Chapter 18


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ABSTRACT

This research chapter is concerned with the control of a photovoltaic powered plant connected to a single-phase grid. The system is equipped with dc–dc converters, which allow the panels’ maximum power point to be tracked, and the voltage at their terminals to be regulated. Power is injected into the grid using an adequate control of a single-phase inverter connected to a filter and loads. In this research chapter, the active and reactive powers are controlled using the Voltage Oriented Control strategy, taking into account the grid and the loads characteristics. The control strategy is tested by simulation, and the obtained results prove its performance even under solar radiation change.

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Smart Control Strategy for Small-Scale Photovoltaic Systems Connected to Single-Phase Grids

INTRODUCTION

Smart grids systems face challenges related to performing reliable operating, following the systems demands and the generated power by the sources (Gungor et al., 2013). This means that in these types of systems, which are based on highly controllable supply, they have to match a largely uncontrolled demand. Moreover, the variability in the climatic parameters, namely the solar radiation, makes necessary using reliable control strategies that ensure a safe operation for the power sources, from the one hand, and provide the loads with the power in need, from the other one (Penner, 2014). However, with the dual concerns of climate change and energy security, this can cause problems with the conventional system balancing methodologies, since penetration levels of energy sources and the loads demands are variable, in addition to its dependency on intermittent climatic parameters (Sivarasu et al., 2015; Yahyaoui, 2016b).

Fortunately, smart grids are characterized by their potential to mitigate these types of issues, since on one hand, they generally include flexible energy management strategies and power distribution, and on the other, they are able to make the system operating on both the supply-side and the demand-side (Logenthiran et al., 2012). This can be achieved in many ways from active demand-side management to temporary storage technologies, whether dedicated to electricity or sourced through a symbiotic supply (such as electric vehicles).

Moreover, smart grids systems encompass a wide range of technologies and applications, which include advanced metering infrastructures, that facilitate remote disconnection/reconnection of consumers, load control, detection and response to outages, energy theft responsiveness, and monitoring of power quality and consumption (Valverde et al., 2016). They are also equipped with distribution, outage management and geographic information systems and advanced intelligent electronics devices. All of this equipment is to ensure a safe operating for the system and fulfilling the load demand in power (Siano et al., 2014).

Photovoltaic (PV) energy represents one of the main energy sources in smart grids systems, as well as wind turbine and fuel cells (Phuangpornpitak et al., 2013; Yahyaoui, 2016b). In smart grids plants, the power generated in excess can be stored or injected into the grid. In this case, PV grid connected systems must be associated to control strategies, which are needed to regulate the powers flow, following the grid restrictions and constraints. This is relevant, to not perturb the grid operation, the grid power quality, namely the frequency and the power factor, and to maintain a continuous and stable power supply for the loads (Reddy et al., 2014).

Generally, three-phase PV grid connected systems are used to inject power into the grids (Pattnaik et al., 2016). These type of grids are well studied in the literature, for which several control techniques are conceived. However, few research works focus on single-phase grids, since they are used in small-scale plants (Romero-Cadaval et al., 2013).

Thus, this research is concerned with the development of a control strategy for a PV single-phase system connected to the grid. The PV panels are coupled to boost converter, a single-phase inverter that injects the power converted from DC to AC into the grid (Figure 1).

The present work is organized as follows: first, the components models are explained in Section 1. Section 2 describes the strategy proposed to control the active and reactive powers. The results and discussion are detailed in Section 4. Finally, conclusions are presented in Section 5.