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Exploring frequency control capability of a PV system in a hybrid PV-rotating machine-without storage system

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ABSTRACT

When the penetration of inertia-free photovoltaic (PV) system is rapidly increasing, it is of timely importance to make the system capable of handling the disturbances safely so that the system stability can be assured by maintaining the system frequency. In this paper a novel control strategy has been formulated for frequency regulation utilizing the output from the PV generators itself without going for any kind of storage technologies. A multi bus system with two conventional generators and twelve PV systems which are working away from the maximum power point of operation is the system used for the study. Frequency control of the deloaded PVs with frequency controller is simulated using Power Factory Software. An improved controller which considers not only the frequency deviation of the system but also the available reserve in the photovoltaic is proposed. This ensures that the PV with more reserve will participate more in the frequency control compared to those with less reserve so that the frequency control capability is evenly distributed throughout the system. Two modes of operation for deloaded PV is suggested to derive maximum benefit when it is used for frequency regulation. A cost analysis is carried out to show that the concept of deloaded PV is economical when compared to battery usage for frequency control.

1. Introduction

In conventional power system which is frequently subjected to disturbances, due to the machine inertia, energy exchanges takes place between the rotating machines and the other part of the system. The primary/secondary frequency control is provided by the automatic generation control (AGC) to maintain the required balance between load and generation. In future, the renewable energy sources especially in the form of small capacity generations are expected to outnumber the conventional sources. They are usually integrated with the grid at low voltage as distributed generators (DGs). Since most of these DGs, like the photovoltaic (PV) generators are interfaced with grid by means of power electronic converters, stability will be a big concern for the system operators due to the absence of inertia which makes them incapable of providing inertial/primary frequency response, if not regulated properly. Any generator is said to participate in frequency regulation when its output varies depending on load conditions and hence balances out the generation and demand. Due to expensive nature of solar panel, efforts are made to extract maximum power from the panels by using maximum power point tracking (MPPT) methods as could be seen in literature whose comparison study is done in [1]. Authors in [1] have reviewed and compared 19 distinct MPPT methods from 90 papers for the photovoltaic systems. This shows the thrust given for maximum power extraction from a PV panel. Using such MPPT algorithms, under varying conditions of temperature and irradiation, the power output from the solar panel is maintained at their maximum value irrespective of the load condition, implying that no frequency regulation contribution from the PV. With the help of proper control philosophies implemented in a battery storage system the frequency disturbances can be handled effectively. However the expenditure on the battery storages which includes their maintenance and replacement costs is an extra burden. Authors in [2] had done a performance analysis on storage devices and concluded that the battery storage is not economical. When the ancillary services like frequency control are gaining importance in the changing scenario with high renewable penetration, it is important to incorporate these features into photovoltaics itself, which is the main objective of this paper.

In [3–9], usage of battery or other storage devices along with renewable energy systems is considered to mitigate the various issues like output leveling, voltage unbalance, voltage rise, frequency regulation etc. However, photovoltaics participating in frequency control without using any external resources like battery, supercapacitors etc. is hardly seen. For wind turbines the frequency

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