Chapter 18

An Optimal Photovoltaic Conversion System for Future Smart Grids

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ABSTRACT

Smart grid technology is the key for a reliable and efficient use of distributed energy resources. Amongst all the renewable sources, solar power takes the prominent position due to its availability in abundance. In this chapter, the authors present smart grid infrastructure issues and integrating solar PV-sourced electricity in the smart grid. Smart grid has many features, including reliability, flexibility on network topology, efficiency, sustainability, and market-enabling. The authors select a photovoltaic active power line conditioner as a case study. This line conditioner is a device designed to extract the maximum power of a photovoltaic (PV) system and to compensate the nonlinear and unbalanced loads of the electrical power systems. The performance of the PV conditioner with the neuro-fuzzy control designed has been analyzed through a simulation platform.

INTRODUCTION

For many years the fossil fuel was the major source of energy. But the whole world suffered from the depletion of fossil fuel as well as its bad effects on the atmosphere around the globe. The major bad effect is reflected global warming and changes in the Earth’s climate (Partridge, et al. 2017). Due to all the above-mentioned reasons, the researches for other sources of energy begin in the recent years.
The renewable energy is the best solution to use a clean energy for the most applications to stop the pollution and have unlimited power sources. Renewable energy resources such as solar energy and wind power can be operated in an optimal mode to provide electricity in a lower price. This chapter focuses in providing a comprehensive survey on the methods that can be used for achieving such operation status. Likewise, a mathematical and theoretical models of solar energy systems are presented. The different methods for achieving maximum power point have discussed. Furthermore, all parts and components of PV systems have been illustrated. Moreover, different case studies have been presented for demonstrating the ability of solar energy system for providing an optimal power by using some optimization methods.

The rest of this chapter is organized as follows. Firstly, a brief background and review literature is presented in background section. Then some definitions and the mathematical model of PV systems are presented. The different components of PV system are then illustrated. Some method for design an optimal PV system are demonstrated in PV system design section. After that, a comprehensive review and discussion in the optimal methods are presented. In the next section, the different case studies are presented to show the important of using the optimization methods in smart grids and PV systems. Likewise, the future trends in smart grid and optimization method are illustrated in future research direction section. Final, a conclusion and the references that have been used in this chapter are presented accordingly.

BACKGROUND

Most of the recent researches have tended to use renewable energy sources found in nature such as, solar energy, wind energy, and tidal energy (Alva, et al. 2017). Due to the increasing demands in clean and new energy resources, the solar energy industry is one of the fastest growing forces in the market. In the last decade, there are several major directions for solar technology development (Thornton, 1992; Chaar, et al. 2008; Mohandes, et al. 2009; Al Hanai, et al. 2010). For example, photovoltaic systems directly convert the solar energy into electrical energy while concentrated solar power systems first convert the solar energy into thermal energy and then further convert it into electrical energy through a thermal engine (Chu & Meisen, 2011).

In literatures, many methods have been used of optimal design and operation of PV systems (Nazarpouya, et al. 2015). Evolutionary optimization methods have the major application in solar systems for getting the maximum power operation point (Patcharapratiti & Premruudeepreechacharn, 2002). Also, different met-heuristic algorithms such as genetic algorithm, PSO, wind driven optimization algorithm have a good performance for designing and operation of PV systems (Injeti & Padma, 2015).

A comprehensive literature reviews and state of arts in these topics could be found in (Ram, et al. 2017; Gordon, J. M. 2013). Due to space consideration, in this chapter, Authors discuss in depth the solar energy system component and the optimization methods used in solar systems to make their operation more effective.