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Development of an Analysis System for Low-Voltage Distribution Systems

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Abstract

In recent years, the use of distributed generators (DG) such as photovoltaic (PV) power generation systems and wind-turbine generator systems has increased, which means that the number of DGs connected to distribution networks also has gradually increased. This situation has led to several problems such as increases in voltage fluctuation, short circuit current, and harmonics phenomena, making it difficult to examine the effects of interconnection and to design new distribution systems. However, an analysis support system to evaluate the effect of connecting DGs to low-voltage distribution systems has not yet been developed.

We therefore have developed such an analysis system for low-voltage distribution systems. With this system we can accurately evaluate the influence of DGs, examine the interconnections, and design the configuration of distribution networks. In this paper, we describe the concept of the analysis system, the load flow method for an unbalanced V-connection 3-phase 4-line distribution system, and several load and photovoltaic (PV) models. An outline of the man/machine interface and examples of calculation results for a sample network are also presented.

The analysis system supports the following functions.

(1) Unbalanced load flow calculation method for a 3-phase 4-line distribution system.

A load flow calculation algorithm was developed for a 3-phase 4-line system. It can calculate the unbalanced voltage profile due to single and 3-phase load unbalance, the PV interconnection, and the occupancy rate of a pole transformer.

(2) Primary voltage calculation of a pole transformer using measurement data.

An estimation value based on measurement data of a distribution SCADA is used as the primary voltage of a pole transformer for load flow calculations, to obtain a practical solution.

(3) Power flow analysis considering daily variations using load and PV output models.

Daily variations of several types of loads and PV systems are modeled, considering typical patterns based on measurement data and typical solar radiation patterns. The model enables the practical analysis of voltage and current profiles by load flow calculations for a 24-hour period (at 30-minute intervals).

(4) PV output evaluation using an output control model of a PV inverter.

The output control model of a PV inverter to prevent voltage violation is developed. The output power of each PV is calculated using the model.

This system enables us to recognize the effect of a DG, such as a PV system, more accurately and effectively. It can reduce the time needed to investigate the influence of a DG connection in half the time required by traditional procedures.