Data Center Energy White Paper 07 — How to Select a Proper UPS for Precision Air Conditioners of Data Centers

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Preface

With the wide use of high-density IT cabinets in data centers, to ensure business continuity of data centers, the requirement of continuous cooling provided by precision air conditioners becomes increasingly urgent. All users attach importance to strengthening protection for cooling. Can the UPS, a key business assurance device, really protect precision air conditioners? I tried giving some answers to the question in this document.

1. Challenges Faced in Power Supply and Distribution for Precision Air Conditioners

In recent years, with the quick development of cloud services and mobile Internet services, the density of data centers becomes higher and the scale of data centers becomes larger. The power density of IT cabinets in data centers increases constantly. ASHARE research reports and test data of some large-scale carriers show that the power density of IT devices increases from below 2 kW/cabinet before to 5 kW/cabinet, 10 kW/cabinet, and even 20 kW/cabinet now. In data centers, air conditioners are allowed to be stopped for a few minutes only. IT devices will shut down due to high temperature even if air conditioners stop running for several minutes only, which will cause high losses that are hard to be estimated.

1.1 Need of High-density Data Centers

The following table specifies rack density and shutdown time in 2014 of a carrier. We can see that, after the rack density reaches 5 kW/cabinet, cabinets shut down only 4 minutes after air conditioners stop running. In addition, with the increase of the rack density, the shutdown time will become earlier. Therefore, it is meaningless even loads are supplied with the power by the UPS after power off and more batteries are used.

Table 1 Rack density and shutdown time when air conditioners stop running

	Seconds									
Watts per Cabinet		30	60	120	240	300	360	420	480	540
	1500 W	21.1	22.2	24.4	28.9	31.1	33.3	35.5	37.7	39.9
	3000 W	23.4	26.7	33.4	46.9	53.6	60.3	67	Shutdown command	
	5000 W	26.4	32.7	45.5	70.9	Shutdown command				
	8000 W	30.9	41.7	63.4	Shutdown command					
	10000 W	33.9	47.7	75.4	Shutdown command					
	15000 W	41.4	62.7	Shutdown command						
	20000 W	48.9	Shutdown command							
	30000 W	Shutdown command								

**Data source: 2014 test data of a carrier*

1.2 Continuous Cooling Requirements of Uptime Institute for Data Centers

Tier standards of the Uptime Institute specify three continuous cooling classes for data centers, raise continuous cooling requirements for high-power data centers whose power density is 4 kW/cabinet or above, and give corresponding solutions, as shown in the following table.

Table 2 Continuous cooling definitions and configuration requirements of the Uptime Institute

No.	Continuous Cooling Class	Continuous Cooling Requirements	IT Power Density	IT Power Density Value
1	Class C	Interruptible cooling; the UPS supplies power for no cooling devices.	Low	P < 0.6 kW/rack (P < 20 W/ft^2) (P < 215 W/m^2)
2	Class B	Continuous cooling; the UPS supplies power for precision air conditioner fans and not for the chilled water pump.	Medium	0.6 kW < P < 1.2 kW/rack (20 W < P < 40 W/ft^2) (215 W < P < 430 W/m^2)
3			High	1.2 kW < P < 3.3 kW/rack (40 W < P < 110 W/ft^2) (430 W < P < 1184 W/m^2)
4	Class A	Uninterruptible cooling; the UPS supplies power for precision air conditioner	Ultra high	P > 4.0k W/rack (P > 133 W/ft^2) (P > 1432 W/m^2)

No.	Continuous Cooling Class	Continuous Cooling Requirements	IT Power Density	IT Power Density Value
		fans and the secondary chilled water pump. The chilled water tank is configured.		

1.3 Why the UPS Needs to Be Used for Power Supply for Precision Air Conditioners?

To resolve the problem of power distribution for air conditioners, in general solutions, diesel generators are used to supply power for IT devices and air conditioners. However, a period of time is needed for starting diesel generators. According to requirements in the preceding table, in high-density data centers, diesel generators must be started within 4 minutes. Risks actually exist.

Due to all these factors, people started to consider about using the UPS to supply power for precision air conditioners, to ensure that continuous cooling requirements are still satisfied when mains power supply powers off or diesel generators cannot work normally. Using the UPS to distribute power for precision air conditioners can ensure that continuous cooling requirements are satisfied in data centers of data centers.

(1) When diesel generators are configured, using the UPS can ensure that precision air conditioners continuously work when diesel generators cannot be normally started, to avoid service interruption caused by shutdown of devices due to too high temperature.

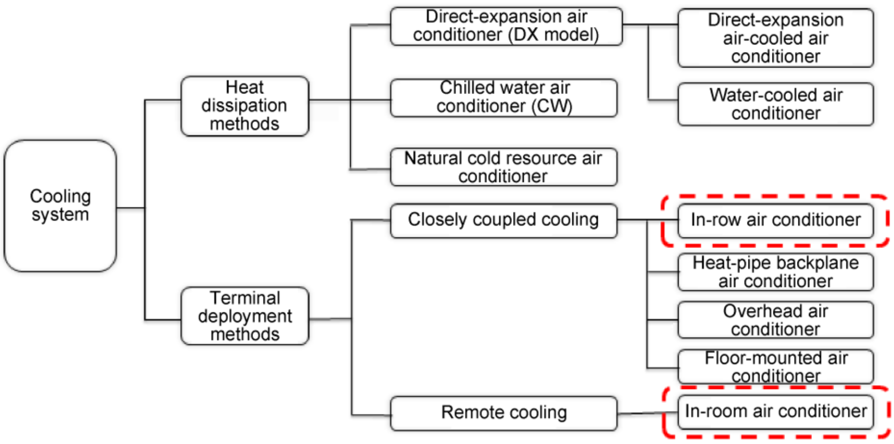
(2) When diesel generators cannot be configured due to the limited space or other restrictions, using the UPS to supply power for precision air conditioners can meet continuous cooling requirements.

As precision air conditioners are inductive loads, a general belief in the industry is that their start-up currents have high impacts. When you plan to use the UPS to supply power for precision air conditioners, how to select the one with the proper capacity is a key issue.

2. Architecture Requirements of Precision Air Conditioners for Power Distribution

At present, precision air conditioners that are commonly used are classified into closely coupled cooling in-row air conditioners and remote cooling in-room air conditioners based on terminal deployment methods and into direct-expansion air conditioners and chilled water air conditioners based on heat dissipation methods. The common cooling system of a data center is shown in the following figure.

Figure 1 Precision air conditioners that are commonly used by a data center

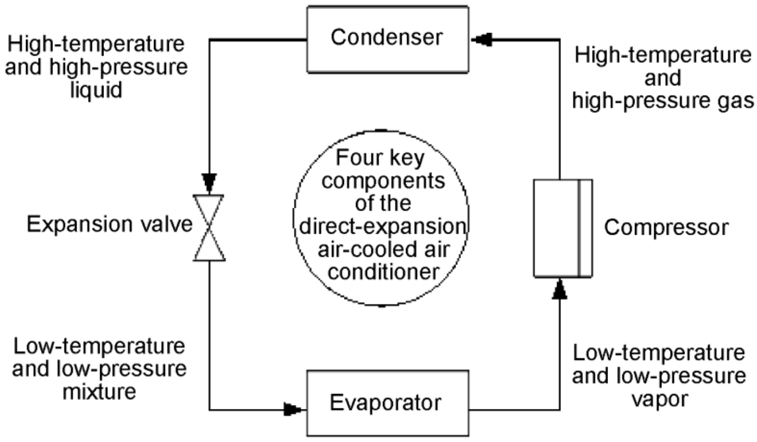


2.1 Characteristics of Power Supply and Distribution for Direct-expansion Air Conditioners

The operating principle of direct-expansion air conditioners is as follows: The cooling compressor compresses the refrigerant in the gaseous state to change its state into high-temperature and high-pressure. The condenser then condenses the refrigerant into the high-temperature and high-pressure liquid to release the heat. The liquid refrigerant flows through the throttling device (also called expansion valve) for pressure drop and evaporates in the evaporator to the low-temperature and low-pressure gas, which absorbs heats of neighboring devices and lowers the ambient temperature, to achieve the cooling target.

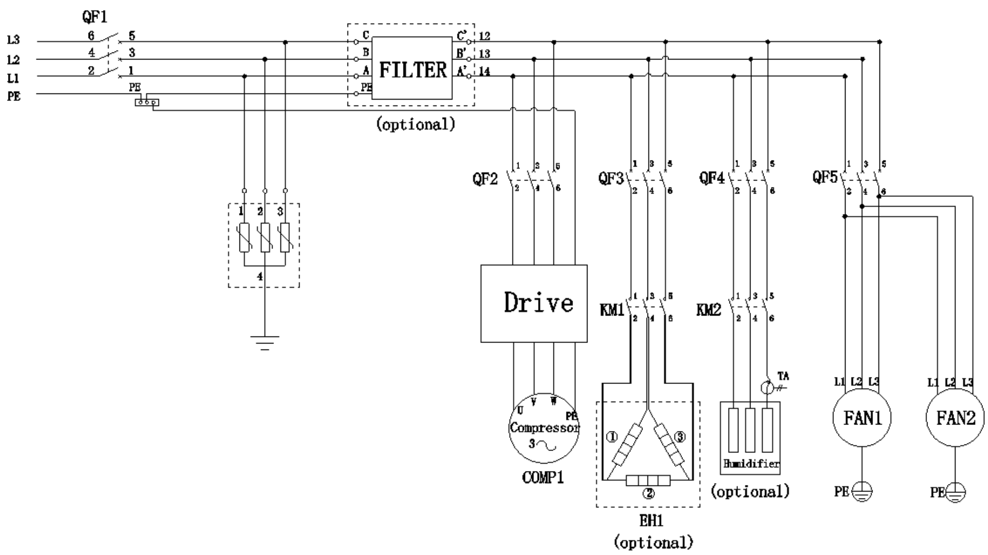
Direct-expansion air conditioners have four key components, evaporator, compressor, condenser, and throttling device (expansion valve). Figure 2 shows the operating principle of direct-expansion air conditioners. In actual use, to facilitate running of the evaporator and condenser, they need to be configured with forced-convection fans separately and be installed in two enclosures separately, one is indoors and the other is outdoors (also called indoor unit and outdoor unit).

Figure 2 Key components of a direct-expansion air conditioner



The three-phase power mode is usually adopted for direct-expansion air conditioners. The power supply is usually 380–415 VAC/50 Hz, 380–415 VAC/60 Hz, and 440–480 VAC/60 Hz. In an air conditioning system, indoors units (fans and control system) are usually started first, the outdoor condenser is then started, and the cooling compressor is started at last. Figure 3 shows power distribution for the direct-expansion air-cooled air conditioner. When you plan to use the UPS to supply power, consider power supply requirements of the indoor air conditioner fans and control system as well as outdoor condenser and cooling compressor based on the power distribution architecture and unit starting sequence to select a proper UPS to ensure high cost efficiency.

Figure 3 Power distribution architecture of the direct-expansion air-cooled air conditioner



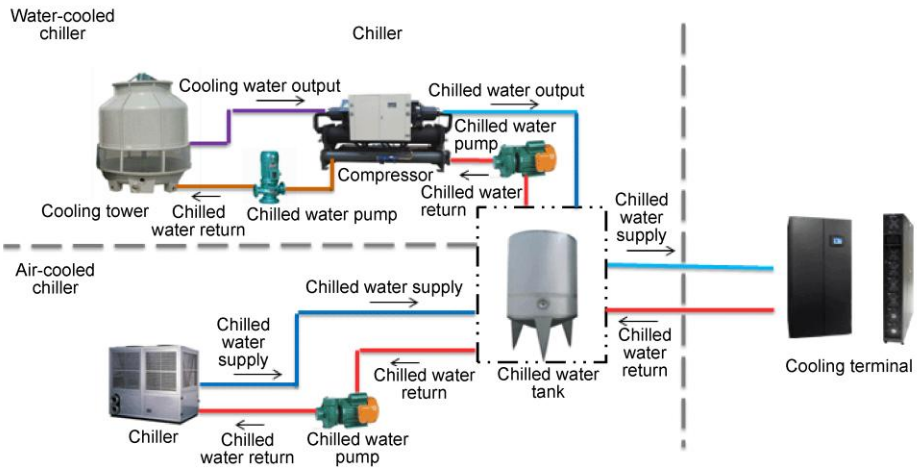
2.2 Characteristics of Power Supply and Distribution for Chilled Water Air Conditioners

With wider and wider application of data centers with high power density (the power density/cabinet exceeds 5 kW), the heat density of data centers increases accordingly. At the same time, the new generation of green data centers requires lower PUE. All these require adoption of the cooling method with the higher energy efficiency ratio for data centers. Chilled water air conditioners can better satisfy cooling requirements of the new generation of data centers.

Chilled water air conditioners use the chiller to produce low-temperature chilled water. Driven by the chilled water pump, the chilled water is sent to the chilled water air conditioner in the data center through water pipes. Air conditioner fans drive indoor air to flow through the surface of the chilled water pan for temperature drop to cool IT devices. Chilled water flows back to the evaporator of the chiller through pipes for temperature drop again if its temperature rises. When the chiller powers off, cold air circulation in the data center can still be ensured only if we ensure power supply for the chilled water pump and the air conditioner.

Chillers, as devices that realize cooling through vapor compression, can be classified into water-cooled chillers and air-cooled chillers based on different heat dissipation methods of their condensers. Water-cooled chillers use the chilled water for heat dissipation of condensers. Cooling towers are usually configured. Air-cooled chillers utilize the ambient air for heat dissipation of condensers. The constitution of the two types of chillers is shown in the following figure.

Figure 4 constitution of two types of chillers



The single-phase power mode is adopted for chilled water air conditioners. The power supply is 200-240 VAC/50 Hz or 200-240 VAC/60 Hz. When using the UPS, mainly consider power supply requirements of terminal fans.

3. Analysis of UPS Configuration for Precision Air Conditioners

For direct-expansion air conditioners and chilled water air conditioners that are most commonly used in data centers, basic suggestions for UPS selection are given in the following.

3.1 Analysis of UPS Configuration for Direct-expansion Air Conditioners

Direct-expansion air conditioners include direct-expansion air-cooled air conditioners and water-cooled air conditioners. The difference between them is heat dissipation methods of outdoor condensers.

At present, in the industry of direct-expansion air conditioners, indoor cooling compressors are usually scroll compressors to adjust the variable capacity. Scroll compressors usually adopt digital scroll technologies, AC frequency conversion technologies, and DC frequency conversion technologies to realize adjustments of the variable capacity. Comparison of these technologies are as follows.

Table 3 Technology comparison of compressors of direct-expansion air conditioners

	Digital Scroll Technologies	AC Frequency Conversion Technologies	DC Frequency Conversion Technologies
Basic principle	Flexible design of compressors; adjust the output of compressors by adjusting the axial distance of two scrolls.	Use the asynchronous motor. Change AC into DC through the frequency converter and then change DC back to AC. In this way, change the frequency of the power supply and control the rotational speed of the motor.	Use the synchronous permanent magnet motor. The frequency converter serves as the motor rotor. There is no electric power loss.
Rotational speed	50/60 Hz	15–120 Hz	15–120 Hz
EER	3.0–3.4	2.2–2.6	3.1–3.5
IPLV	3.2–3.6	2.6–3.0	3.6–4.0
Impacts of start-up currents	The intensity of start-up currents is 4 to 7 times as high as that of rated currents.	Start-up currents have no impacts and their intensity is lower than that of rated currents.	Start-up currents have no impacts and their intensity is lower than that of rated currents.
System stability	Some loads frequently increase and reduce the load. As a result, the fluctuation of the compressor between the high voltage and the low voltage is as high as about 3 bars. Components are easily damaged. Reliability is low.	Some loads convert the frequency to adjust the speed and run stably. The fluctuation between the high voltage and the low voltage is lower than 1 bar. Reliability of components is high and the service life of them is long.	Some loads convert the frequency to adjust the speed and run stably. The fluctuation between the high voltage and the low voltage is lower than 1 bar. Reliability of components are high and the service life of them is long.

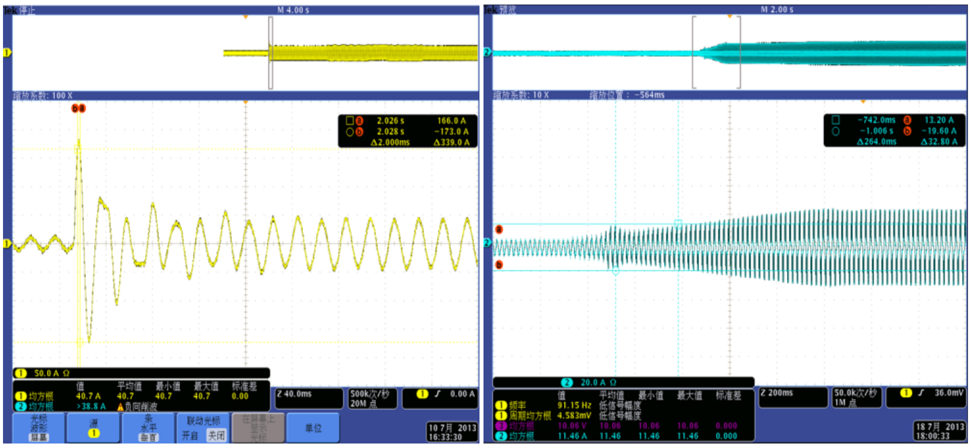
Seeing from the performance and reliability, the motor of the compressor that adopts DC frequency conversion technologies has large start-up torque and high efficiency (low loss and high power factor) and is precise in speed adjustment. In addition, the motor has high power to volume ratio and reliability and its service life is long. Technologies are mature and stable. In comparison, though digital scroll technologies have been applied in markets for a long period of time, their speed adjustment range is small and their IPLV is worse than DC frequency conversion technologies. They cannot properly support cooling of data centers that require high efficiency of some loads.

The most prominent difference between compressors that adopt AC frequency conversion technologies and that adopt DC frequency conversion technologies is the drive technology. If the synchronous permanent magnet motor is used, it means that DC frequency conversion technologies are adopted. If the asynchronous AC motor is used, it means that AC frequency conversion technologies are adopted. Though DC frequency conversion technologies and AC frequency conversion technologies are both frequency conversion technologies, they are two generations of technologies. AC frequency conversion technologies are basically replaced by DC frequency conversion technologies as AC frequency conversion technologies have many disadvantages such as low energy efficiency and complicated magnet excitation logic. Therefore, mainstream compressor vendors all focus on DC frequency conversion technologies, as the technologies can better support load change and energy saving requirements of data centers.

As shown by table 3, start-up currents of digital scroll compressors and frequency conversion compressors have great differences in terms of impacts. When the UPS is used for power distribution for direct-expansion air-cooled air conditioners, consider impacts of start-up currents of compressors. Take the 35 kW air-cooled in-row precision air conditioner as an example. Vendor A uses the digital scroll compressor, while vendor B uses the DC frequency conversion compressor. Start-up currents are as shown in the following.

Figure 5 Start-up current comparison of 35 kW air-cooled in-row precision air conditioners

a. Digital scroll compressor b. DC frequency conversion compressor



(Test conditions: 40.6°C and 20% RH indoors and 45°C outdoors)

Technical parameters provided by vendors A and B and test results show that the intensity of start-up currents of the DX model precision air conditioner using the digital scroll compressor is 5 times as high as that of rated currents, while the intensity of start-up currents of the DX model precision air conditioner using the DC frequency conversion compressor is lower than that of rated currents. Test results are as follows.

Table 4 Start-up current comparison of typical DX model precision air conditioners

	Vendor A (Using the Digital Scroll Compressor)	Vendor B (Using the DC Frequency Conversion Compressor)
Cooling capacity (kW)	35	35
EER	3.0–3.4	3.1–3.5
Full-load current (A)	36.7	32
Start-up current (A)	173	Lower than 32
Start-up current/Rated current	4.7	Lower than 1

Direct-expansion air-cooled air conditioners consist of the fan rotational speed controller (including the compressor frequency converter), electric control box, condenser, rack, and fans. The intensity of their start-up currents is lower than that of full-load currents. When using the UPS to supply power for air-cooled condensers, only take into consideration their full-load rated currents.

For example, with T1 conditions (temperate climate; the ambient temperature ranges from –20°C to +45°C), the air-cooled outdoor unit with 38 kW heat dissipating capacity whose input power mode is 380–415 VAC/3 Ph/50/60 Hz. The intensity of its full-load currents is 2.5 A. Set the power factor to 0.8. Then power of the outdoor unit is

$$\sqrt{3} \cdot 2.5 \cdot 380 \cdot 0.8 = 1.3kW$$

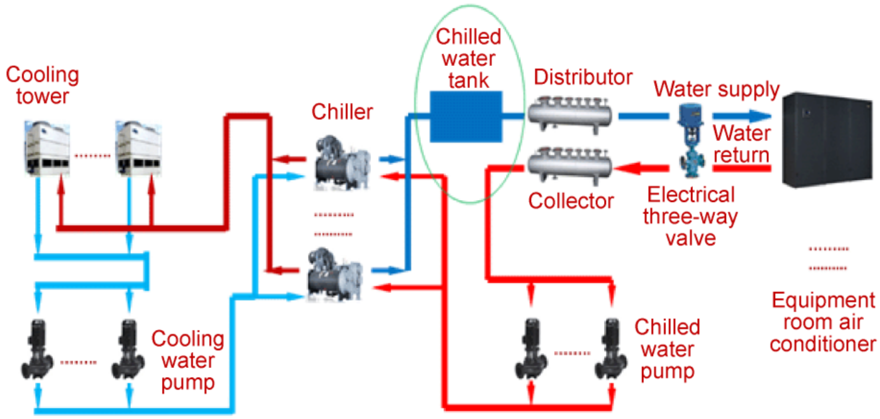
For water-cooled air conditioners, if the digital scroll compressor is used, impacts of currents whose intensity is 5 times as high as that of rated currents should be taken into consideration. If frequency conversion technologies are applied, to use the UPS to supply power, only the power of rated currents needs to be taken into consideration, as the intensity of start-up currents of the frequency conversion compressor is lower than that of rated currents. Moreover, according to GB/T50174-2008 redundancy design principles, consider redundancy coefficient of 1.2 times.

The cooling system of water-cooled air conditioners is configured with the cooling water pump and cooling tower. Cooling water pumps include constant frequency pumps or variable frequency pumps. In the cooling tower, fans are used. Therefore, UPSs can be selected based on specific pumps and fan types.

3.2 Analysis of UPS Configuration for Chilled Water Air Conditioners

According to definition of continuous cooling classes of the Uptime Institute for the chilled water air conditioning system, the UPS is used to supply power for air conditioners in the uninterruptible cooling scenario (class A) and the continuous cooling scenario (class B). The different between the two is whether the chilled water tank is configured and whether the secondary chilled water pump is supplied with power by the UPS. If the chilled water tank is configured to store chilled water and the secondary chilled water pump and the terminal air conditioner are supplied with power by the UPS in the whole air conditioning system, the continuous cooling class is A. If only secondary chilled water pump and the terminal air conditioner are supplied with power by the UPS but the chilled water tank is not configured, the continuous cooling class is B. In the actual application, the overall architecture of a chilled water air conditioning system is shown in the following figure.

Figure 6 Overall architecture of the chilled water air conditioning system



According to the overall architecture of the chilled water air conditioning system, business continuity requirements of data centers, and configurations of the cooling system, the following solutions can be adopted:

Solution 1: Configure UPSs for the whole cooling system. For the chilled water air conditioning system, configure UPSs for the chiller, chilling tower, primary and secondary pumps, and precision air conditioner, to ensure uninterruptible operations of the whole cooling system. However, as costs are high, the solution is rarely adopted in actual projects.

Solution 2: In the chilled water air conditioning system, configure air conditioner fans and secondary pumps with UPSs and increase the chilled water tank in the chilled water circulation system to store chilled water. When the power supply powers off or the chiller cannot start due to power off, provide cooling sources through water circulation between the chilled water tank and pumps and have air conditioner fans run to maintain cold air circulation indoors, to ensure uninterruptible cooling in the data center. Compared with the first solution, this solution is more cost-efficient.

Above-mentioned two solutions can reach class A defined by the Uptime Institute.

Solution 3: In the chilled water air conditioning system, configure air conditioner fans and secondary pumps with UPSs but not configure the chilled water tank. When the power supply powers off or mechanical cooling fails, air conditioner fans maintain air circulation in the data center and utilize residual chilled water in pipes to ensure cooling and slow down temperature rise in the data center. This solution reaches class B defined by the

Uptime Institute. Moreover, it is also cost-efficient.

3.3 Suggestions for UPS Configuration for Terminal Air Conditioners

No matter in which cooling scenarios, class A or B defined by the Uptime Institute, first consider UPS configuration for terminal precision air conditioners.

The main component of terminal precision air conditioners in the chilled water air conditioning system is fan. There are AC fans and EC fans for selection. In the actual application, motors of EC fans are DC brushless maintenance-free with in-built intelligent control modules. They have characteristics of high intelligence, high energy saving, high efficiency, long service life, slight vibration, small noise, and uninterruptible working. They can realize stepless speed regulation, better match with air volume of servers, and achieve the best energy-saving effect. Therefore, most of vendors select EC fans for terminal precision air conditioners.

The intensity of start-up currents of terminal precision air conditioners that use EC fans is lower than that of rated currents. Therefore, when configuring UPSs, mainly consider full-load operating power of terminal air conditioners. Take the 30 kW chilled water in-row air conditioner of a brand as an example. The air conditioner is configured with 8 fans. The intensity of its full-load currents is 5.5 A. The power factor is usually set to 0.8. Then, the full-load power is: 5.5 A x 220 V x 0.8 ≈ 1 kW. With consideration of the 0.9 output power factor and the redundancy coefficient of 1.2 times of the UPS, the required UPS capacity is: 1.2 x 1/0.9 = 1.3 kVA.

3.4 Suggestions for UPS Use for Secondary Chilled Water Pumps

The secondary chilled water pump is another key component of the chilled water air conditioning system. For continuous cooling, consider using the UPS to supply power for pumps.

Secondary chilled water pumps are usually selected based on the installation position, space, pressure bearing, water flow rate of pipes, and head. Secondary chilled water pumps are classified into constant frequency pumps and variable frequency pumps based on electrical characteristics. Take into consideration types of pumps used in actual projects in selecting UPSs. In configuring UPSs for secondary chilled water pumps, for constant frequency pumps, consider start-up currents whose intensity is 5 times as high as that of rated currents. For variable frequency pumps, consider a certain redundancy coefficient, usually 1.2 times.

4. Suggestions for UPS Selection for Precision Air Conditioners

After analyzing UPS configuration for direct-expansion air-cooled air conditioners and chilled water air conditioners, we can see that UPSs can be used to supply power for precision air conditioners to meet continuous cooling requirements. Select a cost-efficient solution after comprehensively considering business requirements, cooling class, and investment costs. In principle, UPSs are selected based on the air conditioning system. There are two main types of air conditioners, direct-expansion air conditioners and chilled water air conditioners. Calculation for selection is as in table 5.

4.1 Suggestions for Selecting UPSs for Direct-expansion Air Conditioners

Table 5 Calculation for selecting UPSs for direct-expansion air conditioners

No.	Description	Calculation	Remarks
1	Full-load current of the indoor unit of an air conditioner I (A)	I	Data can be obtained from product manuals of vendors. If the air conditioner uses the digital scroll compressor, adopt the intensity of full-load current without heating and humidification as the I value.
2	Full-load power of the indoor unit of an air conditioner P1 (W)	$P_1 = \sqrt{3} \cdot I \cdot 380 \cdot \cos\varphi$	The input of the direct-expansion air conditioner is three-phase 380 V. The power factor cosφ is usually set to 0.8.
3	Total power of indoor units of air conditioners Ptotal (W)	$P_{total} = P_1 \cdot (n-1)$	The total power is the total operating power of all air conditioners. "n" is the total number of air conditioners that have the continuous cooling capability.
4	Required UPS power P_{UPS} (W)	$P_{UPS} = P_{total} + 5 \cdot \sqrt{3} \cdot I \cdot 380 \cdot \cos\varphi$	The air conditioning system is controlled by the group control system, and units are started

No.	Description	Calculation	Remarks
		$P_{UPS} = P_{total} + \sqrt{3} \cdot I \cdot 380 \cdot \cos\varphi$	according to an order. The first formula should be used in calculation for precision air conditioners equipped with the frequency conversion compressor. The second formula should be used in calculation for direct-expansion air conditioners equipped with the digital scroll compressor.
5	UPS capacity (VA)	$1.2 \cdot P_{UPS} / PF$	PF is the output power factor of the UPS. For high-frequency UPSs, the factor value should be 0.9. For power-frequency UPSs, the factor value should be 0.8 and the redundancy coefficient value is 1.2 times. Select the USP that meets capacity requirements.

If the UPS is used to supply power also for the outdoor condenser in using direct-expansion air-cooled air conditioning system, the whole system meets uninterruptible cooling requirements and reaches class A of the Uptime Institute. If the UPS is used to supply power only for indoor precision air conditioners, when mains power supply powers off, use UPS batteries to supply power to ensure air circulation and slow down temperature rise in the data center.

4.2 Suggestions for Selecting UPSs for Chilled Water Air Conditioners

Table 6 Calculation for selecting UPSs for chilled water air conditioners

No.	Description	Calculation	Remarks
1	Full-load current of the terminal air conditioner I (A)	I	For terminal air conditioners in the chilled water air conditioning system, mainly consider fan types. EC fans are used most commonly.
2	Input electric power of the terminal air conditioner P1 (W)	$P_1 = U \cdot I \cdot \cos\varphi$	The input of the terminal air conditioner in the chilled water air conditioning system is single-phase 220 V. The power factor value is usually set to 0.8.
3	Total power of air conditioners Ptotal (W)	$P_{total} = P_1 \cdot n$	The total power is the total operating power of all air conditioners. "n" is the total number of air conditioners that have the continuous cooling capability.
4	Power of the cooling water pump P2 (W)	$P2$	Power of a pump
5	Total power of pumps Ppump (W)	$P_{pump} = P2 * \lambda$	"λ" is the number of pumps needed for ensuring chilled water circulation in continuous cooling.
6	Required UPS power P_{UPS} (W)	$P_{UPS} = P_{total} + (P_{pump} + 5 \cdot P2)$ $P_{UPS} = P_{total} + P_{pump}$	Assume that only an air conditioner and a pump start at one time. If the pump is with constant frequency, use the first formula. If the pump is with variable frequency,

No.	Description	Calculation	Remarks
			use the second formula.
7	UPS capacity	$1.2 \cdot P_{UPS} / PF$	PF is the power factor of the UPS. For high-frequency UPSs, the factor value should be 0.9. For power-frequency UPSs, the factor value should be 0.8 and the redundancy coefficient value is 1.2 times. Select the USP that meets capacity requirements.

Note: As distortion of the output voltage may be caused by running of precision air conditioner fans, a separate UPS should be configured for the air conditioner rather than have the air conditioner use the same UPS with IT devices.

5. Configuration for Reference

Take air-cooled in-row precision air conditioners and chilled water in-row precision air conditioners launched by Huawei as examples, to express the principle of configuring UPSs for precision air conditioners.

5.1 UPS Configuration for Air-cooled Precision Conditioners Using Non-frequency Conversion Compressors

The compressor of Huawei NetCol 5000-A 20 kW in-row air conditioner is a non-frequency conversion compressor. Impacts of start-up currents on the UPS need to be taken into consideration. From the product manual, we can get information that the intensity of full-load currents of Huawei NetCol 5000-A 20 kW in-row air conditioner is 23 A (16.5 A without heating and humidification). The heating and humidification function of the air conditioner in start-up is not considered temporarily. Set the power factor value of the air conditioner to 0.8.

When the heating and humidification function is not considered, the maximum electric power P1 of the 20 kW air conditioner is

$$P1 = \sqrt{3} \cdot 16.5 \cdot 380 \cdot 0.8 = 8.7kW$$

Even when the air conditioner is in a full-load state, the power required is

$$\sqrt{3} \cdot 23 \cdot 380 \cdot 0.8 = 12.1kW$$

When impacts of start-up currents of the air conditioner are taken into consideration, what only needs to be considered is to ensure that the intensity of full-load currents without the heating and humidification function be 5 times as high as that of rated currents without the heating and humidification function. At this time, the power of the UPS should be

$$P_{total} = 5 \cdot \sqrt{3} \cdot 16.5 \cdot 380 \cdot 0.8 = 43.5kW$$

The UPS also needs to be used to supply power for the outdoor condenser. Assume that conditions are T1. Use the NetCol500-A 032 condenser provided by Huawei. The intensity of its full-load currents of the condenser is 2.5 A. Set the power factor to 0.8. Then, the power of the condenser is

$$P_{outdoor} = \sqrt{3} \cdot 2.5 \cdot 380 \cdot 0.8 = 1.3kW$$

According to aforesaid analysis, as the power of the outdoor condenser is low. For the whole air-cooled precision air conditioning system, in determining the UPS capacity, only consider corresponding electric power of start-up currents of the compressor to meet power distribution requirements.

When the high-frequency UPS is used to supply power for the 20 kW direct-expansion air-cooled air conditioner, set the output power factor of the UPS to 0.9 and consider the redundancy coefficient of 1.2 times. The UPS capacity is

$$1.2 \cdot 43.5 / 0.9 = 58kVA$$

5.2 UPS Configuration for Air-cooled Precision Conditioners Using Frequency Conversion Compressors

The NetCol 5000-A 25 kW air-cooled in-row precision air conditioner using DC frequency conversion technologies is used. The intensity of its full-load currents is 29 A. Set the power factor to 0.8. Then, the electric power P1 is

$$P1 = \sqrt{3} \cdot 29 \cdot 380 \cdot 0.8 = 15.3kW$$

The UPS also needs to be used to supply power for the outdoor condenser. Assume that conditions are T1. Use the NetCol500-A 032 condenser provided by Huawei. The intensity of its full-load currents is 2.5 A. Set the power factor to 0.8. Then, its power Poutdoor is

$$P_{outdoor} = \sqrt{3} \cdot 2.5 \cdot 380 \cdot 0.8 = 1.3kW$$

Therefore, the power required by the whole air conditioning system is

$$P_1 + P_{outdoor} = 15.3 + 1.3 = 16.6kW$$

When the high-frequency UPS is used to supply power for the 25 kW direct-expansion air-cooled air conditioner, set the output power factor of the UPS to 0.9 and consider the redundancy coefficient of 1.2 times. The UPS capacity is

$$1.2 \cdot 16.6 / 0.9 = 22.1kVA$$

5.3 UPS Configuration for Chilled Water Air Conditioners

Huawei provides the chilled water in-row air conditioner NetCol 5000-C030H. Its terminal fans are EC fans, whose start-up currents have low impacts. Seeing from product parameters, the intensity of full-load currents is 5.5 A. Set the power factor to 0.9. Then, the electric power P1 is

$$P1 = 5.5 \cdot 220 \cdot 0.8 \approx 1kW$$

Use the high-frequency UPS to supply power for the terminal air conditioner in the chilled water air conditioning system. Set the output power factor of the UPS to 0.9 and consider the redundancy coefficient of 1.2 times. Then, the UPS capacity is

$$1.2 \cdot 1 / 0.9 = 1.3kVA$$

What needs attention is that chilled water pumps usually need to be configured for storing chilled water in the chilled water air conditioning system. The power of chilled water pumps should be determined based on the installation position, space, pressure bearing, water flow rate of pipes, and head. No more information is introduced here. However, to realize continuous cooling, at least use the UPS to supply power for chilled water pumps.

5.4 Recommended UPS Configuration for Huawei Air-cooled Precision Air Conditioners

Consider using UPSs to supply power for all Huawei air-cooled precision air conditioners. According to recommended configuration parts and above-mentioned configuration principles, the recommended UPS capacity is shown in the following table.

Precision Air Conditioner Model	Netcol5000-A020H	NetCol5000-A025H	NetCol5000-A035H	NetCol8000-A050D	NetCol8000-A0100D
Terminal deployment methods	In-row horizontal air supply air-cooled			In-room under floor air supply	
Outdoor condenser model (T1 conditions)	NetCol500-A032*1	NetCol500-A032*1	NetCol500-A038*1	NetCol500-A072*1	NetCol500-A072*2
Outdoor condenser model (T3 conditions)	NetCol500-A038*1	NetCol500-A038*1	NetCol500-A072*1	NetCol500-A088*1	NetCol500-A088*2
Recommended UPS capacity	60 kVA	30 kVA	30 kVA	160 kVA	280 kVA

6. Summary

High reliability and high usability are always pursued by data center builders. With constant application of high-power data centers, continuous cooling is a topic that must be attached with importance. Using UPSs to supply power for precision air conditioners for continuous cooling has gained attention in the industry and has been realized in some places. Data center designers need to select proper UPSs by comprehensively considering the installation environment, investment costs, and maintenance easiness to supply power for precision air conditioners to satisfy requirements of data centers whose heat density becomes higher and higher and support service development of data centers.

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