Priority Subjects — **Development of a Supply/Demand Infrastructure for Next-Generation Electric Power**

Development of Technologies for Next-generation Power Distribution Networks

Background and Objective

Photovoltaic generation (PV) for both residential and non-residential was introduced based on a feed-in tariff system in an accelerating way. As a result, power transmission lines and power distribution lines became overloaded, and reverse power flow to a power distribution line occurs in some areas. Consequently, it is becoming difficult to secure stable power supply.

In this report, problems relating to operation and control in power distribution systems when renewable energy is introduced in large quantities are identified, and methods of operation and load management under normal and abnormal situations are developed using information from section sensors. This has contributed to maintaining the stability of power distribution systems.

Main results

1 Estimation by comparing voltage regulation method of transformers for distribution in substation systems with PV large penetration

The voltage control methods of transformers in distribution substations that are adopted as equipment of the current state are program control, scalar type load drop compensation and vector type load drop compensation. We must evaluate the effect of system voltage regulation regarding these voltage control methods and clarify the optimal method (Fig. 1(a)).

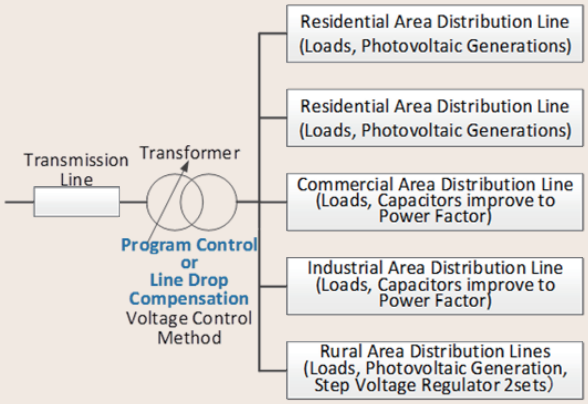
As a result of comparing these voltage control method, we cleared that vector type load drop compensation is suitable method, and adding control of maintaining power factor of photovoltaic generations was brought to more suitable method. Moreover, we cleared that when considering this, it's necessary to consider impedance of transmission power line (R14021).

2 Improving voltage imbalance of power distribution systems by using voltage data from section switches

In middle voltage distribution lines with three phases, voltage becomes imbalanced if single phase transformers are connected to the distribution line in imbalance. It is possible that increasing PV causes voltage imbalance. In order to solve these problems, we investigated the relationship between imbalance of the connection load and imbalance of the voltage. From the investigation results, we proposed a connection method of a pole-mounted transformer to improve the voltage imbalance of the power distribution system by using voltage data from the three phase measurement function of the switch. We confirmed that the method is effective for improving imbalance of the voltage by comparing the method with the conventional method (Fig. 2) (R14003).

3 Development of an estimation method for photovoltaic generation output using power flow information from section sensors in distribution systems

We proposed a new separation method of the power generation curve of PV systems and demand curve as a solution of the overcurrent problem and other power quality problems. Power flow measured by using section switch with sensor is resolved into PV output and load every measurement interval, and PV output is resolved into active power and reactive power by the method. PV output can be calculated by integrating the active power. Average specific inaccuracy of data for 10 days was found to be 7% through a comparison with PV output data measured via a sensor (Fig. 3) (R14012). We confirmed that the method is effective for faults in distribution lines as well as planning distribution equipment because the method can estimate in real time.



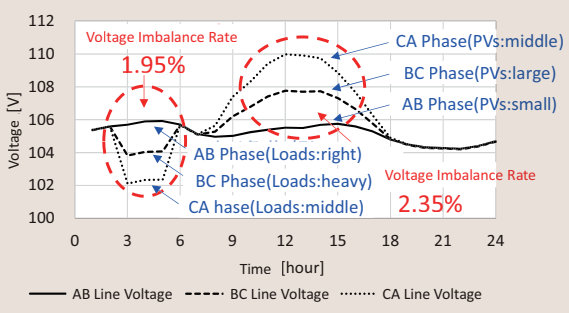
(a)Bank model for estimation

Bank Control Method	Introduction Limit Rate of PV
Program Control (Schdule Operation)	less than 20%
Scalar Type Line Drop Compensation	less than 20%
Vector Type Line Drop Compensation	40%
Vector Type Line Drop Compensation and Power Factor Constant Control of PV	60%

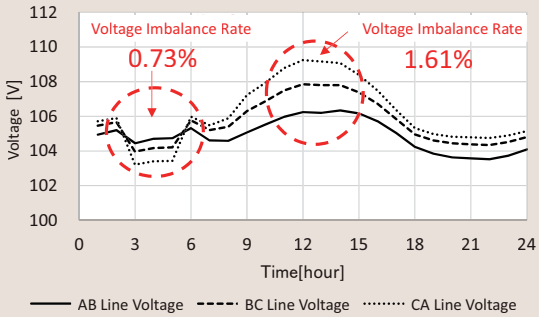
(b)Calculation results

Fig. 1: Comparing results of voltage control method for transformers of substations in distribution systems

As shown in Fig. 1, in severe bank model of substation transformer relatively, the method of voltage control is compared and estimated by increasing the PV introduction rate in the view point of rate at starting voltage deviation (Fig. 1 (b)).



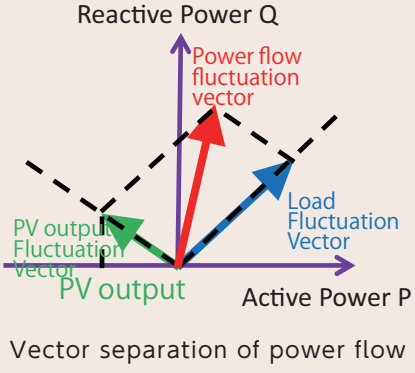
(a)Before adopting improving method



(b) After adopting improving method

Fig. 2: Calculation example when middle voltage is adopted improving method

These results are calculated based on a standard residential distribution model, and shows that voltage imbalance reduces throughout the day.



Vector separation of power flow

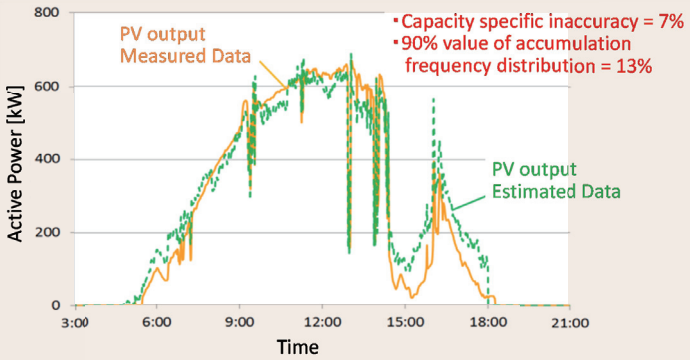


Fig. 3: Outline of estimation method of photovoltaic generation output and estimation results

As shown in the left side of Fig. 3, the power flow vector measured by using section switch with a sensor can be resolved into PV output vector and load vector, and PV output can be resolved into active power and reactive power. As a result, PV output can be estimated as shown in the right side of Fig. 3.