High-Capacity Power Supply System That Contributes to Stable Power Supply for Data Centers

HAMADA, Ippei*

ABSTRACT

In recent years, there has been an increase in the number of large-scale data centers (DCs) throughout the world as companies move information systems to the cloud and expand their use of e-commerce. This trend has also increased the demand for high capacity uninterruptible power systems (UPSs) capable of stabilizing the supply of power to the DCs. Fuji Electric, providing lineups of electrical equipment for power systems, has been promoting its Comprehensive Electrical Equipment Proposals that enhance supply reliability and economy. We have downsized our UPSs, which are key equipment of power systems, to reduce their footprints, migrated I/O-M functions to switchboards to shorten installation periods, and provided HE mode to save energy.

1. Introduction

In recent years, there has been an increase in the number of large-scale data centers (DCs) throughout the world as companies move information systems to the cloud and expand their use of e-commerce. This trend has also increased the demand for high-capacity power supply systems.

Fuji Electric has been providing DCs with electrical equipment, such as generators, uninterruptible power systems (UPS), gas-insulated switchgear (GIS), and transformers, as core components of large-scale power supply systems. The company uses its comprehensive technical capabilities to enhance the power supply reliability and economy of power supply systems. It is promoting its "Comprehensive Electrical Equipment Proposals" for all stages of the product life ranging from introduction planning to on-site construction and maintenance services to contribute to stable operation.

In this paper, we describe a high-capacity uninterruptible power systems (UPSs) that contributes to the stable power supply of DCs. It uses our "UPS7500WX" high-capacity UPS (see Fig. 1), which is designed to meet the requirements of footprint reduction and energy saving.

Fig.1 "UPS7500WX"

2. UPS System for Large-Scale DCs

2.1 Overview

Figure 2 shows the overall configuration of the power supply system for DCs. Electric power from extra-high voltage substation equipment consisting of transformers, switches, and other devices, or from emergency power generation equipment, is supplied to UPS system equipment through UPS input device, which changes power sources using devices such as switches. Individual UPS systems then distribute

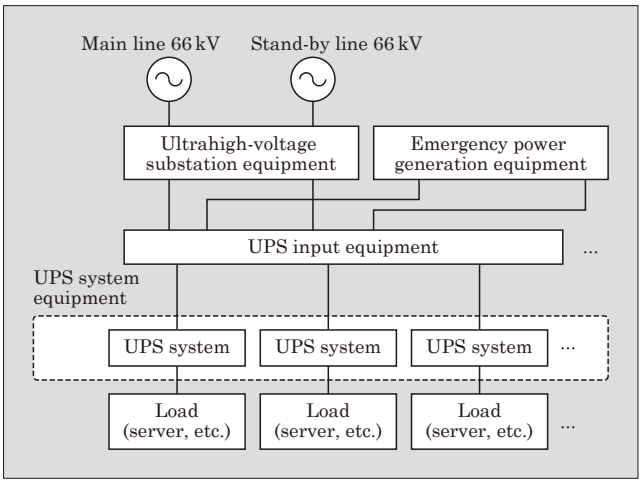

Fig.2 Overall configuration of the power supply system for DCs

* Power Electronics Energy Business Group, Fuji Electric Co., Ltd.

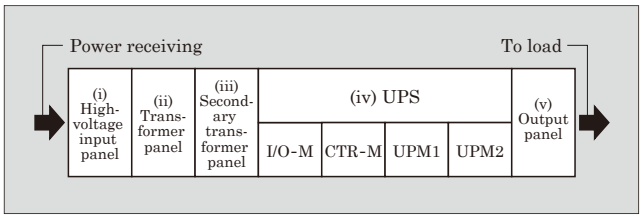

Fig.3 Example of UPS system configuration

power to servers and other loads. UPS systems are designed to protect servers and other information equipment from power failures, such as power outages and voltage fluctuations caused by lightning strikes, contributing to stable DC operations.

Figure 3 shows an example of a configuration for a UPS system. The UPS system consists of a high-voltage input panel, transformer panel, secondary transformer panel, UPS, and output panel. The high-voltage input panel, transformer panel, and output panel are generically referred to as peripheral panels. The high-voltage input panel receives the power from the UPS input equipment, and the output panel is connected to servers and other loads. Cables and bus ducts are used to connect the UPS to peripheral panels and between peripheral panels.

The UPS is the core piece of equipment in the UPS system. The basic configuration consists of an input and output module (I/O-M) for connecting main circuit cables and control signal lines, a control module (CTR-M) equipped with controllers and internal bypass circuits, and power conversion modules (UPM1 and UPM2) with a built-in rectifier and inverter.

2.2 UPS system challenges

(1) Reducing the installation footprint

A UPS system that comprises a high-capacity uninterruptible power system becomes large for the following reasons.

(a) Increased heat generation requires large heat sinks for cooling.

(b) Since the cross-sectional area of the conductor (busbar) increases in proportional to the square of the current value, the I/O-M that houses it needs to be larger.

At the same time, DC operators are requiring smaller footprints of electrical equipment to maximize the number of servers to be installed.[(1)]

(2) Shortening installation time

As the capacity of UPS systems increases, there is also an increase in the amount of wiring work since there will be more terminals that need to connect the UPS to peripheral panels and more cables and bus ducts used for the wiring.

DC operators need to set up servers and storage devices as quickly as possible. They thus require shorter on-site installation times for UPS systems and other power supply systems.

(3) Energy saving of UPS systems

Key equipment such as servers and storage devices require a high quality power feed with low fluctuations in voltage and frequency. On the other hand, some loads, such as air conditioning, are less affected by voltage and frequency fluctuations but consume a large amount of power. For these loads, the operation of UPS systems must prioritize energy saving over power quality.

3. UPS Systems with the "UPS7500WX"

3.1 Reducing UPS system footprint

(1) Reducing the size of the UPS

The UPS7500WX can be expanded in capacity from 600 kVA to 2,400 kVA by combining up to four 600-kVA power conversion modules (UPM) per system. Figure 4 shows the external dimensions of the UPS7500WX (1,200 kVA rated), and Table 1 shows its specifications.

The UPS7500WX (1,200 kVA rated) has a bottom surface with a dimensions of 3,500 mm wide and 900 mm deep, smallest in the industry. It can be installed compactly by placing it close to a wall or using two units back-to-back, because there is no need to provide maintenance space on the back or left and right sides of the unit.

(a) Improving the efficiency of UPM cooling

The interior of the UPM is divided into a forced-air cooling area (reactor, capacitor, rectifier, and inverter), where equipment with large heat generation is housed, and a self-cooling area (contactors and subcontroller), where equipment with small heat generation and no need for forced-air cooling is housed. Furthermore, only the forced-air cooling area is designed to directly receive cold air. This improves the cooling efficiency and reduces the size of the heat sink.

(b) Top exhaust and front maintenance

Forced air cooling is designed as a front intake and top exhaust system. This eliminates the need for exhaust space at the rear. The component layout enables maintenance to be performed from the front

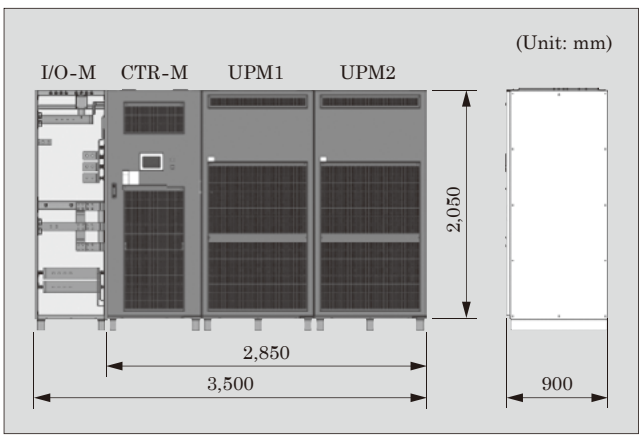

Fig.4 Outline of "UPS7500WX" (1,200 kVA rated)

Table 1 Specifications of the "UPS7500WX" (1,200 kVA rated)

Item		Specification
System		Normal inverter feeding (HE mode selectable)
Rated capacity		1,200 kVA/1,200 kW
Dimensions		W3,500 × D900 × H2,050 (mm) (Including the I/O-M) W2,850 × D900 × H2,050 (mm) (Not including the I/O-M)
Conversion efficiency (max.)		96.6% (VFI*1), 99.0% (VFD*2)
Switchover time		Uninterrupted (VFI), <2 ms (VFD)
AC input	Number of phases (wires)	Three-phase four-wire
	Voltage	380, 400, 415, 420 V
	Frequency	50/60 Hz
	Input power factor	0.99 (lag) or higher, 1.0 or lower
	Input harmonic current	Overall 3% or less
Bypass input	Number of phases (wires)	Three-phase three-wire or three-phase four-wire
	Voltage	380, 400, 415, 420 V
DC input	Rated voltage	480 V
	Type	Lithium ion battery, lead-acid storage battery
AC output	Number of phases (wires)	Three-phase three-wire or three-phase four-wire
	Voltage	380, 400, 415, 420 V
	Frequency	50/60 Hz
	Output power factor	0.7 (lag) to 1.0
	Voltage accuracy	±1% or less (load balancing)
	Transient voltage fluctuation	±3% or less (sudden load change)
	Voltage distortion rate	2% or less (linear load) 2.5% or less (IEC 62040-3)
	Overload capability	125%: 10 min, 150%: 1 min (At recommended temperature)
Environment	Ambient temperature	0°C to 40°C (recommended 25°C)
	Ambient humidity	5% to 95% (no condensation)
Communication protocol		Web/SNMP, Modbus*3 RTU, Modbus TCP/IP

*1 VFI: Voltage and frequency independent
*2 VFD: Voltage and frequency dependent
*3 Modbus is a trademark or registered trademark of Schneider Automation, Inc.

of the equipment, eliminating the need for maintenance space on the left and right sides.

These enhancements have resulted in a reduced installation footprint.

(2) Reducing the size of the UPS systems

In general, I/O-Ms for UPS systems, in addition to their function of connecting cables, are equipped with electrical components, such as surge absorbers that protect electronic equipment from surge voltages caused by lightning strikes. The UPS7500WX moves these electrical components into the CTR-M. This made it possible to build a UPS system without an I/O-M by incorporating functionality to connect cables during the design and manufacture of the secondary transformer panel and output panel. The width of the UPS7500WX without the I/O-M is 2,850 mm, as shown in Fig. 4. This reduced the installation footprint by 19%.

3.2 Shortening installation time

Figure 5 shows the panel configuration diagrams of the UPS systems installed side-by-side.

As shown in Fig. 5(a), conventional UPS systems are configured by connecting the UPS and peripheral panels, and the UPS and peripheral panels are wired through an I/O-M. This requires external wiring out-

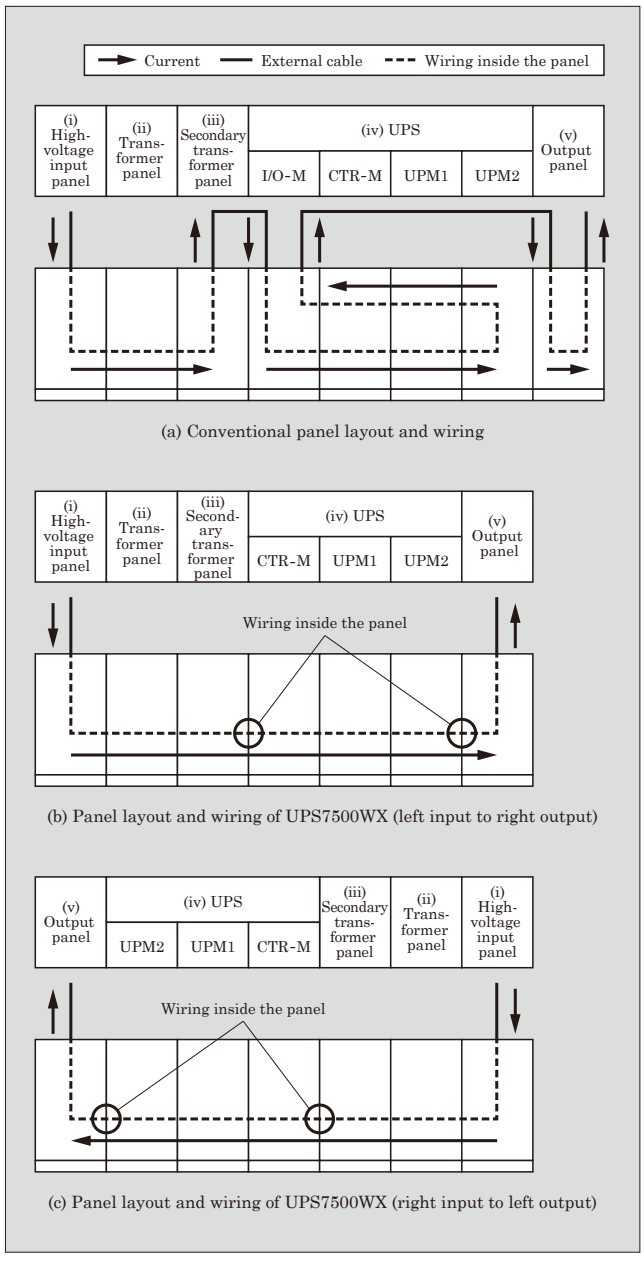

Fig.5 Panel configuration diagrams for UPS systems installed side-by-side.

side the panel using external cables and bus ducts. A larger DC increases the number of terminals and wiring work and lengthens the cable. This results in a longer installation period.

On the other hand, a UPS system that uses the UPS7500WX can be wired without an I/O-M. This means that all wiring between the UPS7500WX and the secondary transformer panel and output panel can be done inside the panel as shown in Figs. 5(b) and 5(c). Therefore, wiring outside the panel is limited to the input of the high-voltage input panel and the connection from the output panel to the load. This reduces wiring work and installation time compared to conventional systems.

The UPS7500WX can receive power from either the left or right side, as shown in Figs. 5(b) and 5(c). This is due to the interchangeable left and right layout of parts inside the CTR-M. The internal impedance and inductance remain the same regardless of whether power is received from the left or right side. This ensures that the quality of power supply is identical.

This design allows power to be received from either the left or right side, which is effective in reducing installation time when multiple UPS systems are to be installed.

Figure 6 shows the panel configuration diagrams (ceiling view) of the UPS systems installed side-by-side. As a specific example, it shows how two UPS systems can be installed back-to-back. Figure 6(i) through (iii) and (v) show the same panels as Fig. 5(i) through (iii) and (v). Conventional UPS systems can only receive power from a single side, as shown in Fig. 5(a). Therefore, as shown in Fig. 6(a), one UPS system can be wired to the UPS input equipment and server room at a minimum distance, but the other rear-mounted UPS system requires long-distance wiring from the UPS input equipment to the transformer panel, and from the output panel to the server room.

In contrast, a UPS system using the UPS7500WX can receive power from either the left or right side, and the flow of electricity can be in one direction from the UPS input equipment to the server room, as shown in Fig. 6(b). This allows any UPS system to be wired at the shortest possible distance.

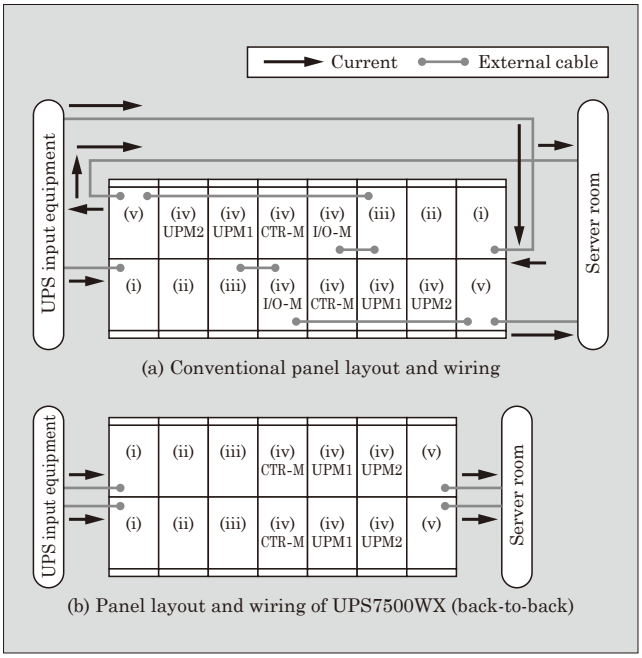

Fig.6 Panel configuration diagrams (ceiling view) of the UPS systems installed side-by-side.

3.3 Achieving energy saving using a high efficiency mode (HE mode) bypass circuit

As shown in Fig. 7, the UPS7500WX is equipped with a hybrid bypass circuit [see Fig. 7(a)] and HE mode bypass circuit [see Fig. 7(b)]. By selecting these circuits according to the type of load, the UPS system can achieve high efficiency and energy saving.

The hybrid bypass circuit is also included in conventional systems. It is a normal inverter feeding type that converts power with a rectifier and inverter during normal operation. It comes with a parallel circuit consisting of an AC switch that uses a thyristor designed for short-time withstand current and a switch. If a power failure or abnormality occurs, it switches to bypass input without interruption.[2] Its power conversion efficiency is 96.4%, but the minimal fluctuations in voltage and frequency make it suitable for feeding

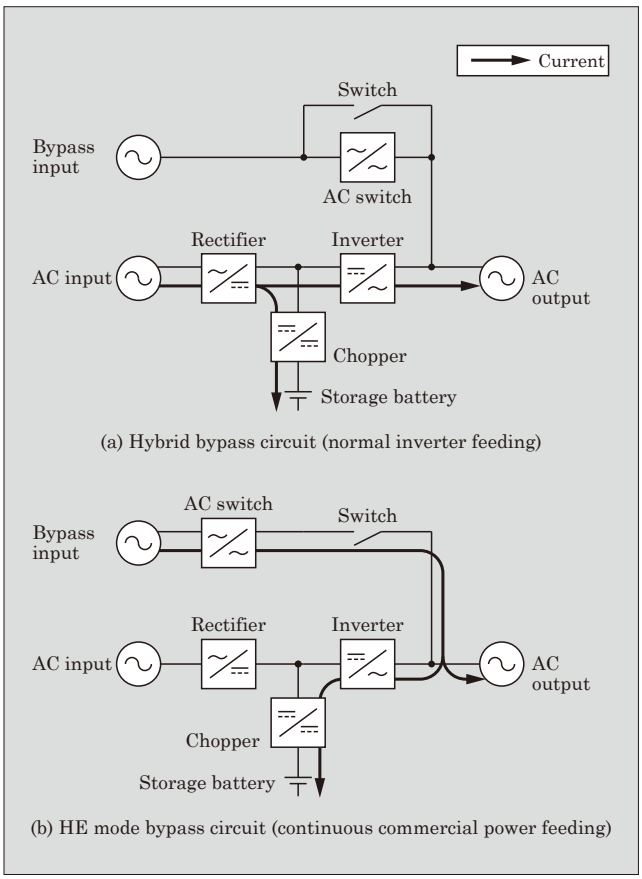

Fig.7 Selectable power feed methods

critical loads, such as servers and storage devices.

On the other hand, the UPS7500WX also comes with an HE mode bypass circuit that feeds the AC output from the bypass input during normal operations. It is a continuous commercial power feeding type that does not require a rectifier or inverter. Its series circuit consists of a switch and an AC switch that uses a thyristor designed for continuous operation current withstand. Its power conversion efficiency of 98.4% exceeds that of the hybrid bypass circuit. However, it is susceptible to voltage and frequency fluctuations, and it is suitable for use in loads with low power quality requirements, such as air-conditioning. Since it is a continuous commercial power feeding system, it is expected to be used to achieve energy saving in various countries with high grid power quality.

Moreover, if it detects a thyristor misfire or power failure due to power outage or lightning strike when the HE mode bypass circuit is selected, the system automatically switches to inverter power supply within 2 ms. In general, it takes approximately 10 ms for a power failure to adversely affect electrical and electronic equipment. However, this system performs switchover at a much faster speed.

4. Postscript

In this paper, we describe a high-capacity uninterruptible power system that contributes to stable power supply for data centers.

Moving forward, Fuji Electric will continue to contribute to reducing various environmental impacts, including global warming, through products and services that utilize its energy and environmental technologies.

References

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