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

Development of a Next-Generation Coordination System for Power Demand and Supply

Background and Objective

Expectations towards renewable energy sources (RES) such as photovoltaic (PV) power generation are intensifying and it is predicted they will penetrate the utility system in high volume. As such, it is necessary to develop techniques to achieve both effective use of RES and preservation of power quality, safety and stability of the utility system at a low cost. The objectives of the research are to establish basic techniques for the distribution system such as restraint of voltage rise, protective cooperation and so on, and to develop coordination system techniques of power demand and supply including a technique for the effective use of distributed power generation.

Main results

1 Development of an islanding prevention method in case of secondary transmission system faults

In addition to an islanding prevention method responding to distribution line faults, it is also necessary to establish a prevention method of islanding*1 that may occur on a wide scale in the case of upper secondary transmission system (66kV) faults upon high PV penetration. In the study, islanding detection characteristics*2 of the marketed PCS for PV use were tested under the condition of parallel operation of rotation type distributed generator (SG) on the assumption of the islanding covering a wide area. The results led to the following findings; islanding duration tends to increase under SG operation. The bigger the rate of PCS capacity is to SG capacity, and the longer the electrical distance between PCS and SG is, the larger the probability of islanding detection within the regulated 3 seconds (Fig. 1). In addition, the conditions under which PCS can detect the islanding were also clarified by a computer simulation using the developed XTAP*3 instantaneous value model (Table 1). (R12020)

2 Evaluation of influence of 3-phase imbalance condition in distribution line on voltage management and development of countermeasures

Voltage management of high voltage distribution lines may be difficult due to the increase of 3-phase imbalance by penetration of large capacity single-phase appliances such as heat pump type water heaters in addition to a PV system. Problems on the voltage management of the distribution line using SVR and effective control method of SVR were analyzed by computer simulation using the 3-phase imbalance analysis program developed by CRIEPI. SVR model was added to the program for the simulation. Results confirmed that SVR might not control distribution line voltage within the proper range and not judge power flow direction exactly by the conventional SVR control method in which SVR monitors only a part of the phases (Fig. 2). As a countermeasure, a method was proposed in which control mode change of SVR through reverse power flow is executed by judgment with the sum of real power flow and the sum of reactive power flow of 3 phases. The validity of the method was confirmed by computer simulation (Fig. 3, Table 3). (R12021).

3 Development of a new reactive power control method to suit the rate of PV output change

When the volume of PV systems installed in a distribution system increases, the required capacity of high-cost control equipment (SVC) may increase in order to suppress voltage fluctuation. Therefore, reactive power control in proportion to the rate of PV output change was proposed as a new method, and the proposed method was evaluated by simulation analyses with residential area distribution system model. The simulation results show that the required capacity of SVC was reduced by the proposed method as much as the constant power factor control at 0.97 (Fig. 4). In addition, the distribution line loss when the proposed method was applied was smaller than that in the case of constant power factor control (Fig. 5). (R12012)

(Notes)
*1 Islanding phenomena in a wide area including plural 6kV distribution lines.
*2 Detection characteristics of "Frequency feedback method with step injection" which is an active type islanding detection method regulated in 2011 which has fast detection and is noninterference.
*3 Instantaneous value analysis program developed by CRIEPI.

Other reports: (R12018)

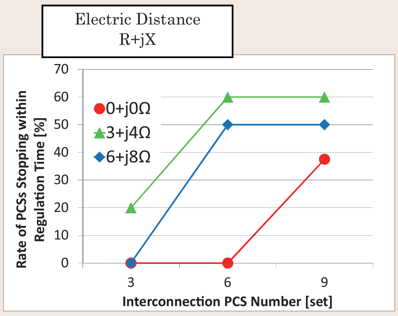

Fig. 1: Relation of PCS/SG capacity, electric distance, detection rate of islanding phenomena

The possibility of detecting islanding phenomena within regulation time increases as PCS capacity/SG capacity becomes greater, and electric distance between SG and PV is larger.
(SG Capacity: 150kW, Method of Reactive Power Variation, PCS Capacity: 4kW/set, new islanding detection method)

Table 1: PCS/SG Capacity, Electric distance, detection rate of islanding phenomena
(SG Capacity：2MW、PCS：new detective method of islanding)

600kW or more PCS with new islanding detective method is needed to detect islanding within regulation time.

Electric Distance [Ω] / PCS Capacity／SG Capacity	0+j0	1+j1	3+j4	6+j8
0	×	×	×	×
0.3	×	×	○	○
0.4	○	○	○	○
0.6	○	○	○	○

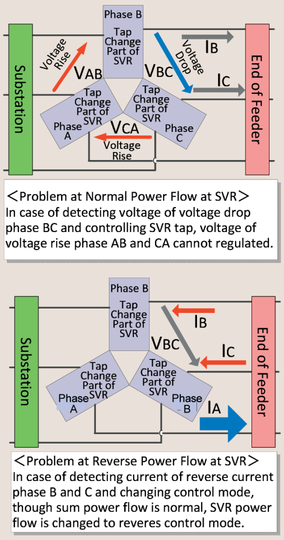

Fig. 2: Problems of present control method

Upper figure shows problems at normal power flow. Lower figure shows problems at reverse power flow.

Table 2: Comparing the present method with the proposed method by PV introduction possibility rate (PIPR)
(PV Introduction Rate = Sum of PV capacity/Feeder capacity)

PIPR is less than 20% with the present method, however increases to 60% with the proposed method.

Control Method		PV Introduction Possibility Rate
Present Method	Detecting Phase AB	20% or less
	Detecting Phase BC	20% or less
	Detecting Phase CA	20% or less
Proposed Method		60%

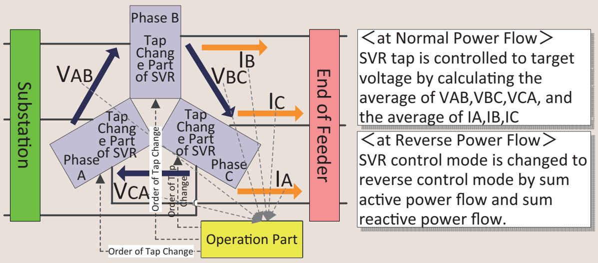

Fig. 3: Proposed SVR control method

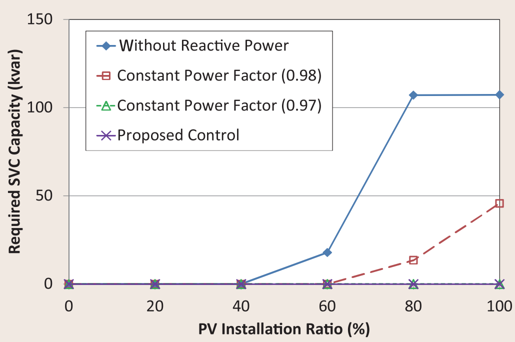

Fig. 4: Comparison of SVC capacity reduction effect between control methods (In case of 4km distribution system of the residential area)

By the proposed method, a similar effect is obtained as that of the constant power factor control (power factor is 0.97).

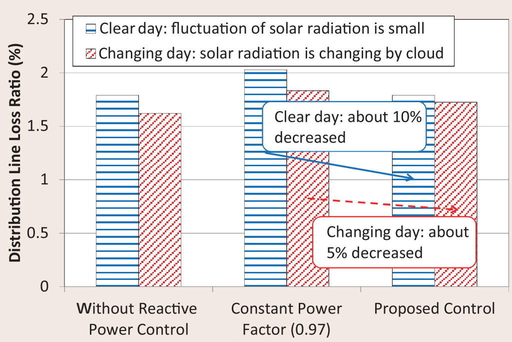

Fig. 5: Comparison of distribution line loss between control methods (PV installation ratio is 100%)

By the proposed method, distribution line loss ratio is smaller than the constant power factor control (10% smaller on a clear day, 5% smaller on a "changing" day).