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A Photovoltaic Power Unit Providing Ancillary Services for Smart Distribution Networks

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Abstract. This paper deals with grid-connected photovoltaic (PV) power plants for supplying ancillary services to the distribution grid. The power converter, interfacing the photovoltaic system with the grid, can be controlled in order to achieve both the primary goal of power generation and the chosen ancillary services. In particular, in the paper, a power converter configuration with an opportune control algorithm is suggested; they make the photovoltaic system capable of generating the maximum power available from the solar source and, at the same time, capable of contributing to the voltage regulation of the grid and to the suppression of the current harmonics absorbed by loads close to the system. The control strategy is then applied to a sample grid-connected PV unit, simulated in Matlab Simulink environment. Numerical results, showing the effectiveness of the proposed solution, are reported.

Key words

Photovoltaic power systems, maximum power point tracking, ancillary services, voltage regulation, harmonic suppression.

1. Introduction

The reliability and security of electrical power systems require usually ancillary services, such as reactive power support, power quality, spinning reserves, energy balancing and frequency regulation. In a deregulated power system market, the responsibility of maintaining the correct operations of the system is basically attributed to the System Operator, that, hence, purchases these services directly from the generators [1]. Since the support of the power system with an ancillary service implies a reduction of the active power supplied to the grid, a financial compensation should be given to the provider by the System Operator. Moreover, the ancillary service supplied should be the most appropriate for the technical characteristics of the generator. In the case of generation with switching power converters, which is the case of most of the renewable energy generators, the more suitable ancillary services are the voltage regulation and the harmonic suppression [2]. In particular, the photovoltaic (PV) generation system, being connected to the grid by means of a voltage-source inverter (VSI), can provide reactive power anytime the power available from the source is lower than the maximum one. This eventuality happens for many hours during the day. In this way it can participate in voltage regulation without additional costs. The amount of necessary reactive power should be given by the system operator or, in alternative, can be derived from the PV system by measuring the voltage at its node. In the last situation the reactive power requested by loads connected at the same node of the PV unit can be realized without any signal from the network. At the same manner, the PV generation unit can be used to compensate current harmonics measured on the grid. In this way, all the harmonics due to loads connected at the same node of the PV system can be suppressed without significant additional costs in the interface converter.

The possibility of using renewable energy sources also for providing ancillary services appeared only recently in the technical literature, because switching power converters are normally devoted to regulate the injection of power into the grid in order to maximize the energy delivered by the renewable source. In case of wind turbines, the ancillary services proposed have been the compensation of reactive power [3] and the governor response [4]. Also some controls for harmonic compensation have been