# Static Transfer System Cabinet for Data Centers That Contributes to Stable Power Supply

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**ABSTRACT**

The need for supplying stable power to information equipment, such as servers is increasing as the use of cloud information systems and e-commerce are expanding. Fuji Electric has developed a static transfer system cabinet necessary for transferring in a 2N (duplex) system, a redundant configuration for power supply systems. It has a hybrid switch that uses mechanical switches and semiconductors switch together to speed up transferring, lower loss, and downsize the cabinet. It also deliver functions, such as accommodating a built-in bypass breaker for maintenance, supporting the redundancy of major components, and reducing the effect on the load when switching under UPS synchronization, to improve the reliability of power systems, contributing to stable power supply.

## 1. Introduction

In data centers, which play a major role in the information society, the need is increasing for supplying stable power to information equipment, such as servers.

A measure to improve the reliability of power supply systems is to build a redundant system in which spare power supply equipment is incorporated. Even when a failure occurs in one power supply, the other unit continues to supply power. In such a case, the equipment that transfers power systems is called a static transfer system cabinet, whose reliability greatly affects the reliability of the whole power supply system.

This paper describes the static transfer system cabinet for data centers that improves voltage stability and maintainability to supply stable power.

## 2. Static Transfer System Cabinet Overview

### 2.1 Redundancy of power supply systems

Figure 1 shows examples of typical configurations of power supply systems using uninterruptible power systems (UPSs).

Assuming that N is the required number of UPSs, an N+1 configuration can supply power from the remaining UPSs even if one of the UPSs fails. A "2N" configuration is a dual power supply system including power receiving systems. Table 1 shows the advantages of these configurations. The "2N" power supply system has the highest reliability, but requires the static transfer system cabinet to transfer between the two power supply systems.

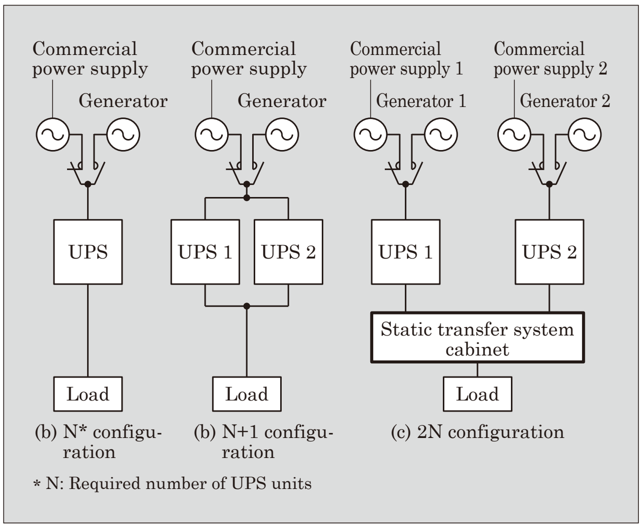


Fig.1 Examples of typical configurations of power supply systems (when N = 1)

Table 1 Comparison of power supply system configurations

○ : Advantageous, △ : Standard, × : Disadvantageous

| | N | N+1 | 2N |
|---|---|---|---|
| Cost | ○ Low in cost due to the simplest configuration | △ | × High in cost due to the largest number of equipment |
| Reliability | × Unable to cope with power outage or momentary power failure in the event of a UPS failure | △ Able to cope with power outage or momentary power failure even if one UPS fails. However, if an accident occurs in a common part such as the UPS input or output component, there is a risk of power supply stoppage. | ○ Able to supply power even in the event of a failure or a trouble not only in a UPS but also in higher level systems (such as a power supply or generator) |

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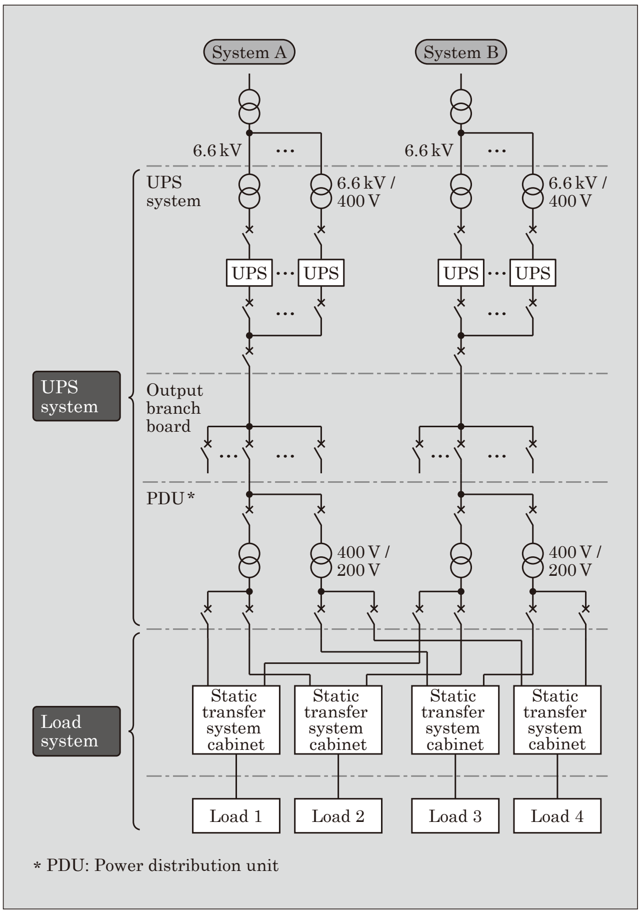


Fig.2 Example of power supply system configuration

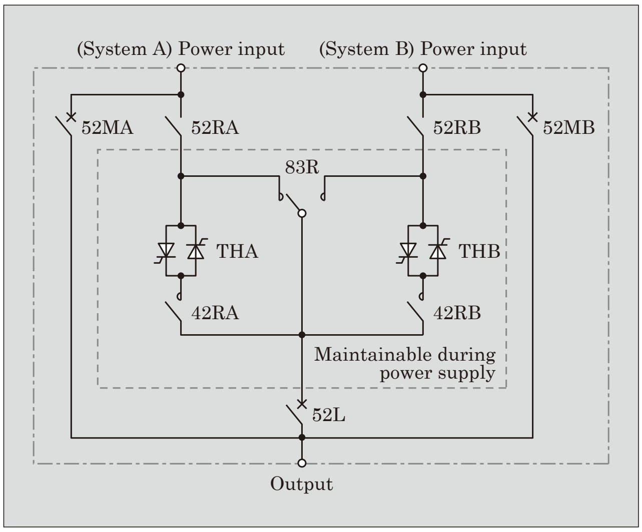


Fig.3 Internal configuration of the static transfer system cabinet

### 2.2 Power supply system configuration using the static transfer system cabinet

Figure 2 shows an example of a configuration for power supply systems combining the static transfer system cabinets and UPSs. This configuration is to divide a UPS output according to the load capacity, and with transformers provided individually, perform power supply system transferring for load systems using the static transfer system cabinets. Thus, even if a failure occurs in one of the systems, the power supply from the other system can continue, thereby providing a highly reliable power supply system.

### 2.3 Internal configuration of a static transfer system cabinet

Figure 3 shows the internal configuration of a static transfer system cabinet. It is composed of a high-speed opening, double-throw magnetic contactor (mechanical switch) (83R) connecting the power supply input of system A and system B to the bus output, quick-acting bidirectional semiconductor switches (THA, THB) connected in parallel with 83R, input switches (non-trip switches) (52RA, 52RB), bypass breakers for maintenance (52MA, 52MB), and an output bus circuit-breaker (52 L). Output magnetic contactors (42RA, 42RB), normally in a closed state, are provided to prevent a sneak current from the other power supply when a power outage occurs in the power supply input component and to disconnect the line when a semiconductor switch failures.

52RA, 52RB and 52 L are breakers for maintenance purposes and are always in a closed state during operation.

## 3. Problems with Conventional Static Transfer System Cabinets

### 3.1 Compatibility between transferring speed enhancement and low power loss and size reduction

During power supply transferring, the power supply to loads is instantaneously cut off. It is thus important for static transfer system cabinets to perform transferring operation at high speeds.

For this reason, conventional static transfer system cabinets have used continuously energized semiconductor switches, which have high responsiveness, but they are disadvantageous in that they cause large power loss because of the need for continuous energization and affect power quality because of their frequency dependence. In addition, the semiconductor switches require coolers and cooling equipment, which increase the overall equipment size.

To cope with these problems, some systems have used mechanical switches rather than semiconductor switches for transferring. The closing time, however, is usually several tens of ms, and even a high-speed type takes 10 to 20 ms, meaning that they are not suitable for speed enhancement.

### 3.2 Maintainability improvement

Regular maintenance is essential to maintain the reliability of static transfer system cabinets. However, conventional static transfer system cabinets have no bypass circuit that enables maintenance under a continuously energized state. For this reason, it has sometimes been necessary to perform maintenance work while carrying out wiring outside the cabinets. On the other hand, there has been a problem that the incorporation of such a bypass circuit in the cabinet leads to increase in the number of wires, resulting in increase in the cabinet size.

### 3.3 Stable power supply to loads during transfer

Data centers are rated at the Tiers* according to various factors, including earthquake risk assessment and UPS reliability. The Tier level (importance) is ranked at 1 to 4, and Tier 4 power supply systems, used for high-importance loads, use redundant (N+2 or 2N) transmission paths. Some data centers, therefore, use a 2N system with the static transfer system cabinet, and in terms of stable power supply to high-priority loads such as server equipment, it is necessary to suppress voltage fluctuations associated with transferring to a different power supply so as not to affect the loads.

## 4. Newly Developed Static Transfer System Cabinet

### 4.1 Overview

Figure 4 shows the appearance of the static transfer system cabinet, and Table 2 lists the specifications. The static transfer system cabinet is available in three current capacities of 400, 600 and 800 A, with each type supporting three-phase three-wire input and single-phase three-wire input.

### 4.2 Compatibility between transferring speed enhancement and low power loss and size reduction

By building a hybrid switch that uses a mechanical switch and a semiconductor switch together, it has become possible to shorten the time when the output is in a non-voltage state at the time of transferring and to reduce the influence on load equipment.

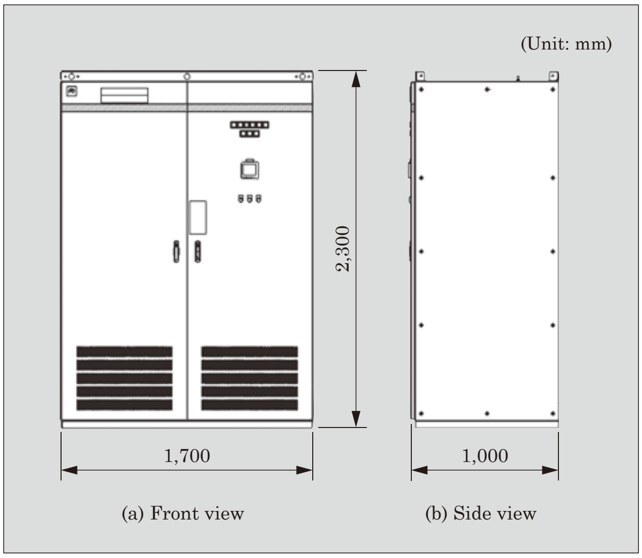

Fig.4 Static transfer system cabinet (800 A)

Table 2 Specifications of the static transfer system cabinet

| Item | | Specification |
|---|---|---|
| Rated current | | 400 A, 600 A, 800 A |
| AC input AC output | Rated voltage | 3-phase 3-wire 100 V, 105 V, 200 V, 210 V<br>1-phase 3-wire 200 / 100 V, 210 / 105 V |
| | Voltage fluctuation range | ±10% |
| | Frequency | 50 / 60 Hz |
| | Frequency fluctuation range | ±5% |
| AC output | Current overload capacity | 800%, 1 s (normal time)<br>300%, 1 cycle / 125%, 1 s (transferring time) |
| Synchronization condition | Voltage difference | 8 V or less |
| | Frequency difference | 5 Hz or less |
| | Phase displacement | 8.5° or less |
| Transferring time | Manual transferring | 5 ms or less |
| | Automatic transferring | 5 ms or less (synchronous time)<br>0.3 s or less (asynchronous time) |
| Structural specifications | Dimensions | 400 A: W1,200 × D1,000 × H2,300 (mm) |
| | | 600 A: W1,300 × D1,000 × H2,300 (mm) |
| | | 800 A: W1,700 × D1,000 × H2,300 (mm) |

The configuration of this hybrid switch has been also used in Fuji Electric's UPSs. In this way, the static transfer system cabinet uses UPS technologies, including control equipment and detection circuits, to achieve high-speed transferring operation.

(1) Transferring speed enhancement

Figure 5 shows an operation timing chart at the time of transferring. During power supply from system A, the A side of the mechanical switch (83R) is energized and the semiconductor switch on the A side (THA) is not energized. Manually transferring a power source to the system B will send instructions to the mechanical switch (83R) and the semiconductor switch (THB) to energize the B side. First, after approximately 1 ms, semiconductor switch B (THB) becomes energized, and power supply from the system B starts. Several tens of ms after the transferring, the B side of the mechanical switch (83R) also becomes energized. After this, it continues to be energized and semiconductor switch B becomes de-energized. As described above, one of the features of the hybrid switch is that the non-voltage time is shortened by supplying power through the semiconductor switch B (THB) during the transferring operation of the mechanical switch (83R).

Figure 6 shows the voltage and current waveforms at the time of manual power supply transferring from system A to system B. A short transferring time of 0.4 ms and no output voltage fluctuations allow power systems to continue to supply power stably without load stoppage.

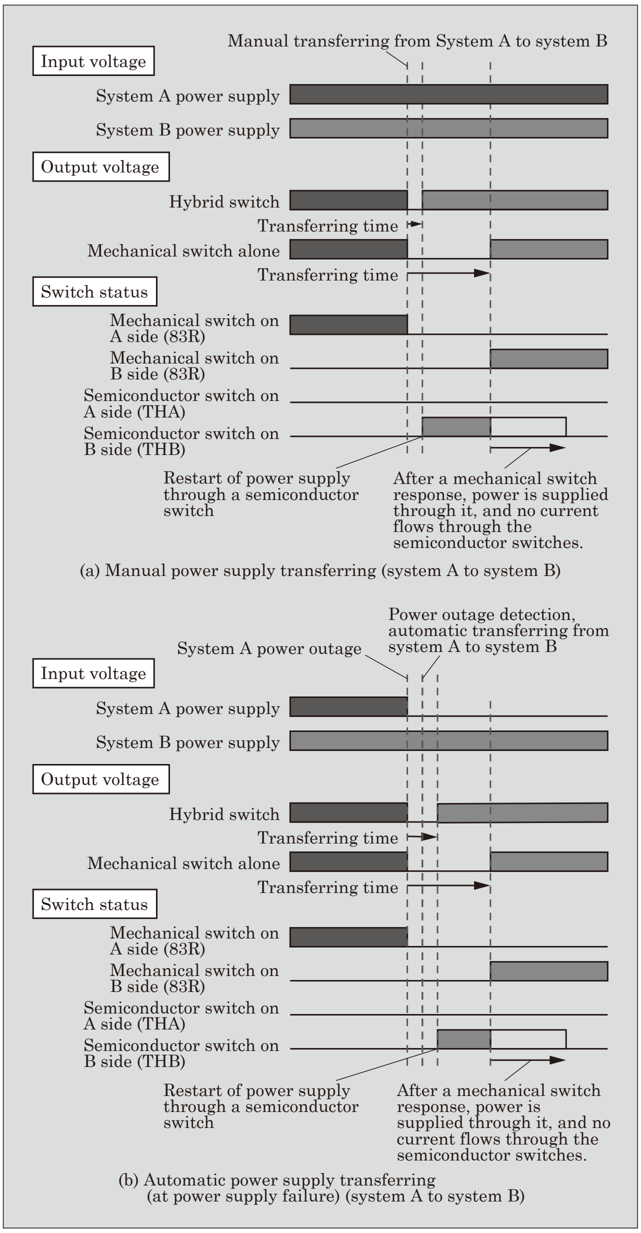


Fig.5 Operation timing chart at the time of transferring (image)

Figure 7 shows the voltage and current waveforms at the time of automatic power supply transferring from system A to system B at the time of a power outage. By detecting a power outage immediately to perform instantaneous transferring, the static transfer system cabinet can minimize the time of instantaneous power interruption to approximately 1.5 ms. Although not shown in Fig. 7, with the use of a mechanical switch alone, the instantaneous interruption time becomes 10 ms.

The same operation as described above also applies to the transferring from system B to system A.

(2) Low power loss and size reduction

The static transfer system cabinet can reduce loss by supplying power through the mechanical switch during continuous power feeding. Further, since the semiconductor switches are energized only for a short time at the time of transferring, low capacity ones can be selectable with respect to the continuous rated thermal current, and cooling becomes unnecessary. It thus has lower power loss and smaller size than conventional panels.

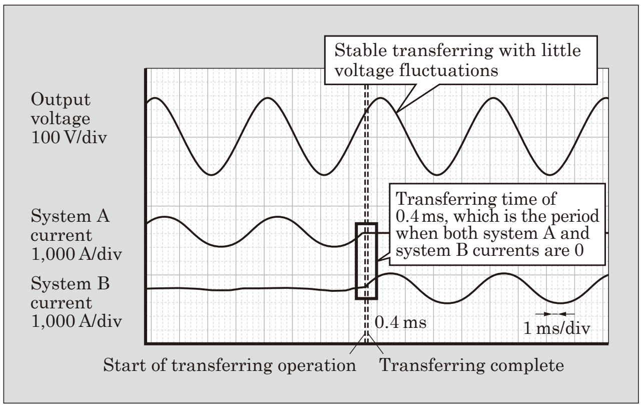


Fig.6 Voltage and current waveforms at the time of manual power supply transferring (system A to system B)

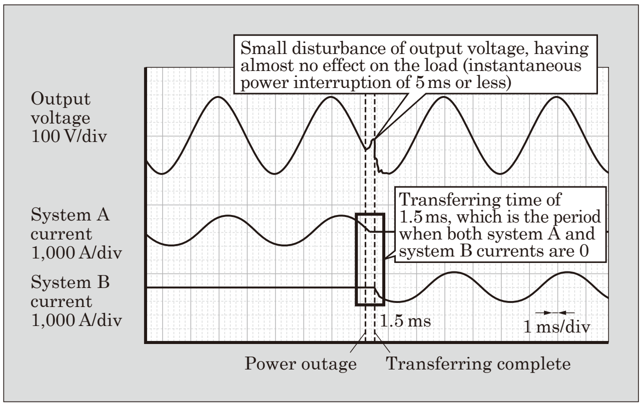


Fig.7 Voltage and current waveforms at the time of automatic power supply transferring (system A to system B)

### 4.3 Maintainability improvement

Figure 8 shows an example of the maintenance procedure of the static transfer system cabinet. The static transfer system cabinet has built-in maintenance bypass breakers (52MA, 52MB). During maintenance, breaking 52RA, 52RB and 52 L with either 52MA or 52MB closed allow a specific part to be de-energized. This enables maintenance, replacement and operation check of internal equipment while keeping continuous load feeding.

The static transfer system cabinet consists of the areas that are energized and de-energized during maintenance. The de-energized area houses periodic replacement parts, such as power supplies, switches and control circuits. This layout achieves compact cabinet size and permits maintenance while supplying power to loads.

In addition, it uses same parts as those used in UPSs for the power supply and the control circuits for detecting power outage and driving semiconductor

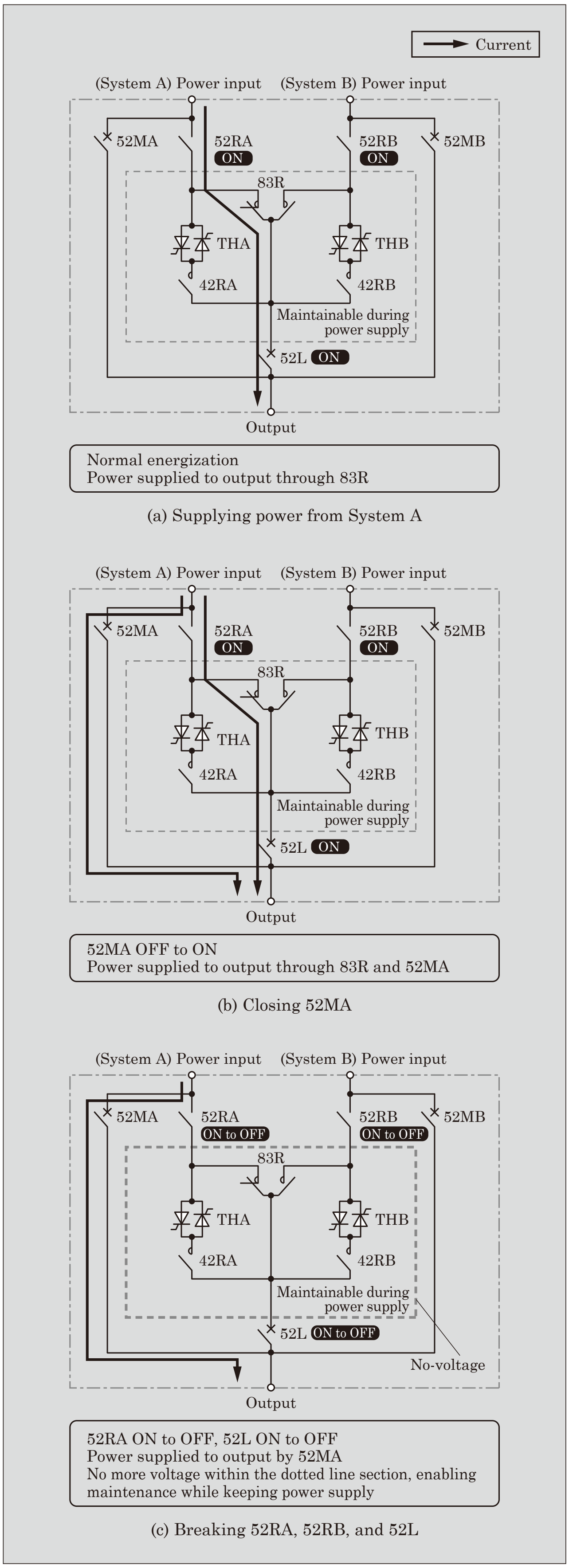


Fig.8 Example of the static transfer system cabinet maintenance procedure

switches to standardize maintenance parts. Reducing the types of maintenance parts in power supply systems as a whole, we have made it possible to keep maintenance parts available firmly to achieve rapid recovery in the event of failure.

Among the components of the static transfer system cabinet are power supplies for control and device driving, which are configured in duplex not to hinder switching even when a failure occurs in a power supply.

### 4.4 Stable power supply to loads at transferring

For the purpose of power supply quality improvement, the static transfer system cabinet performs transferring between the input power systems A and B with the two inputs being synchronized, thereby preventing voltage and phase surges and reducing the influence on loads.

The basic operation of the UPS is to perform transferring to a commercial power supply without voltage fluctuations by synchronizing with its own bypass voltage when a failure occurs in it. On the other hand, 2N power supply systems with the static transfer system cabinet, the voltages of the two systems must always be synchronous. Therefore, the cabinet controls the UPSs by exchanging signals with them to synchronize the voltages of the UPS output on the side that is not supplying power to loads with the UPS output voltage on the side that is supplying power to loads.

Figure 9 shows an example of the power supply system configuration for the static transfer system cabinet using the function for synchronization with the other system of the UPS. When the cabinet supplies power from the power supply of system A to the load, the UPS in the system B receives a signal from the cabinet and synchronizes with the output voltage of system A. In addition, the UPS in the system B transmits an interlock signal to the UPS in the system A not to synchronize the UPS of system A with the output voltage

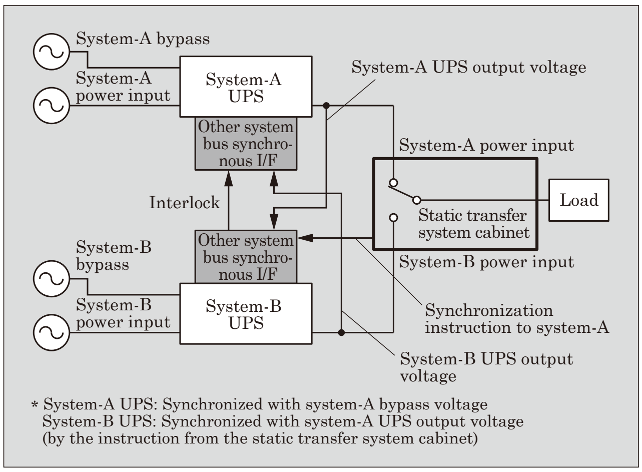


Fig.9 Example of the power supply system configuration of the static transfer system cabinet using the function for synchronization with the other system of the UPS

of system B. Without this interlock, synchronization is not completed because both systems attempt to synchronize with the other side system at the same time, and the cabinet cannot recognize the completion of the synchronization, which is needed to move to the next operation.

Through cooperation with the UPS synchronization function, the static transfer system cabinet has improved reliability to provide power supply solutions.

## 5. Postscript

This paper described the static transfer system cabinet for data centers as a product that contributes to stable power supply. This product has promise to be used for a wide range of power supply equipment that requires high reliability, other than data centers.

Fuji Electric will continue to introduce new technologies and provide power supply systems that meet customer expectations.

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