DEVELOPMENT OF PLC SYSTEM WITH LARGE CAPACITY AND HIGH RELIABILITY

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ABSTRACT

In Kansai Electric Power Co., Inc., smart meter data is transmitted from meter to the concentrator by RF mesh system or PLC system. We mainly apply PLC system to multi -dwelling buildings. In order to extend the coverage and improve usefulness of PLC system, we developed new PLC system especially for the multi-dwelling buildings receiving electricity at 22kV, which have sub transformer chambers.

1. INTRODUCTION

In recent years, smart meters have been introduced in many countries. The Kansai Electric Power Co., Inc. (KEPCO) started basic research to realize smart meter system in 1999, and started installation in 2008. As of December 2016, KEPCO has implemented approximately 7 million smart meters, and will have completed smart meter installation in 2022.
In Japan, smart meter must have the function to measure 30-minute interval consumption data and transmit those data every 30 minutes. To realize those requirements effectively, as communication technologies, we apply RF mesh technology and PLC technology. PLC system is applied to multi-dwelling buildings which receive electricity at 6.6kV or 22kV. In the case of applying PLC system to multi-dwelling buildings receiving electricity at 22kV, concentrator for PLC system must be installed in each sub transformer chamber due to the capacity limitation of our PLC system caused by its transmission speed. In order to solve this problems, we developed new PLC system.

2. GENERAL OUTLINE OF SMART METER

2.1 Smart Meter

Fig.1 shows the smart meter communication network in KEPCO. For residential customers, KEPCO mainly apply RF mesh system and PLC system; either one of communication system (unit) is embedded in each smart meter [1]. In RF mesh system, the data measured at each smart meter is transmitted to concentrator through neighbouring smart meters. However, in the case of multi-dwelling buildings, RF mesh system is not suitable communication technology due to the difficulty of penetration. Therefore, for multi-dwelling buildings, PLC system is mainly applied to the smart meter communication system. In our PLC system, the data measured at each smart meter is transmitted to concentrator through neighbouring smart meters, too.

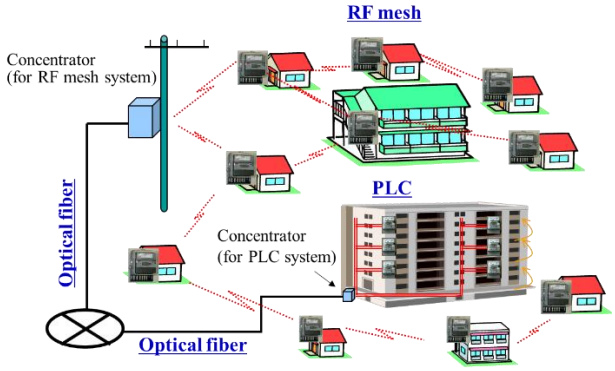

Fig.1: Outline of smart meter communication network

2.2 PLC System for Smart Meter

PLC system is applied to multi-dowelling buildings, but there are two types of multi-dwelling buildings based on their receiving voltage. One is receiving electricity at 6.6kV; 6600V/200V transformers are installed in a transformer chamber (shown in Fig.2). This method is generally applied to middle scale multi-dwelling buildings.

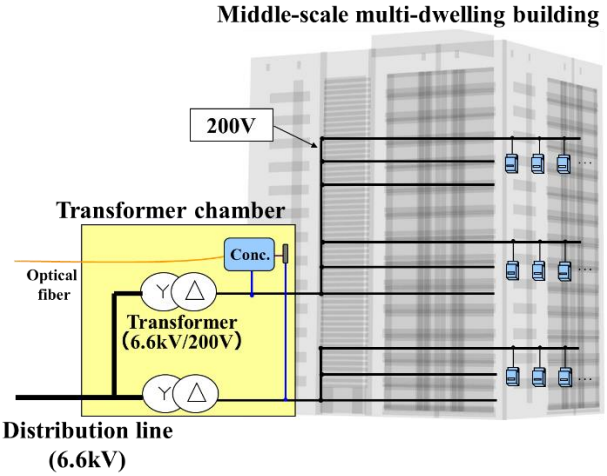

Fig.2: Outline of middle-scale multi-dwelling buildings (Receiving electricity at 6.6kV)

The other is receiving electricity at 22kV; 22000V/400V transformers are installed in a transformer chamber and 400V/200V transformers are installed in sub transformer chambers to distribute electricity to each customer (shown in Fig.3). This method is generally applied to large scale multi-dwelling buildings.
Our PLC system adopts “ITU-T G.9905” [2] as routing algorithm so that the necessary time to collect 30-minute

interval data is relatively short in spite of its communication speed is low. Nevertheless, in order to collect all the 30-minute interval data every 30 minutes, the maximum capacity of the concentrator must be limited to 180 smart meters. This number is not enough to apply our PLC system to large scale multi-dwelling buildings. In addition, concentrators are connected to secondary side of 400V/200V transformers; we must install many concentrators on secondary side of each sub transformer and optical fiber to each sub transformer chamber. This causes expensive construction cost and complicated system configuration.

In order to solve these problems, we attempted to develop new PLC system that the concentrator has the ability to accommodate the larger number of smart meters and can be connected to secondary side of 22000V/400V transformer directly.

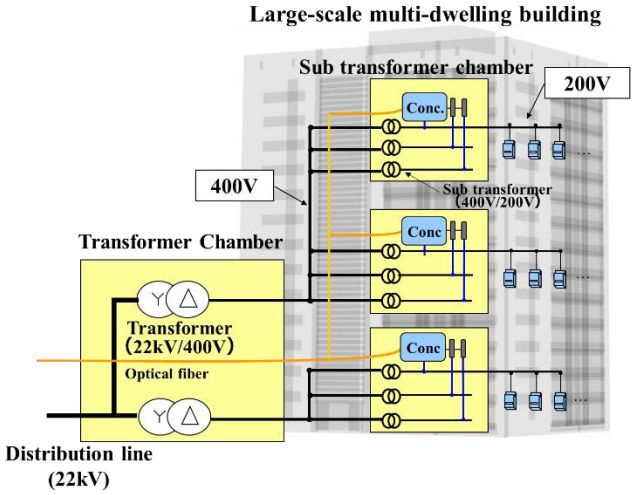

Fig. 3: Outline of large-scale multi-dwelling buildings (Receiving electricity at 22kV)

3. DEVELOPMENT SUBJECT

In order to realize the required PLC system, there are mainly 3 development subjects as follows:

(i) Development of coupler for 400V wiring
(ii) Increase in communication speed
(iii) Evaluation of signal attenuation

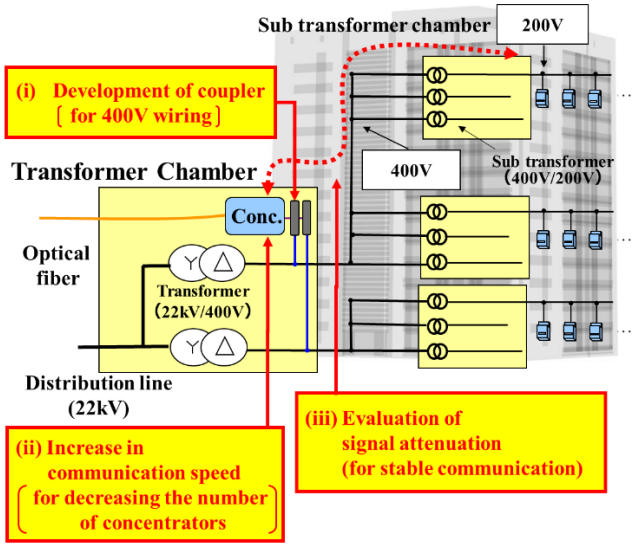

Fig.4: Development subjects

4. OUTLINE OF DEVELOPMENTS

4.1 Development of Coupler for 400V Wiring

To suppress the cost of newly developing coupler, we made use of the conventional coupler case, instead of that, changed internal components, such as fuse, varistor, resistance elements.

4.2 Increase in Communication Speed

The increase in communication speed was required to collect all the measured data every 30 minutes in Large-scale multi-dwelling buildings, which might have as many as several hundred residences. Therefore, we changed communication specification to increase the concentrator capacity. In conventional our PLC system, 3 to 5 concentrators are needed to collect that amount of data. We set the development goal: new concentrator's capacity should be more than 500 smart meters.

In our PLC system, securing stable communication between concentrator and the first smart meter is essential; in our conventional PLC system, we have confirmed the stable communication between these two. Accordingly, in order to realize our development goal, we decided to enable the communication speed variable between low-speed communication and high-speed communication from the first smart meter to other smart meter ahead. To be concrete, in case of poor communication environment, low-speed communication is selected, or in other cases, high-speed communication is selected. As a result, even if the number of hops increases, communication time should be supressed. Fig.5 shows the concept of the newly developed PLC system. 10 communication speed options are added as in High-speed communication mode, as shown in Table 1.

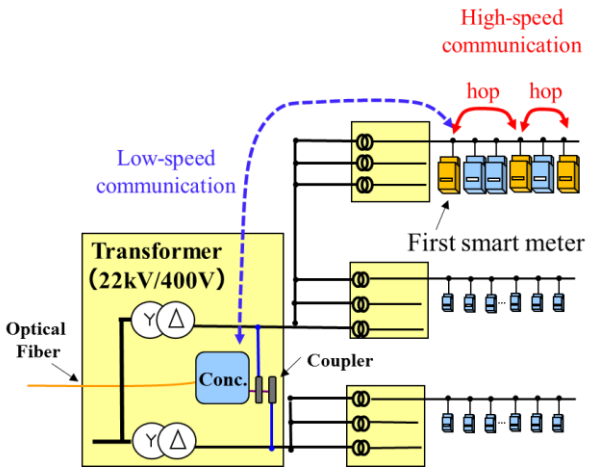

Fig. 5 Concept of the newly developed PLC system

Table. 1 Communication speed options

	Communication speed options
Low-speed mode (Conventional system)	7.5kbps, 5kbps, 1.25kbps
High-speed mode (Developed system)	500kbps, 300kbps, 250kbps, 150kbps, 125kbps, 75kbps, 40kbps, 20kbps, 10kbps, 7.5kbps

Furthermore, in the case we just simply increase the communication speed, there is a possibility that the system could not collect smart meter data every 30 minutes because of the increase in data volume. Therefore, in addition to the increase in communication speed, we performed data compression reviewing the meter data frame structure. Consequently, we could expand the capacity of concentrator from 180 smart meters to 540 smart meters. In addition to that, we confirmed the data collection time for 540 smart meters is reduced by approximately 90%.

4.3 Evaluation of Signal Attenuation

Newly developed PLC system is required to have the ability to communicate through the longer distance via sub transformer, between the concentrator and first smart meter. In order to confirm the communication reliability, we measured signal attenuation at several actual facilities. The facilities and the measurement results are shown in Table.2, and in Fig. 6, 7.

Table.2 Result of signal attenuation

Facility	Configuration	Distance (Transformer Chamber ~ first smart meter)	Range of signal attenuation	Signal attenuation on sub transformer
A	45 story building	200m	10dB~35dB	6dB
B	41 story building	240m	17dB~37dB	6dB
C	Multiple buildings	190m	10dB~**46dB**	15~20dB
D	48 story building	200m	27dB~**43dB**	18dB
E	Multiple buildings	200m	15dB~40dB	5~20dB

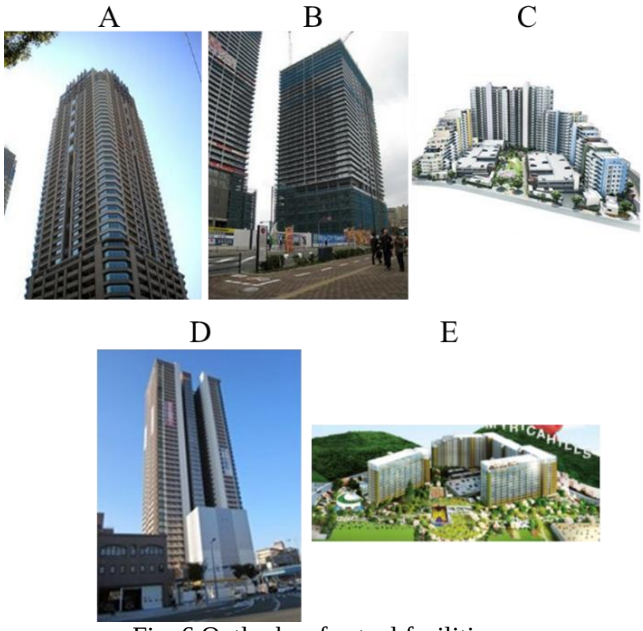

Fig. 6 Outlooks of actual facilities

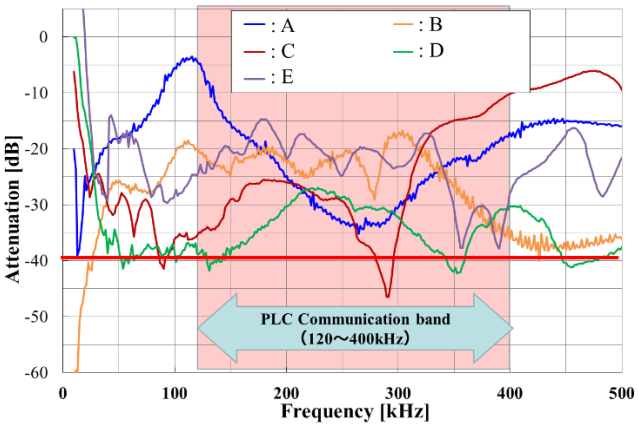

Fig.7: Signal attenuation by communication band

For stable communication in High-speed mode between the secondary side of 22000V/400V transformer and the first smart meter, signal attenuation criteria is approximately -40dB. As a result, we confirmed most of

the measured values are within the tolerance. Even if the signal attenuation deviates from the criteria: communication environment is poor, the system automatically select the suitable communication mode, that is the Low-speed mode.

Based on these verification results, we started introducing newly developed PLC system to actual multi-dwelling buildings which receives electricity at 22kV, and we confirmed stable communication.

5. CONCLUSION

In order to improve PLC system introduction efficiency to multi-dwelling buildings which receives electricity at 22kV, we developed new PLC system: coupler development for 400V wiring, increase in communication speed. As a result, we achieved system configuration simplification and significant cost savings. At present, we have installed more than 70 thousands smart meters with PLC communication system.

As our future work, we will complete the smart meter installation as planned, utilizing this newly developed PLC system.

6. REFERENCES

[1] Yoshinori Yoneda, 2016, “Development of operation system for smart meter data providing service”, CIRED workshop, AIM.

[2] Telecommunication standardization sector of ITU, 2013, “ITU-T G.9905”, ITU.