Development of Operation and Control Method for Autonomous Demand Area Power System
－ Study on Method for Regulating Voltage according to Interconnection Rate of Dispersed Generation －

Background

In recent years, there is growing concern over impact on the operation and control of power distribution systems caused by expanded connection of distributed generation. To cope with such problems, Autonomous Demand Area Power System (ADAPS)＊1 was proposed as a new power system and the methods of operation and control＊2 for voltage regulation and loss reduction were developed using Loop Power Flow Controller. The effect of voltage regulation and loss reduction became clear by computer simulation and demonstration tests. To develop ADAPS, it is necessary that suitable voltage regulation method is evaluated by computer simulation in some interconnection areas and different forms of DG.

Objectives

Voltage regulation methods are evaluated from the viewpoint of regulation effect, cost and distribution loss, and suitable method according to interconnection rate becomes clear by computer simulation for voltage regulation in some areas, distribution, power factor＊3 and interconnection rate＊4 of DGs.

Principal Results

1. Study on voltage regulation method according to interconnection rate

In model area shown in Fig.1, the effect of the main voltage regulation method＊5 was analyzed by computer simulation, and suitable voltage regulation method becomes clear according to the interconnection rate (Fig.2).

(1) When DGs are distributed equally in residential areas, without controlling reactive power of DG output, voltage control is necessary in the case where the interconnection rate is 32% or more. With controlling reactive power of DG output, centralized voltage control is necessary in the case where the interconnection rate is about 60% or more.

(2) When DGs are concentrated on the end of feeder in residential area and commercial areas, voltage regulation control by DG or SVC control by self-end information is effective.

2. Evaluation of voltage regulation method in the viewpoint of cost and distribution loss

The conditions to apply SVC and LPC control that is shown above become clear from the viewpoint of cost and distribution loss.

(1) From the viewpoint of cost, price per kVA of LPC is effective regardless of the interconnection rate. In the case of voltage regulation control at one side of a loop point, the price per kVA of LPC is 1.2 or less times of the price per kVA of SVC. In the case of voltage regulation control at both side of a loop point, the price per kVA of LPC is 2.1 or less times of the price per kVA of SVC.

(2) In the viewpoint of distribution loss, distribution loss of LPC is lower than distribution loss of SVC, and the difference (increase) according to interconnection rate is no more than 1%.

Future Developments

In the case where the interconnection rate of DG increases, problems of power distribution system will be extracted and measure method is studied.

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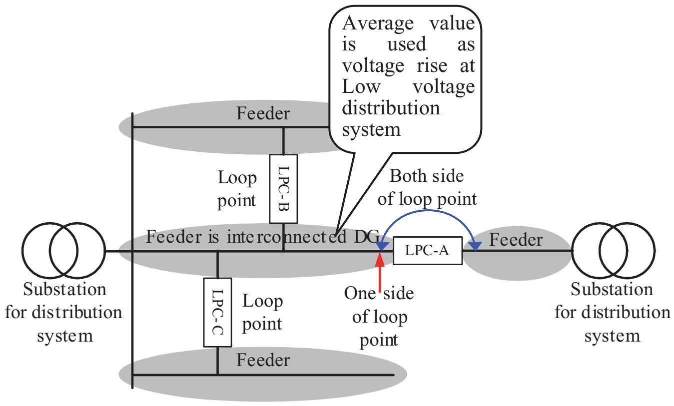
Reference

S. Uemura, 2008, “Development of Operation and Control Method for Autonomous Demand Area Power System: Study on Method for Regulating Voltage according to Interconnection Rate of Dispersed Generation”, CRIEPI Report R07018 (in Japanese)

＊1：Basic composition of the system is loop formation, and Loop Power Flow Controllers are set at the loop point, which control power flow and system voltage actively, and the system control voltage fluctuation and equalize power flow.
＊2：The operation and control is controlling LPC and transformer tap of substation to reduce distribution loss, to equalize power flow and regulate system voltage.
＊3：The value is minimum power factor that PV inverter can control to regulate system voltage.
＊4：The value is the rate of DG capacity to feeder capacity.
＊5：The control methods are to control DG reactive power, to control SVC by using connection point information, to control SVC by using information of whole distribution system, to LPC by using information of whole distribution system



Mode	Residential Area	Commercial Area
Feeder Model	Residential Feeder※	Commercial Feeder※
Feeder Capacity	3.5MVA	3.5MVA
Feeder Length	3.65km	1.93km
Kind of DG	Photovoltaic	Co- generation
Time	at Noon	at 7 am

※Standard Model Feeder is published by Electric Technology Research Vol.37 No.3

Fig.1 Model Distribution System for Commercial and Residential Areas

	Kind of DG	DG Distribution	Power Factor of DG
Commercial Area	Co-gene	Equally	0.9(constant)
Residential Area	PV	End of Feeder	1～0.85
			1～0.95
		Equally	1～0.85
			1～0.95

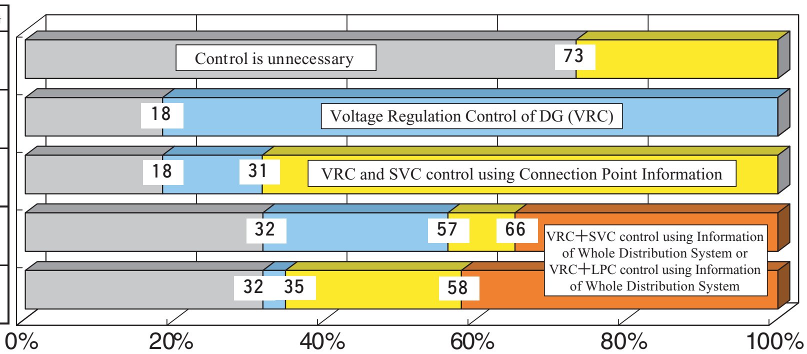


Fig.2 Method for Regulating Voltage according to Interconnection Rate of Dispersed Generation in each Area

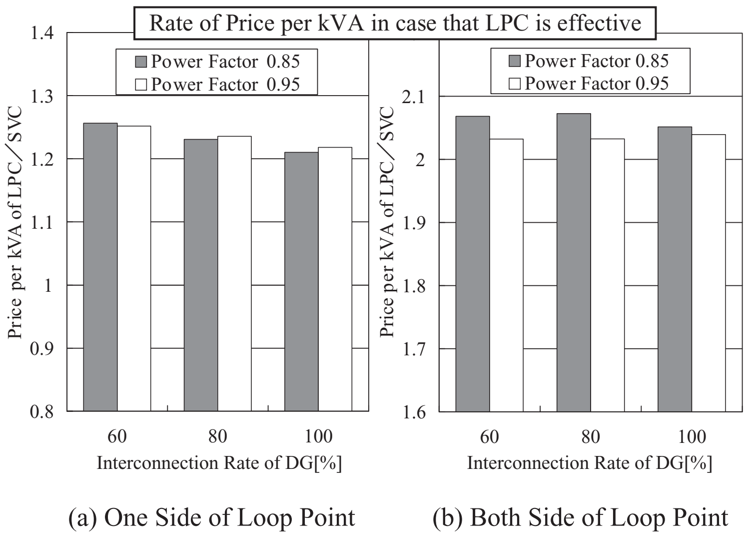


Fig.3 Evaluation from the viewpoint of cost

(Residential Area, Distributed Equally)

※Cost is (Required Capacity)×(Price per kVA)

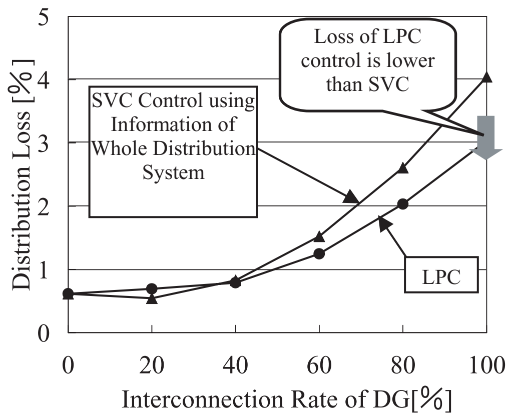


Fig.4 Distribution Line Loss

(Residential Area, Concentrated on the end of Feeder, Power Flow Loss of LPC is 5%)

$$\text{Distribution Loss}[\%] = \frac{\text{Distribution Loss}[\text{kW}]}{\text{Feeder Capacity}[\text{kVA}]}$$