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Development and Introduction of Communication Devices Corresponding to New Applications

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This paper describes two cases of communication systems developed in response to the changing business environment and the network needs of Japanese electric power companies (EPCOs)

1. Trends of communication networks in EPCOs

The business environment for EPCOs has changed considerably due to electricity market reforms, the cross-regional coordination of transmission operators, full retail competition and the growing renewable energy market. In addition, EPCOs have introduced IP networks corresponding to the complexity and sophistication of the power systems, and the continuous maintenance and expansion of such IP networks are required to transmit a variety of information stably and quickly.
EPCOs have developed communication systems utilizing the existing resources of individual power companies in order to respond to such environmental changes and the needs of IP networks.

2. Examples of the development of communication system in Japanese power companies

2.1 Development of a Digital Power Line Carrier System by Tohoku Electric Power Company

2.1.1 Background and motivation:

Conventionally, in mountainous areas where communication lines are difficult to deploy, a Power Line Carrier system using high-voltage (66kV–154kV) power lines provides communication channels. However, along with the rapidly increasing popularity of IP

technology and the digitization of communications devices, development of a Digital Power Line Carrier (DPLC) system is strongly desired.
Tohoku Electric Power Company developed a novel DPLC system for use with power lines. It is applicable to transmission lines with congested channel arrangements, and for use with severely delayed paths.

2.1.2 Implemented techniques

Our developed DPLC system has applied the following techniques.
(1) Adaptive equalizer
A linear adaptive equalizer using the Least Mean Squares (LMS) algorithm and a transversal filter was implemented to improve the degradation of the Bit Error Rate (BER) performance caused by inter-symbol interference.
(2) Digital AFC
Digital Auto Frequency Control (DAFC) can achieve accurate Carrier Frequency Offset (CFO) estimation and compensation in present power transmission lines with severely delayed paths.
(3) Narrow bandwidth
To allow the deployment of multiple channels in a transmission line, a narrow 25 kHz (103 kbps) bandwidth transmission scheme is applied in addition to a 50 kHz (206 kbps) transmission bandwidth scheme.

2.1.3 Field experiment

We conducted a verification experiment on a transmission line with a severe frequency-selective channel.
(1) Minimum Square Error (MSE) characteristics of the adaptive equalizer are obtainable with a convergence value, which confirmed equalization of the transmission line.
(2) Estimation error of the CFO was shown to be 0.1 ppm or less, confirming accurate CFO estimation was achieved.
(3) Results of a one-hour period BER measurement using an error rate tester confirmed that error-free transmission was achieved. Furthermore, one-month period BER measurement results confirmed 6×10-7 transmission.
Results verifying its usefulness in the field demonstrated its applicability.

2.2 Development of a transfer trip signal transmitter as a countermeasure for reverse power flow at distributing substations by Chubu Electric Power Company

2.2.1 Background and motivation

The power flow from distributed power sources such as solar photovoltaics to transmission substations may cause some problems of electric safety and quality. We needed to transfer the trip signal of the transmission protection relay from the transmission substation to the distribution substation where cubicle-type gas-insulated switchgears were installed.
Chubu Electric Power Company developed a transfer trip signal transmitter connected to the existing loop-type optical communication systems.

2.2.2 Consideration of the required specifications

Development apparatus has the following specifications.

(1) Transmission delay time

To shorten the development period, it adopted the signal system (2C1 signal) of the current conventional device. In the case of a power distribution substation powered by a 154 kV transmission line, the transmission delay time must be set to within 80 milliseconds, and a specification was set to transmit one element (one 2C1 signal) in one voice channel of the loop-type optical communication systems.

(2) Miniaturization

As a countermeasure for reverse power flow at distribution substations, it is necessary to transmit four elements (the main protection and backup protection, respectively with respect to transmission line 1L and 2L) of the 2C1 signal. Therefore, the four elements can be accommodated in one device to reduce the number of opposite devices.

The developed device is a unit type with a height of 600 mm or less for installing on Japanese Industrial Standards racks. In addition, to cope with space restrictions on the installation site, the developed device can be maintained only from the front.

(3) Improvements in operations

For each element of the 2C1 signals, the developed device sends a communication failure signal to the relay board, and signal processing units are kept apart in separate sheets; it is thus possible to limit the stopping range during inspection or any equipment failure of the relay board or the developed device.

2.2.3 Overview and benefits

The developed device is composed of a counter of the receiving and transmitting devices. Each 2C1 signal is independently signal-processed and is transmitted by the existing loop-type optical communication systems.

In addition to the merits of miniaturization and operational improvement, we can considerably reduce the costs and construction time by decreasing the number of opposite devices and the need for optical fiber cables.

3. Future prospects

To meet increasing competition and electricity market reforms, efforts will be needed to promote further cost reductions and innovations in EPCOs.

There is a need to provide low-cost flexible communication networks applicable to a variety of communication line needs.