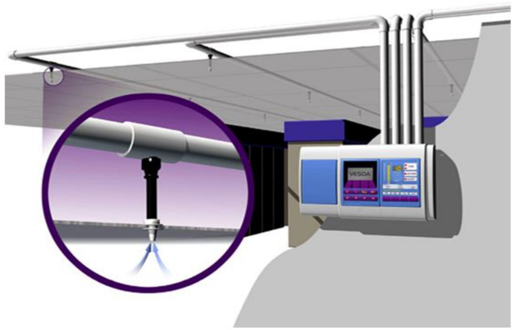
Structure of the Fire Extinguishing System (2)



Structure of the Automatic Alarm System



Automatic Fire Alarm System (1)

Components	Picture	Description
VESDA		VESDA is short for very early smoke detection apparatus. Work principle: Sampling pipes distributed in the protected areas collect air samples. A special device filters out the dust in the air samples and transfers the air samples to the laser detection compartment. The laser detection compartment detects smoke particles in the air caused by burning, determines whether a fire happens by using a program, and generates an alarm as required.
Air Sampling Pipe		The air sampling pipe collects air samples for the VESDA. Sampling holes are evenly distributed on the pipe.

Automatic Fire Alarm System (2)

Components	Picture	Description
Smoke Detector		The smoke detector is a fire detector that detects smoke particles caused by burning. Two types of smoke detectors are available: spot-type smoke detectors and line-type smoke detectors. The transmitter and receiver of a spot-type smoke detector are configured on the same device, and those of a line-type smoke detector are separated. Therefore, spot-type smoke detectors are preferred in small space (with a floor height of less than 9 m).
Heat Detector		The heat detector detects the ambient temperature based on the temperature sensitivity of thermosensitive components. It is generally used with the smoke detector and especially applicable to places with significant temperature rise in a fire. Spot-type and line-type heat detectors are available.

Automatic Fire Alarm System (3)

Components	Picture	Description
Manual Fire Alarm Button		The manual fire alarm button is installed in a public place. When confirming that a fire happens, staff can push down the organic glass sheet on the button, to send a fire alarm signal to the fire alarm controller. After receiving the alarm signal, the fire alarm controller displays the ID or location of the alarm button and generates an audible alarm. Such an alarm is more emergent than a detector alarm and generally requires confirmation.
Audible and Visual Alarm		The audible and visual alarm is installed onsite and is enabled by the fire alarm controller. After being enabled, the alarm generates strong audible and visual alarms to remind onsite personnel.

Automatic Fire Alarm System (4)

Components	Picture	Description
Alarm Bell		Similar to the audible and visual alarm, the alarm bell generates fire alarms that are differentiated from the ambient sound and light, to remind onsite personnel to perform safety evacuation and fire extinguishing.
Fire Display Panel		The fire display panel is a fire alarm display device designed by using a single-chip microcomputer, and is installed on a building floor or in an independent fire protection area. Digit-based and text-based fire display panels are available. The fire display panel is connected to the fire alarm controller through a bus, and processes and displays the data received from the fire alarm controller.

Automatic Fire Alarm System (5)

Components	Picture	Description
Control Module		The fire control module, also called an I/O module, is an important component of the fire linkage control system, and is connected to external devices in the automatic fire alarm system, such as smoke valves, air supply valves, and fire valves.
Fire Telephone		The fire telephone is used for communication between the fire control center and the site. It enables multi-party calls and can be used to report alarms, check fire information, arrange for rescue, and exchange fault information. Generally, the fire telephone consists of a main phone set and extension telephones.

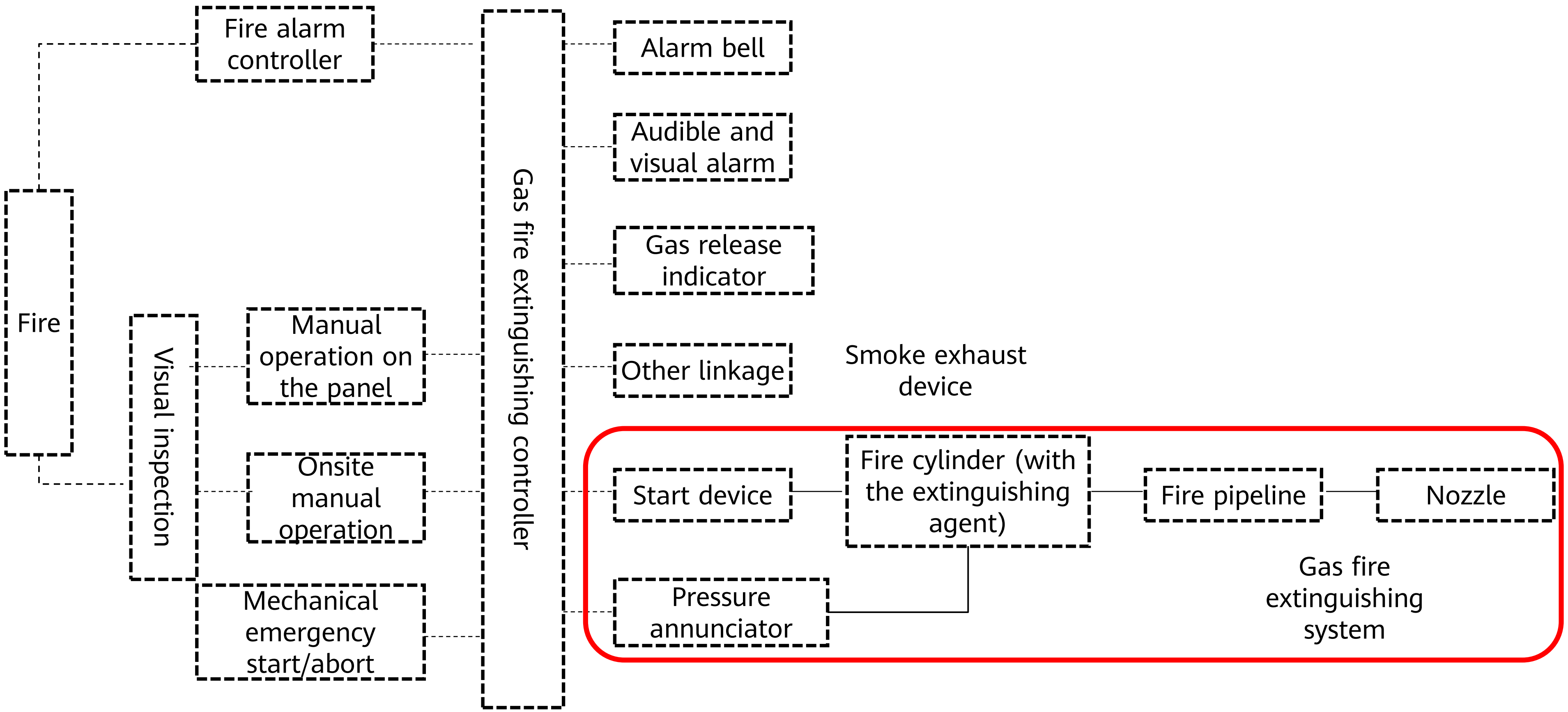
Automatic Fire Alarm System (6)

Components	Picture	Description
Fire Broadcast		The fire broadcast is used by the fire control center to evacuate personnel. Generally, the fire broadcast consists of the emergency broadcast controller, power amplifier, and sound box.
Gas Fire Extinguishing Controller		The gas fire extinguishing controller automatically controls the start/stop of the gas fire extinguishing system. It can be connected to the emergency start/abort switch, manual and automatic transfer switches, gas release indicator, and audible and visual alarm. In addition, the gas fire extinguishing controller provides electromagnetic valve driving interfaces, to enable gas fire extinguishers.

Automatic Fire Alarm System (7)

Components	Picture	Description
Fire Alarm Controller		The fire alarm controller is the core of the automatic fire alarm control system. It receives detection signals, processes alarm information, and provides a linkage alarm platform. Based on the structure, fire alarm controllers are classified into the wall-mounted, cabinet, and table types. A wall-mounted fire alarm controller contains a maximum of two loops and connects a small number of alarm points. A cabinet-type or table-type fire alarm controller contains more loops, has a large capacity, and provides bus and multiline linkage control, meeting the requirements of the complex fire alarm and linkage control system.

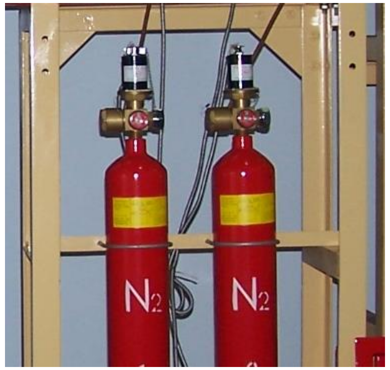
Structure of the Gas Fire Extinguishing System



Heptafluoropropane Extinguishing Agent

- Heptafluoropropane is an environment-friendly extinguishing agent well recognized around the world. It causes no damage to the ozone layer and has the following advantages: superb fire extinguishing performance, no pollution, no conductivity, small storage space, low operating pressure of pipelines, and no slag after fire extinguishing. The extinguishing agent is stored in a liquid state and released as gas. After discharge, the gas is naturally released or fast released based on a ventilation system. No slag is left onsite.

Gas Fire Extinguishing System (1)

Components	Picture	Description
Fire Cylinder		The fire cylinder consists of the extinguishing agent vessel and vessel valve. The extinguishing agent vessel is generally a red steel seamless container covered with epoxy painting, and can be recharged with the extinguishing agent. The extinguishing agent is stored in the vessel in a liquid state and is pressurized to the operating pressure by using nitrogen. When a fire happens, control air flows from the start cylinder trigger an action of the pneumatic valve. Therefore, the vessel valve is opened to release the extinguishing agent. When an emergency occurs, staff can remove the manual safety pin and press the manual button. The vessel valve is immediately opened.
Start Device		The start device stores startup gas (high-pressure nitrogen) and can be started electrically or manually. It releases startup gas to open the selector valve and vessel valve and provides the following functions: sealed storage, release, recharge, low-pressure discharge, and pressure display.

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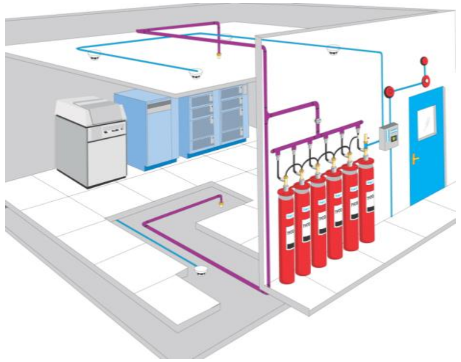
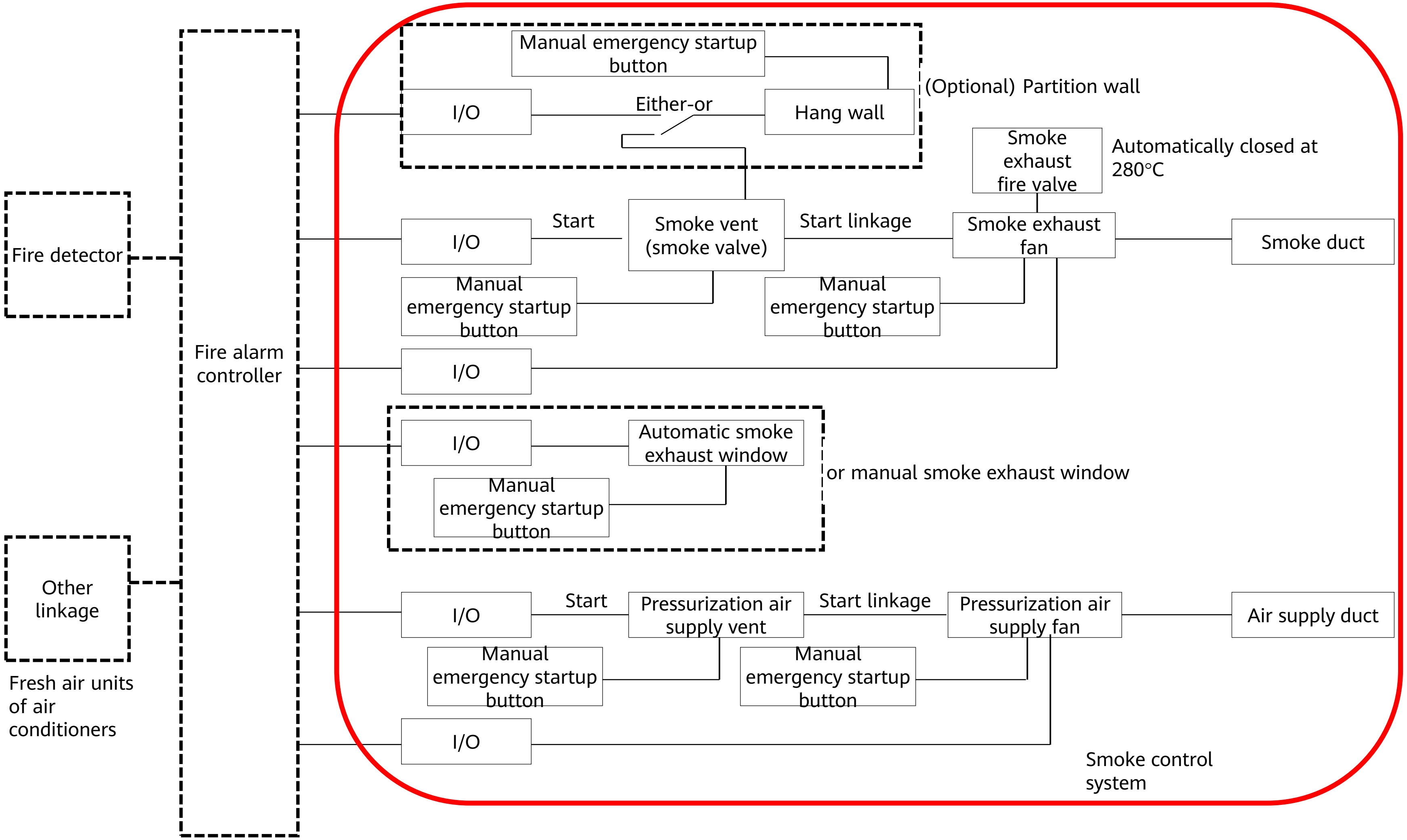
Gas Fire Extinguishing System (1)

Components	Picture	Description
Fire Pipeline		The fire pipeline transports the extinguishing agent to the terminal nozzle. Generally, main pipelines and branch pipelines are available, with different diameters. The pipeline diameter is designed based on the extinguishing agent flow rate.
Nozzle		The nozzle ejects the extinguishing agent in a specific jet form. Therefore, the extinguishing agent is quickly vaporized and reaches the extinguishing concentration in the protected space. Generally, seam-type, pipe mouth-type, and atomizer nozzles are available.

Structure of the Smoke Control System



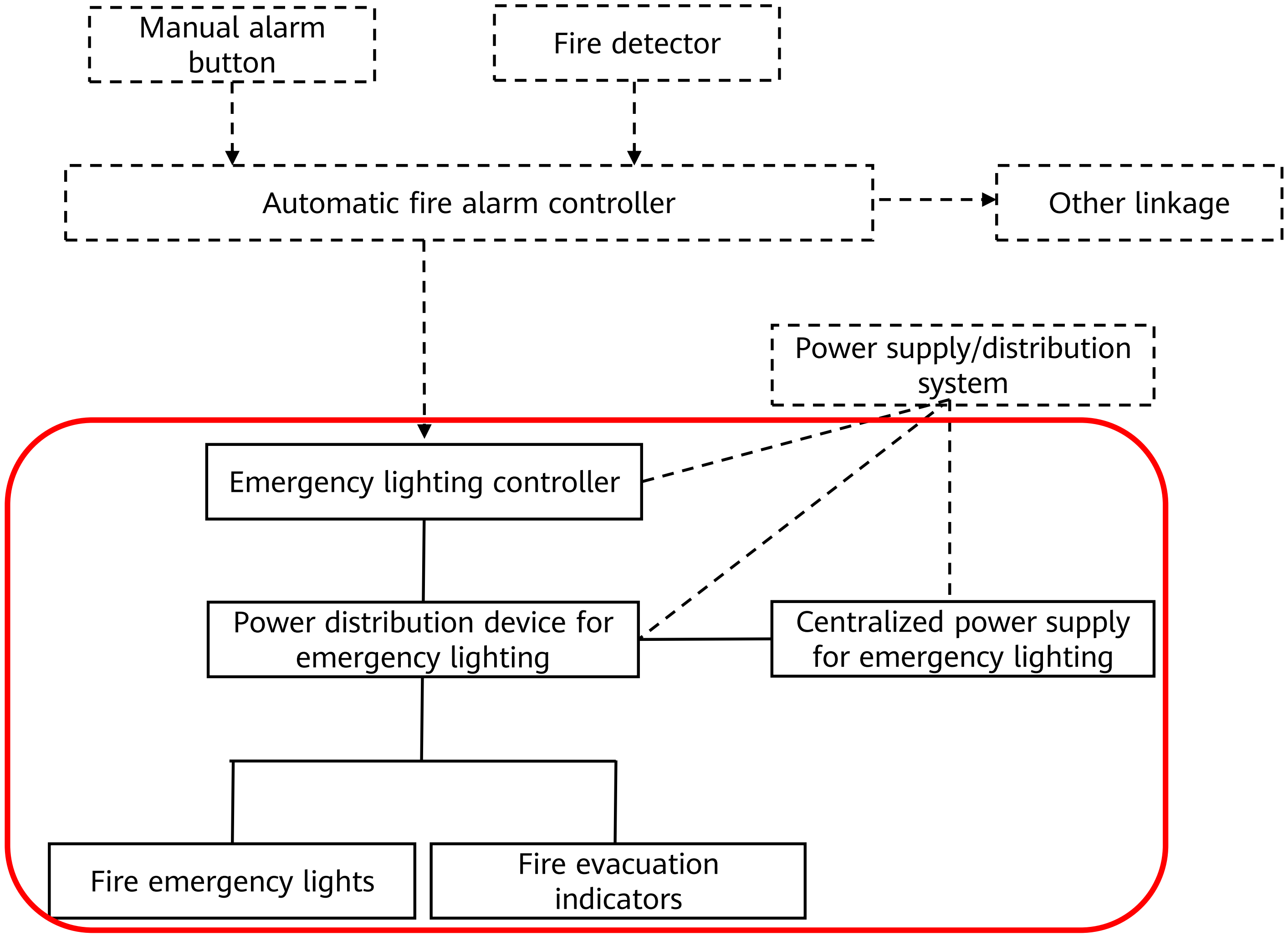
Smoke Control System (1)

Components	Picture	Description
Pressurization Air Supply Fan		The pressurization air supply fan mechanically supplies air to staircases, elevator lobbies, and other protected areas, to generate positive pressure in the areas and prevent smoke from entering the areas. This ensures personal safety during evacuation. The pressurization air supply fan is generally selected based on parameters such as the air capacity, atmospheric pressure, power, and noise.
Pressurization Air Supply Vent		The pressurization air supply vent is also called a positive-pressure air supply vent or a multi-leaf air supply vent. An aluminum alloy air vent is installed in the front of the valve body. The valve body is generally installed on the side wall of an elevator lobby or a staircase. A handling cell is set near the valve body and is configured with a movable door to facilitate operations.

Smoke Control System (2)

Components	Picture	Description
Air Duct		The air duct supplies air or exhausts smoke. The cut-off surface of the air duct is a rectangle or circle. Common air duct materials include thin steel plates, plastic, plywood, fiberboards, concrete, concrete and reinforcing steel, bricks, asbestos cement, and slag gypsum boards.
Smoke Exhaust Fan		The smoke exhaust fan exhausts smoke out of a building, to remove smoke, improve the visibility in the building, and facilitate fire extinguishing. The smoke exhaust fan is generally selected based on parameters such as the air capacity, atmospheric pressure, power, and noise.
Smoke Vent		The smoke vent, also called a smoke valve, is installed on a pipeline of the smoke exhaust system. It is normally closed during proper operating and is opened upon a fire to exhaust smoke.

Structure of the Safety Evacuation System



Safety Evacuation System (1)

Components	Picture	Description
Fire Emergency Light		The fire emergency lights provide lighting for personnel evacuation and fire extinguishing. Key parameters include the input voltage, luminous flux, light source type, and power.
Fire Evacuation Indicators		The fire evacuation indicators provide the following functions by using signs or text: • Indicate the exit, current floor, and shelter floor (room); • Indicate the evacuation direction; • Indicate the locations and directions to the fire extinguishers, fire hydrant boxes, fire lifts, and stairs for the disabled; • Indicate the blocked passages and places and the storage locations of hazardous materials.

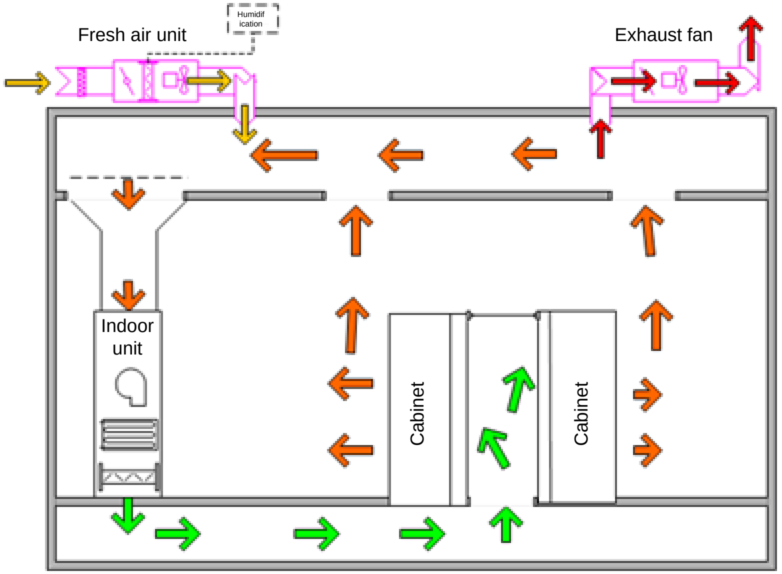
Safety Evacuation System (2)

Components	Picture	Description
Emergency Lighting Controller		The emergency lighting controller controls and displays the operating status of the following components: fire emergency lights, centralized power supply for emergency lighting, power distribution device for emergency lighting (power distribution box for emergency lighting), and other accessories.
Power Distribution Device for Emergency Lighting		The power distribution device distributes power for the emergency lighting and evacuation indication system. Key parameters include the input voltage, output voltage, capacity, and operating time upon power failure.
Centralized Power Supply for Emergency Lighting		When a fire happens, the centralized power supply provides power for the fire emergency lights based on batteries. Key parameters include the power capacity, output voltage, and backup time.

Contents

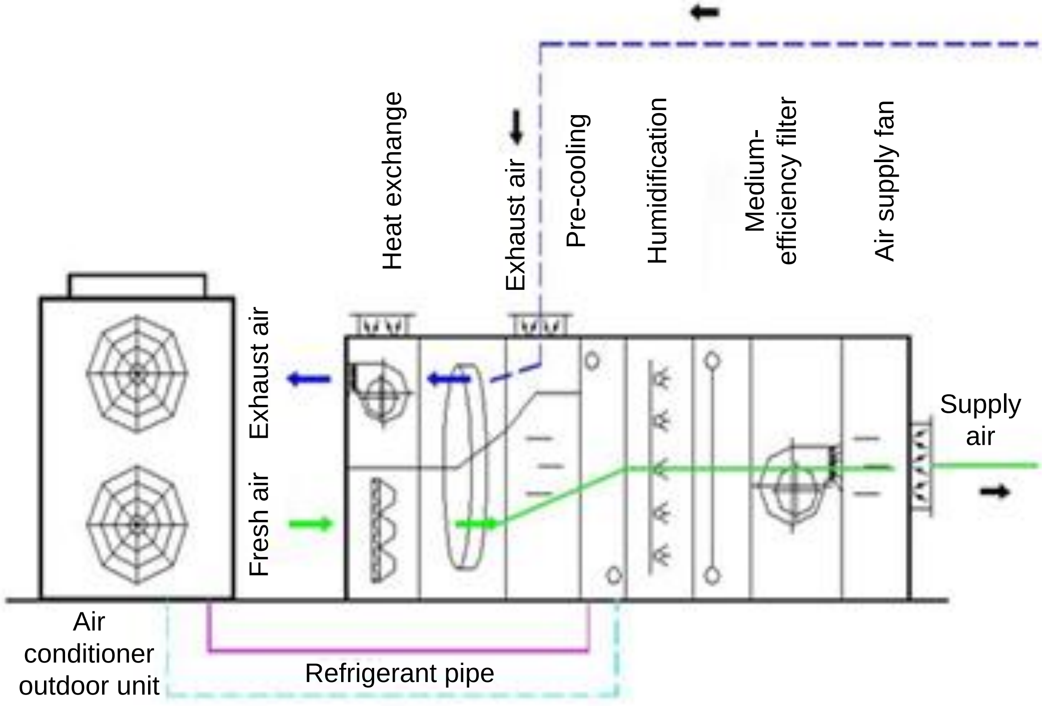
Fresh Air System Overview

- A fresh air system refers to delivering the filtered outdoor fresh air indoors and exhausting the indoor stale air outdoors, achieving system balance while exchanging the air. This system makes scientific convection in a closed environment possible.
- Functions:
  - Maintain the positive pressure difference between the data center and the outside and avoid the entry of dust, ensuring better cleanliness; provide the data center with adequate fresh air, creating a favorable working condition for the personnel; treat the outdoor contaminated air, ensuring the safety of devices inside.



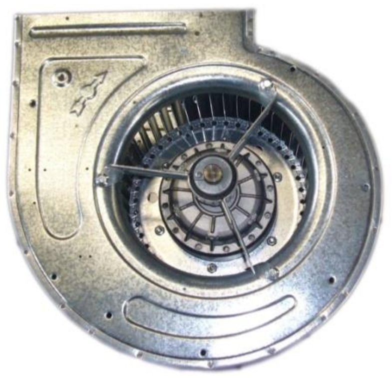
Composition of the Fresh Air System

- The fresh air system consists of the fresh air unit (fan, filter, humidifier, pre-cooling and heat reclamation devices), air exhaust pipes, and air exhaust vents. Out of these, the exhaust fan and filter are mandatory for the fresh air unit. The humidifier, pre-cooling and heat reclamation devices, and chemical filter are optional modules.



Functions of the Components (1)

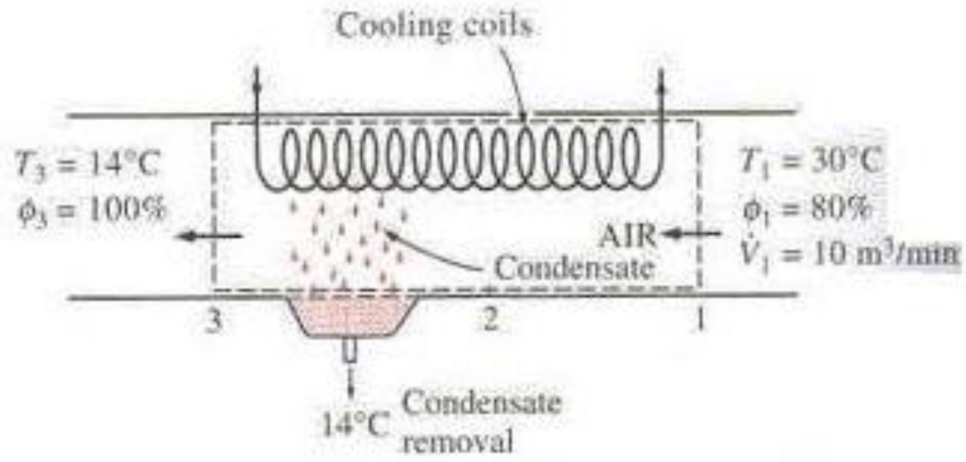
- Fan
  - Fans include the air supply fan and exhaust fan. They are the mandatory items for the fresh air system. They can be variable-frequency and constant-frequency. In general, you are advised to configure a differential pressure controller and select the variable-frequency ones.



- Filter
  - Filters include the coarse-efficiency filter and medium-efficiency filter. The former is a plate filter and the latter is a bag filter. In general, the coarse-efficiency filter is G3 or G4, and the medium-efficiency filter is F5 to F8 in filtering level. The configuration principle of these two types of filters is that the difference should not be greater than four levels. The higher the filtering level, the higher the filtering efficiency, and the higher the cost. Figures on the right show a coarse-efficiency filter and a medium-efficiency filter respectively.

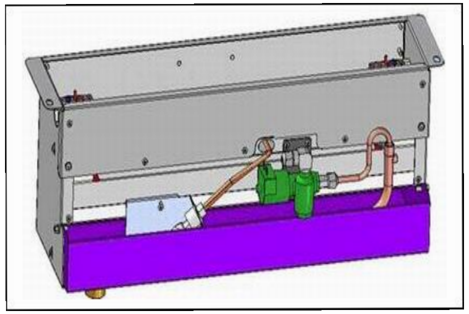
Functions of the Components (2)

- Pre-cooling/Dehumidification device
  - When the fresh air is not delivered to the air return vent of the indoor air conditioner (the indoor air conditioner bears the fresh air loads), you need to configure a pre-cooling section to meet the air supply requirements.
  - When the humidity control uses the independent fresh air control, and the outdoor humidity is higher than the indoor control target, you need to configure a dehumidification section (the cooling dehumidification is generally adopted).



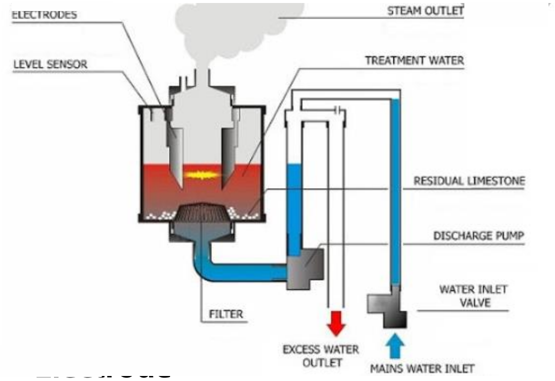
Functions of the Components (3)

- Humidifier
  - When the humidity control uses the independent fresh air control, and the outdoor humidity is lower than the indoor control target, you need to configure a humidification section.

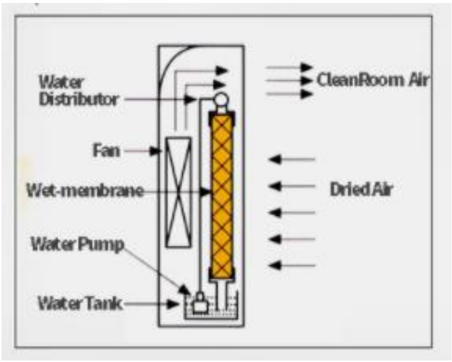


Infrared humidifier

High-pressure micro-mist humidifier



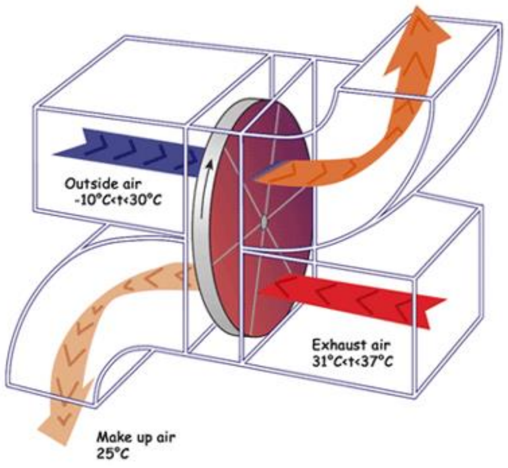
Electrode humidifier

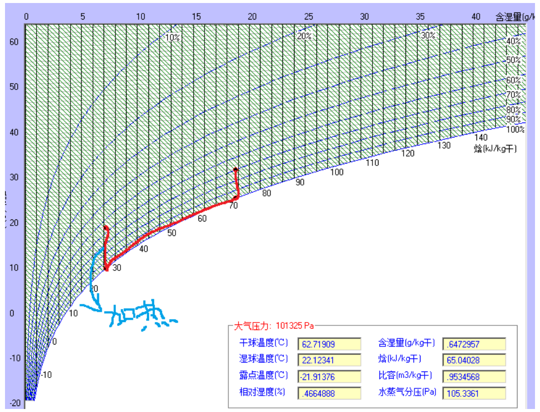


Wet film humidifier

Functions of the Components (4)

- Heat reclamation device
  - To save energy, you can configure a heat reclamation section, using exhaust air to preheat or pre-cool the fresh air. There are two working modes, namely plate type and rotary-wheel type. The figure on the right shows the rotary-wheel heat reclamation.
- Heater
  - You need to configure the heating section only when the fresh air unit adopts the constant-temperature and constant-humidity air supply solution.
  - After the cooling and dehumidification, heat the fresh air unit to dry bulb working conditions at the air supply vent. This solution is not energy-saving and therefore is not recommended.





Contents

Cabinet Overview

- Standard cabinets are widely used in stacking the integrated cabling and cable distribution equipment, computer network equipment, communications equipment, and electronic equipment. Cabinets are classified into server cabinets, network cabinets, and console cabinets.
- Cabinets provide the enhanced electromagnetic shielding, reduce the equipment operating noise, and lower the footprint. Some high-end cabinets have the air filtering function, which improves the operating environment for precision equipment.
- Simple in structure, standard cabinets mainly include the basic framework, internal supporting system, cabling system, and ventilation system.
- General specifications of cabinets are 600 mm or 800 mm in length, 600 mm, 800 mm, or 1000 mm in width, and 24 U, 36 U, 42 U, or 47 U in height.

How to Select a Cabinet?

- **Load-bearing performance**: The cabinet must be solid enough to bear the increasingly small-sized, network-based, rack-mounted, and large-capacity heavy IT devices.
- **Temperature control**: The cabinet must have sufficient heat dissipation capabilities.
- **Cable management**: The cabinet must provide sufficient cable channel and support top and bottom cable routing. The cables must be laid out conveniently and orderly. The cabinet must be close to the cable ports to shorten the cable routing distance and reduce the space occupied by the cables.
- **Power distribution management**: The cabinet must support the vertical installation of a dedicated PDU with two inputs without affecting installation, use, or maintenance of devices. The PDU is often equipped with SPDs.
- **Protection performance**: The cabinet door stile and frame must be reliably grounded. Inside the cabinet there are ground points. The working ground bar and protection ground bar can be connected to the grounding copper bar of the data center. The cabinet is equipped with various monitoring devices for monitoring the temperature, humidity, voltage, current, and smoke.

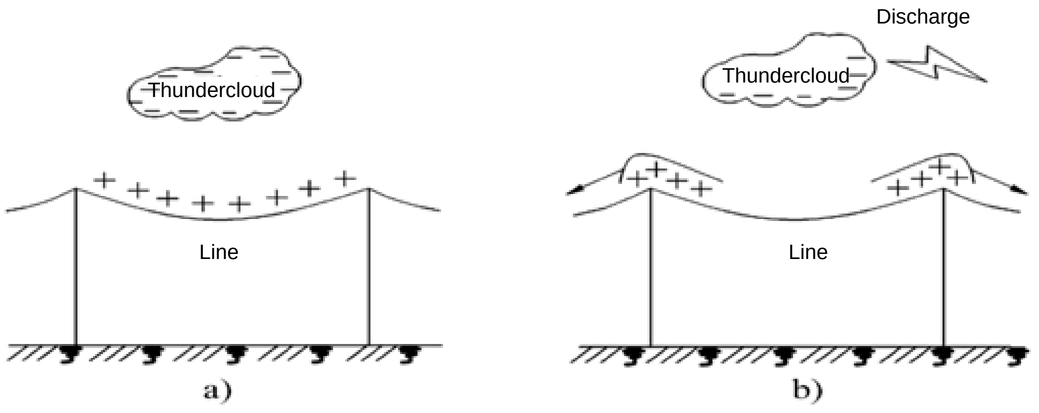
Contents

Lightning Overview

- Lightning phenomenon: Lightning is a result of mutual high-speed movements and fierce friction between clouds in the sky, causing the high-end clouds and low-end clouds to be with opposite charge. In the meantime, the low-end clouds also induce a large amount of hetero-charges on the ground to form a tremendous capacitance. When the capacitive field reaches a certain threshold, the ground discharge is generated.
- Lightning hazards
  - The thermal effects of the lightning current can blow the conducting wires and burn out the electrical equipment.
  - The electrodynamic force generated by the mechanical effects of the lightning current can smash the equipment, towers, and buildings, as well as cause injuries to people and livestock.
  - The electromagnetic effects of the lightning current can generate overvoltage, break down insulated electrical equipment, and even cause fire and explosion, which may hurt and kill people.

Basic Forms of Lightning Overvoltage

- Direct lightning strike: The lightning strikes the electrical devices, cable routes, buildings, and other objects.
- Induction lightning strike: Overvoltage is caused by electrostatic induction or electromagnetic induction from the lightning to the cable routes, devices, or other objects.



Induced overvoltage on the overhead cable routes

Lightning Arrester

- The lightning arrester consists of three parts: air-terminal system, downlead, and grounding device.
  - **Air-terminal system (lightning receiver):** It is a metal conductor that receives the lightning current, and normally uses the lightning rod, lightning conductor, or lightning net (belt).
  - **Downlead:** Ensure that the lightning current does not melt the downlead. Generally, the downlead is made of steel tube whose diameter is at least 10 mm or flat steel whose cross-sectional area is at least 80 mm^2.
  - **Grounding device:** It is a general term for ground conductors and earthing electrodes buried under ground.

Grounding Overview

- Grounding refers to connecting certain parts of the electrical equipment or certain points of the power system to the ground to provide a pathway for discharging the faulty current or lightning current, stabilize potential, and provide the zero potential reference point. It ensures the safe operation of the power system and electrical equipment, as well as personal safety.
- The grounding function is implemented by the grounding device or grounding system.

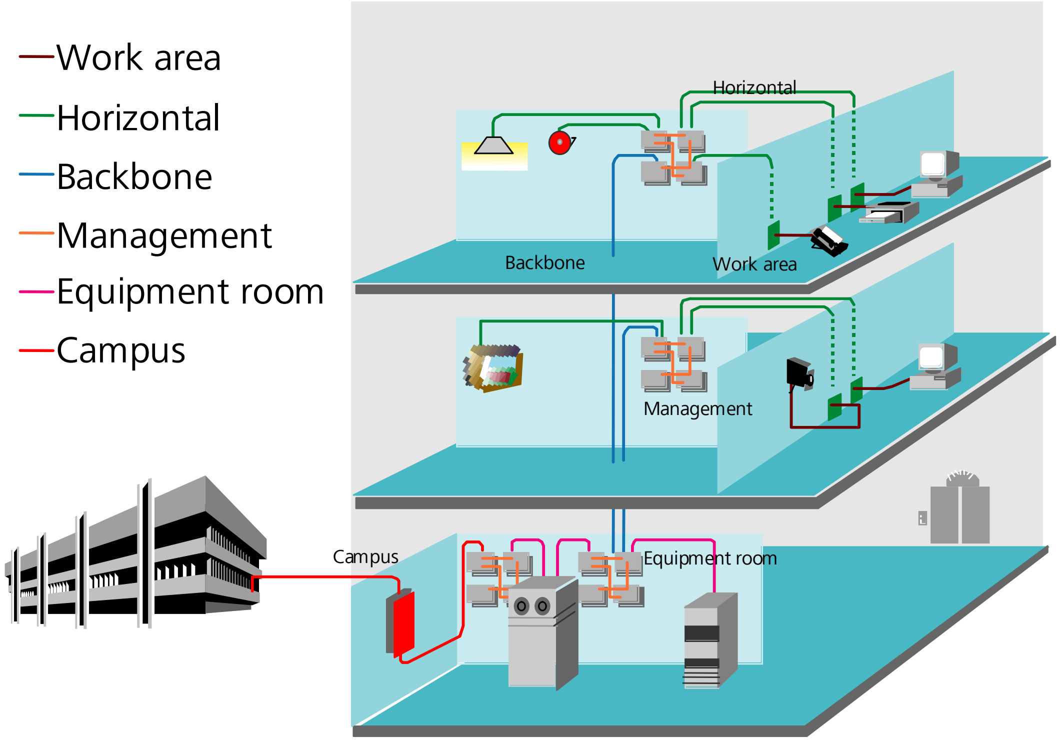
Contents

Integrated Cabling System Overview

- An integrated cabling system is the information transmission channel inside a building or between buildings. It connects voice equipment, data equipment, message exchange equipment, and building automation management equipment in a building to provide a unified physical transmission medium for the building. At the same time, it connects information communications equipment in the building to an external communications network.
- Features:
  - It is a modular and highly flexible information transmission system inside a building or between buildings.
  - Its equipment is independent of lines and features flexibility, openness, compatibility, reliability, economy, and advancement.
  - It adopts unified design and planning for voice and data signals. Unified transmission lines and information connectors are used to transmit different signals in a standard cabling system.

Composition of the Integrated Cabling System

- The Integrated Cabling System is composed of six subsystems: work area subsystem, horizontal subsystem, backbone subsystem, management subsystem, equipment room subsystem, and campus subsystem.



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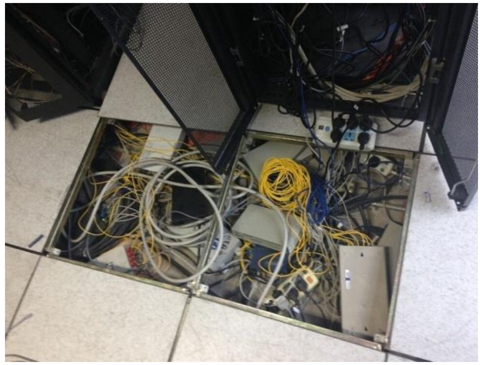
Integrated Cabling in Data Centers

- The determination of cabling mode is an important step of the data center planning. Ignoring the cabling mode reflects the blindness and confusion of the data center planning.
- Cabling modes are classified into overhead cabling and underfloor cabling:
  - Overhead cabling: cables laid out in spaces higher than the device height;
  - Underfloor cabling: cables routed under the raised floor;
  - Cabling on the top of cabinets: troughs for data cables and power cables installed on the top of each cabinet to route cables to each cabinet.



Contents

Composition of Indoor Decoration System

- Electrostatic discharge (ESD) raised floor decoration: As the floor is removable, cable connections, pipe connections, and maintenance are convenient.
- Ceiling decoration: The area above the suspended ceiling is used as the plenum space for air supply or return in a data center, where ventilating ducts can be deployed.
- Partition decoration: mainly includes partition walls and wall decoration. It requires sound insulation, thermal insulation, and fire prevention.
- Shielding system: It is mainly used for anti-interference and information confidentiality. It not only prevents indoor information from leaking or being detected through electromagnetic waves, but also prevents external electromagnetic interference. Common use cases of shielding systems include rooms shielded with metal mesh or plate and shielded cabinets.

ESD floor

Suspended ceiling and partition

Shielded room

Quiz

1. (Short Answer Question) Which kind of fire extinguishing system is applied to data centers?
2. (Short Answer Question) Why is overhead cabling more popular?

Summary

- Fire Protection System
- Fresh Air System
- Cabinet System
- Lightning Protection and Grounding System
- Integrated Cabling System
- Indoor Decoration System

Recommendations

- Huawei - Building A Better Connected World
  - Huawei Enterprise： http://support.huawei.com/enterprise/
  - Online Learning： http://learning.huawei.com/en/
- Popular Tools
  - HedEx Lite

Support APP

Enterprise APP

Support Web

Thank you.

把数字世界带入每个人、每个家庭、
每个组织，构建万物互联的智能世界。

Bring digital to every person, home, and organization for a fully connected, intelligent world.

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