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Optimal voltage control in distribution systems using PV generators

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ABSTRACT

Recently, renewable energy technologies such as wind turbine generators and photovoltaic systems have been introduced as distributed generation. The connection of large number of distributed generators causes voltage deviation beyond the statutory range in a distribution system. In this paper, a methodology for voltage control in proposed by using the tap changing transformers and the inverters interfaced with the distributed generators. In the proposed method, information of the voltage and power is collected via a communication network. Based on these information, the optimal reference values are calculated at the control center, and sent to the transformers and the inverters. The proposed method accomplishes a coordinated operation among the control equipments and reduces the voltage deviation. Effectiveness of the proposed method is verified by the numerical simulation results.

1. Introduction

Fossil fuel consumption increases emissions of carbon dioxide and results in global warming. Recently, from the perspective of mitigating global warming and sustainable energy development, renewable energies such as wind generation and photovoltaic generation are getting attention worldwide. Beside, Japan is moving towards the smart-grid where it is possible to introduce bi-directional information–transmission using the optical fiber communication. Therefore, the uses of renewable energy in the form of distributed generators (DGs) are expected to increase rapidly.

However, the existing distribution networks are not capable of having large number of DG connections. Voltage deviation beyond the statutory range is one of the problems of connecting many DGs and is caused by the followings: reverse power flow from the DGs, and output power variations of the DGs. Considering large number of DGs connected to the distribution network, voltage deviations cause by the output power fluctuations of DGs are significant which cannot be solved by using only load ratio control transformers (LRTs) and step voltage regulators (SVRs).

As a countermeasure, voltage control by off-line methodologies that use mainly the reactive power controllers such as additional reactive power compensators are introduced [1–3]. On-line methods including a coordinated control, of synchronous var compensators (SVCs) are also introduced.

Beside, control of On-Load Tap Changers (OLTCs) [4–6] have been proposed. However, the determination of the optimal setting site in the distribution system for the additional reactive power compensators is difficult because the configuration of distribution network might be changed in the future. Furthermore, set-up cost of the additional reactive power compensators is not beneficial for the system. On the other hands, the methodologies using the interfaced inverters do not including cost as there are some interfaced inverters with the existing DGs in the network. As the methodologies using the interfaced inverters, voltage control schemes based on centralized network information such as voltage and power flow and those using only nearby information are proposed in [10–16]. A centralized control methodology needs extra cost for setting the control center and communication networks. However, it can achieve the coordinated control against a complicated voltage profile in the presence of various equipments. Moreover, it provides the power quality improvement and the capability to disconnect a generator when a fault occurs. In this paper, we propose a voltage control methodology considering the interfaced inverters, LRTs and SVRs in the network. In the proposed methodology, the collected information is used to calculate optimal reference value such as the node voltages and tap positions. The proposed method can be used in the future if the smart-grid in constructed by setting the centralized control of the substations.

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