Compact Medium-Voltage Switchgear for Data Centers

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ABSTRACT

Data centers that have been flourishing since around 2005 are often built near urban areas, and there is therefore a need to be compact and space saving of electrical equipment installed. From above background, we have released a compact medium-voltage Switchgear for data centers that is 900 mm wide and 900 mm deep while maintaining the front maintenance type and does not require maintenance space on the back side. For downsizing, the function of the vacuum circuit-breaker (VCB) fixed frame (Cradle) was integrated into the Switchgear side. In addition, a current transformer (CT) with optimal specifications was adopted and performed down size of the CT. As a result, the installation area of total equipment including UPS has been reduced to about 70% compared to the previous model.

1. Introduction

Data centers that have been increasing rapidly since around 2005 are often built in urban areas because they can recover quickly in case of failure and high-speed communication is possible thanks to the location close to Internet exchange points. However, it has been difficult to acquire a site that can offer a large enough installation area.

In order to address this issue, the electrical equipment installed in data centers needs to be compact and space saving.

As for switchboards, equipment in the data center, a front maintenance type that allows compact installation has become the mainstream.

From the above background, Fuji Electric has developed and released compact, front maintenance type medium-voltage switchgear products intended for use in data centers.

2. System Configuration and Product Overview

There are many types of medium-voltage power receiving and distribution systems used in data centers. Figure 1 shows two examples — one is a system consisting of vacuum circuit-breakers (VCBs) only (called System A in this paper) and the other is a system in which disconnect switches (DSs) are used only for the power supply switching positions and VCBs are used for other positions (System B). In System A, VCBs that allow easy switching operation and can be drawn out from the switchboard are used instead of DSs. These VCBs can be drawn out from the switchboard for inspection, so that maintenance and recovery from accidents are easy.

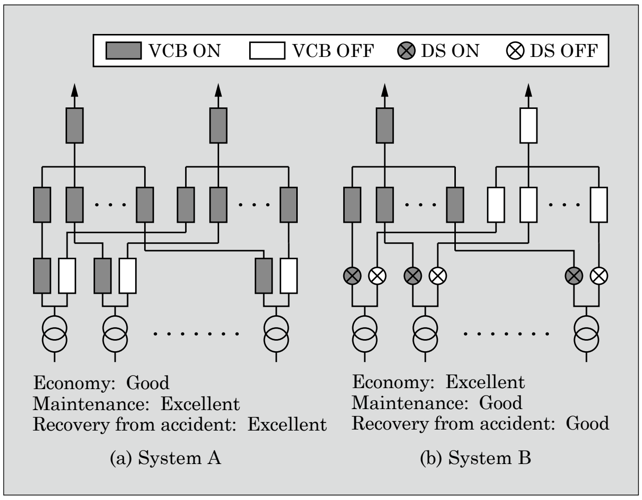

Fig.1 Comparison of power receiving and distribution systems used in data centers

The configuration example shown in Fig. 2 consists of three circuits, a medium-voltage system circuit, an uninterruptible power supply switching system circuit and a low-voltage system circuit. System A is used for the medium-voltage system circuit and generally consists of medium-voltage power receiving panels, medium-voltage feeder panels and input transformer panels.

The external appearance of the medium-voltage feeder panel product developed for data centers is shown in Fig. 3, the front view of its inside is shown in Fig. 4 and its major specifications are shown in Table 1.

The medium-voltage feeder panel shown in Fig. 3 and Fig. 4 has two VCBs in a stacked position. The devices required for the control circuit are grouped together and positioned on the door.

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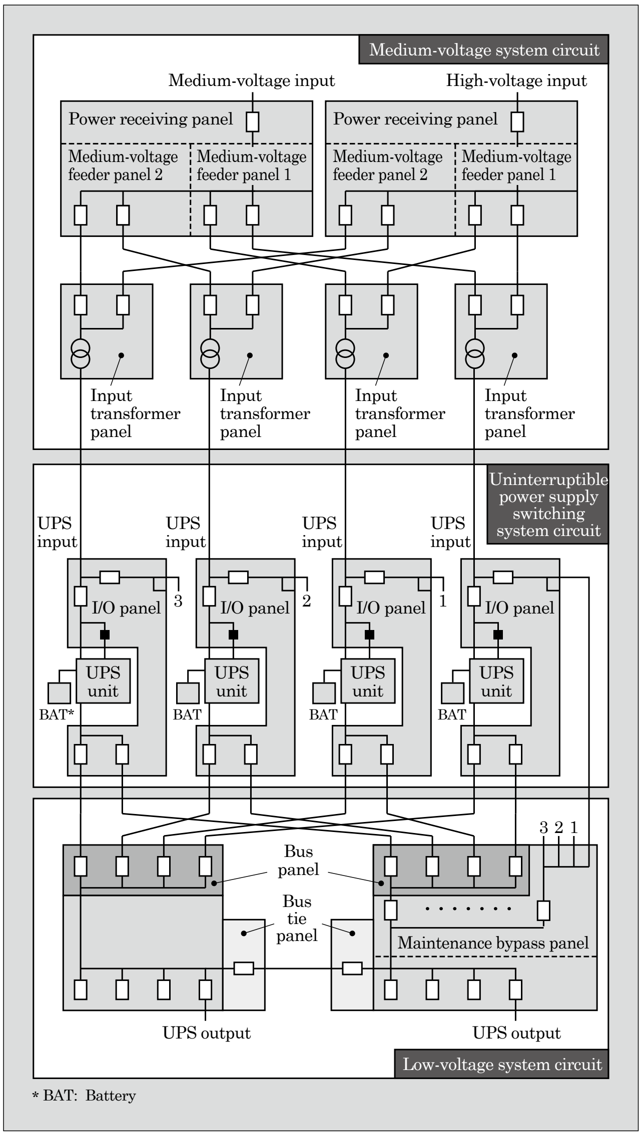


Fig.2 Example of a system for data centers

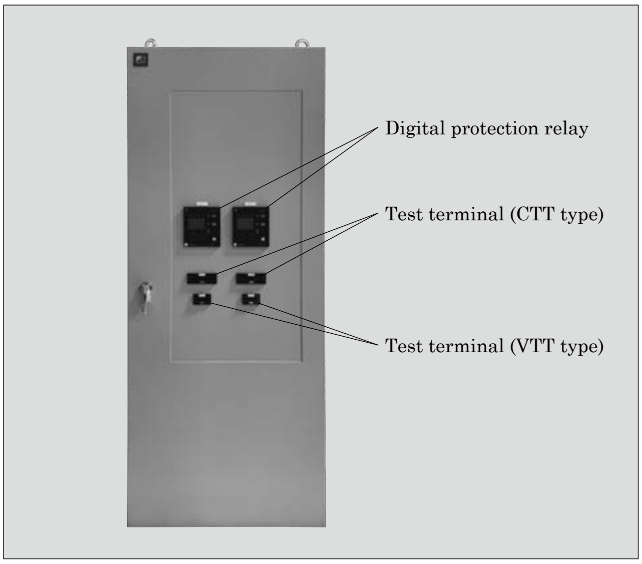


Fig.3 External appearance of the medium-voltage feeder panel

Table 1 Rated specifications of the medium-voltage feeder panel

Item		Specifications
Applicable standard		JEM 1425-CW
Installation environment		Indoor
Rated voltage		3.6/7.2 kV
Rated frequency		50/60 Hz
Rated bus current		600 A
Rated short-time current		20 kA/second
Rated dielectric strength	Commercial frequency	22 kV
	Lightning impulse	60 kV
Degree of protection		IP2X*
Dimensions W × D × H (mm)		900 × 900 × 2,300
Vacuum circuit-breaker (VCB)		Motor charging spring type
Current transformer (CT)	Ratio of transformation	100-150-300/1 A (3 taps)
	Rated load	5 VA

*IP2X: This code means that the product is rated as "dustproof degree 2" and "no degree for waterproof." It is also called "finger protection," meaning the degree of protection that prevents a human finger from getting in.

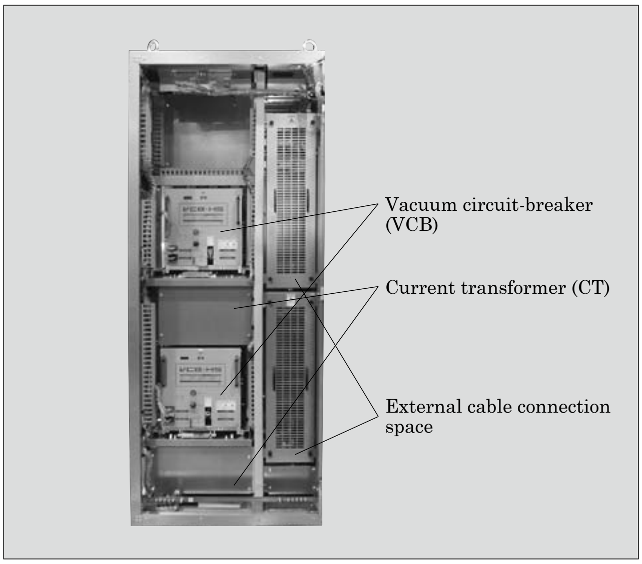


Fig.4 Front view of the inside of the medium-voltage feeder panel

3. Downsizing

We downsized the medium-voltage switchgear to reduce the installation area of the total equipment. We took the following measures in order to adopt the front maintenance structure and limit the depth dimension to the same as that of the uninterruptible power system (UPS) which will be installed side-by-side:

(a) Downsizing of the internal structural member (VCB storage section) by integrating the function of the VCB fixing frame (cradle) to the switchgear side

(b) Downsizing by developing and using a current transformer (CT) with optimal specifications for data centers

3.1 Reducing the installation area of the total equipment

The developed medium-voltage switchgear has a structure allowing for maintenance work on the front side. Conventional products required a working space also on the back side of the switchgear so that an extra installation area was required in an electrical room. Unlike conventional products, the new medium-voltage switchgear does not require a working space on the back side so that it can be installed against a wall. Moreover, the input transformer panel which will be installed next to the UPS was also downsized to be 900 mm in both width and depth. We designed it to have the same depth dimension as that of the UPS so that they can be installed side-by-side. Since work from the back side is unnecessary, it is also possible to install the switchgear and UPS back-to-back. This has lightened the restrictions on the layout to allow switchboards to be positioned in one place. The external cables connected to the switchboards can be grouped together. It should be noted that the layout for data centers also requires consideration to be given to spaces for replacing switchboards without stopping the power supply. After such consideration, we compared the installation area with that of the conventional layout. As shown in the equipment installation example of an electrical room in Fig. 5, the installation area of the total equipment including UPSs is reduced to about 70% when compared with that of Fuji Electric's conventional products.

3.2 Downsizing the medium-voltage switchgear

(1) Downsizing of the VCB storage section

In general, a drawer type VCB is a combination of the VCB unit and a cradle.

As shown in Fig. 6, we integrate the function of the cradle for drawing out and disconnecting the VCB to the switchgear side, reducing the dimensions from 1,100 mm wide × 1,500 mm depth to 900 mm wide × 900 mm depth.

(2) Downsizing of current transformers (CTs)

Conventional products were designed to use CTs that support large-scale equipment capacities with no restriction on the field. In order to support various ratios of transformation, the dimensions were determined to secure enough room for a CT with a primary current of 2,000 A. This made the downsizing impossible.

We checked the delivery record and found out that many of the power receiving and distribution systems used in data centers use transformers rated for 550 kVA, 1,000 kVA and 2,000 kVA. Consequently, we set the primary current in three levels suitable for the capacity of the UPS, 100 A, 150 A and 300 A. In addition, the load on CTs has been decreasing due to the significantly improved performance of equipment connected to the secondary side of CTs. This allowed us to downsize the CT by setting specifications of the rated load to 5 VA and the secondary current to 1 A. Furthermore, as shown in Fig. 7, a tap changing mecha-

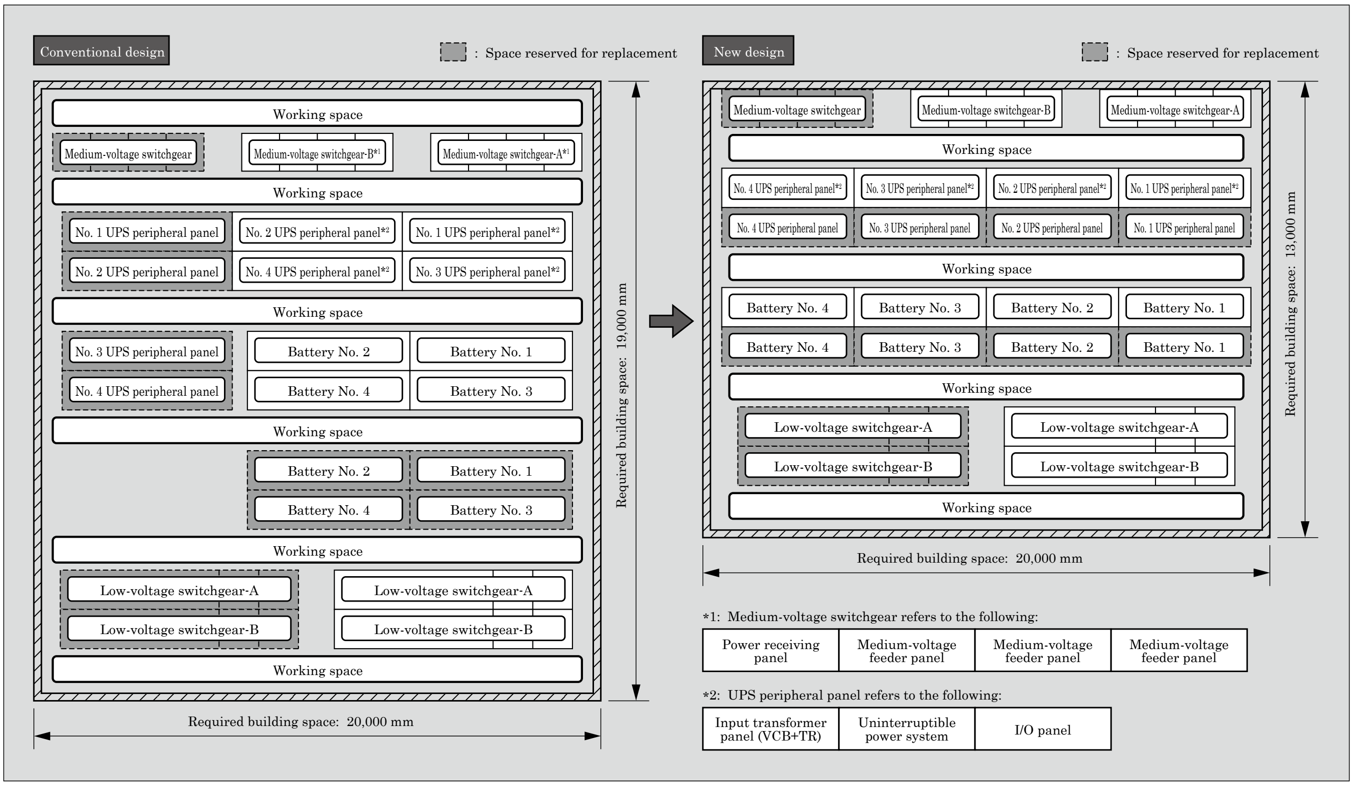


Fig.5 Equipment installation example of an electrical room

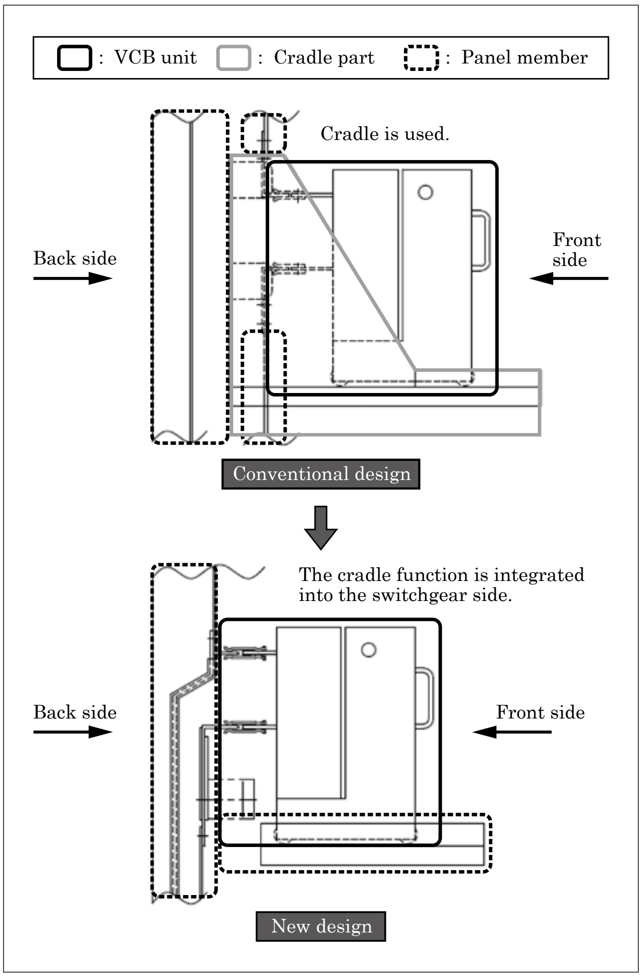
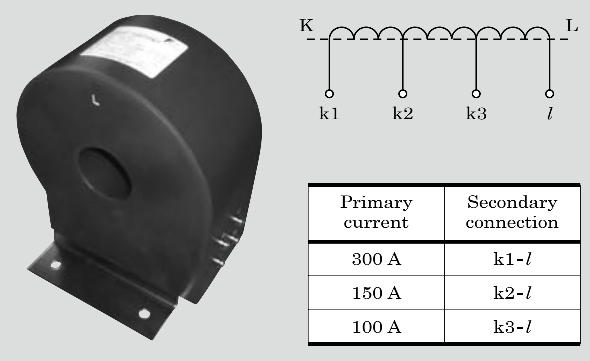


Fig.6 Comparison of the structures of the vacuum circuit-breaker storage section (side view)



Primary current	Secondary connection
300 A	k1-l
150 A	k2-l
100 A	k3-l

Fig.7 Current transformer

nism has been used to support more than one primary current rating.

We also prepare optional specifications of the CT for a secondary current of 5 A and a rated load of 10 VA that makes it possible to select the primary current in accordance with customer specifications to flexibly meet customer requirements.

(3) Facilitating external cable connection

Downsizing switchgear makes it difficult to connect external cables inside the panel.

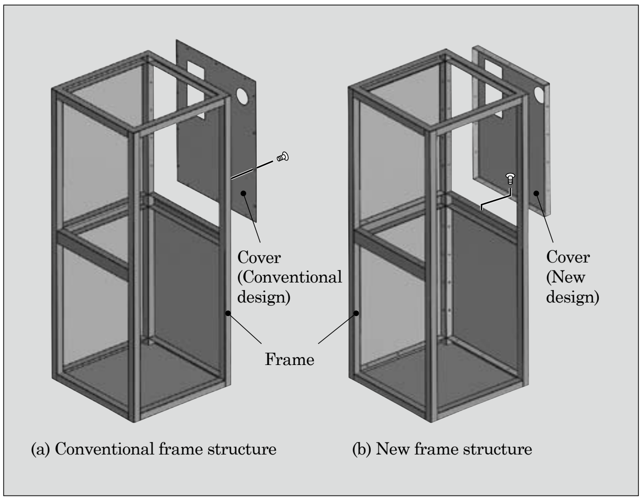


Fig.8 Comparison of the frame structures

The space for cable connection and a space for VCB storage are divided by a pillar positioned at the center in the panel width direction. We changed the position of the pillar to allow workers to put their arms inside and connect external cables more easily.

3.3 Earthquake resistance

Since the Great East Japan Earthquake in 2011, electrical equipment has been required to have higher earthquake resistance.

On the other hand, downsizing, especially a reduction in the depth dimension, may weaken the rigidity against a horizontal seismic force.

To solve this problem, we build a housing structure as shown in Fig. 8 to ensure both strength and internal space. In conventional structures, a plate-like cover was secured onto the frame with a bolt inserted in the horizontal direction, so that the stress concentrated on the bolt. The new structure uses a box-shaped cover to enhance rigidity. Moreover, the cover is designed to be secured by surface contact with the frame to prevent stress from concentrating.

We conducted a three sine wave vibration test by using a prototype in accordance with the Manual of Earthquake-Proof Construction for Switchgear and Controlgear Assemblies (JEM-TR144: 2017). We also conducted vibration tests by simulating the seismic waves of the past earthquakes: "El Centro Earthquake (0.3 G maximum, three axes simultaneously)," "Southern Hyogo Earthquake (0.6 G maximum, three axes simultaneously)" and "Great East Japan Earthquake (1.5 G maximum, three axes simultaneously)." As a result, we confirmed that the product is earthquake resistant satisfying the design-basis seismic intensity criteria of 2.0 and can provide enough resistance to earthquakes that occurred in the past.

4. Postscript

This paper described compact medium-voltage switchgear for data centers.

Fuji Electric will continue its efforts to satisfy customer demands and develop products with even higher reliability and safety.

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