Development of Equipment for HVDC Power Supply Systems

Hidekazu Hoshi, Hiroya Yajima, Tadatoshi Babasaki, Keiichi Hirose, Hidenori Matsuo, Masatoshi Noritake, and Takashi Takeda

Abstract

NTT FACILITIES is conducting research and development focusing on the introduction of high-voltage direct current (HVDC) power supply systems to telecommunication buildings, datacenters, and other such facilities. Future applications involving the direct integration of renewable DC energy sources such as solar panels into smart grids are also in view. This article describes our work on the development, construction, and maintenance of HVDC systems.

Keywords: high-voltage DC power supply system, HVDC rectifier, HVDC PDU

1. Introduction

Servers, data communication equipment, and other information and communication technology (ICT) equipment are in wide use in society and have been supporting substantial economic activity in recent years. ICT equipment is managed centrally in telecommunication buildings and datacenters, and as the use of such equipment spreads throughout society, its importance as a social infrastructure increases. The increasing use is accompanied by an increase in power consumption, however, and consequently, reducing that power consumption has become an issue.

Expectations are high worldwide that high-voltage direct current*1 (HVDC) power supply systems will conserve energy while still providing highly reliable power supplies. The NTT Environment and Energy Systems Laboratories and NTT FACILITIES have been doing basic research on HVDC as well as developing various types of equipment, which are described in the following sections [1].

2. HVDC rectifiers

The HVDC rectifier converts the commercial AC (alternating current) power supplied by power companies to 380 VDC [2]. There are 100-kW capable and 500-kW capable rectifiers, and the maximum conversion efficiency is a high 98%. Adopting a redundant configuration makes it possible to continue operation in the event that a failure occurs.

3. HVDC PDU

To counter the problem of arcing*2 when high-voltage direct current is interrupted, we developed a special HVDC power distribution unit (PDU) (Fig. 1).

The PDU has an internal mechanical switch that does not operate when the power plug of an ICT device is inserted into the socket. After insertion, the switch is slid to the ‘on’ position, and the internal contact points are closed, allowing current to flow. The switch is locked in position so that the plug cannot be removed. To remove the plug, the mechanical

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*1 High-voltage direct current: In the ICT field, ~48 VDC supply voltage is used for telecommunications throughout the world. DC voltages in the range from about 300 V to 400 V, on the other hand, are referred to as high-voltage direct current.

*2 Arcing: A sustained electrical discharge through the air between electrodes that occurs due to the electrical potential across the electrodes.
switch is slid to the ‘off’ position, opening the internal contact points. The arcing is interrupted, and the lock is released so that no arcing occurs outside the mechanism. That makes the plug insertion and removal operations safe for operators and maintenance personnel.

4. **Power conversion equipment for migration**

Introducing an HVDC power supply system involves procuring ICT equipment that is compatible with HVDC, as well as HVDC rectifiers and HVDC distribution panels. However, it is assumed that not all of the ICT equipment to be introduced will be HVDC-compatible in the initial transitional migration period. It is therefore necessary to use power converters that accept 380 VDC from the HVDC rectifiers and output 200 VAC, 100 VAC, and −48 VDC for the ICT equipment that operates on those voltages as provided by the previous power supply systems, without changing the general framework of the HVDC power supply system (Fig. 2).

We developed two power converters, a small-capacity type (S) and a medium-capacity type (M), to suit the equipment being supplied (Fig. 3). The S type was developed for equipment that consumes power on the level of several hundreds of watts such as monitors or other console systems. The M type was developed for ICT equipment that uses power on the level of several kilowatts.

5. **Future development**

We have described here work on introducing HVDC power supply systems to telecommunication buildings, datacenters, and other such facilities. Looking to the future, we will expand our field of view to include the development of HVDC smart...
grids that operate on renewable energy sources, combining distributed DC power generation by solar panels and other such sources with storage batteries [3]. We are currently involved in field testing in Obihiro City, Hokkaido and in Yamagata City, Yamagata as part of the Technology Development and Verification to Counter Global Warming Project of the Japanese Ministry of the Environment (Fig. 4), and we plan to actively apply the results from that work.

<table>
<thead>
<tr>
<th>Power converters for migration (S)</th>
<th>Power converters for migration (M)</th>
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<tbody>
<tr>
<td><strong>AC output</strong></td>
<td><strong>DC output</strong></td>
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<tr>
<td>Externall appearance</td>
<td></td>
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<tr>
<td>Dimensions (mm)</td>
<td></td>
</tr>
<tr>
<td>W: 430 × D: 700 × H: 43 (1U)</td>
<td>W: 430 × D: 700 × H: 43 (1U)</td>
</tr>
<tr>
<td>W: 430 × D: 553 × H: 130 (3U)</td>
<td>W: 430 × D: 652 × H: 130 (3U)</td>
</tr>
<tr>
<td>Input voltage</td>
<td>Rating: 380 VDC</td>
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<tr>
<td>Output voltage</td>
<td>100 VAC</td>
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<tr>
<td>Output capacity</td>
<td>1.0 kW</td>
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<tr>
<td>Unit efficiency</td>
<td>90% or higher</td>
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<tr>
<td></td>
<td>93% or higher</td>
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</table>
| *M type dimensions are for the unit.*

Fig. 3. Lineup of power converters for migration.

**Fig. 4.** Ministry of the Environment Field Testing System (Obihiro, Hokkaido).
References


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He is a member of IEEE, the Institute of Electrical Engineers of Japan (IEEJ), the Institute of Electrical Installation Engineers of Japan (IEIIE), and IEICE. He is also very active in many standards bodies in areas associated with power systems. He is a member of the IEC (International Electrotechnical Commission) SMI (Strategic Management Board) Study Group 4, a member of the Green Grid Power sub-working group, chair of the IEC SC 22E Japanese NC (National Committee), and a recent past secretary of the IEEJ Investigating R&D Committee into DC power distribution. He was awarded the IEEE PELS (Power Electronics Society) INTELEC 3rd best paper award in 2009, the outstanding paper prize from IEEJ in 2010, the best paper award of IEIEJ in 2013, and the Scientific Award of the Japan Society of Energy and Resources in 2013. He was also awarded the Hoshino Award of IIEJ in 2014.
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