Chapter 3

Control-Based Maximum Power Point Tracking for a Grid–Connected Hybrid Renewable Energy System Optimized by Particle Swarm Optimization

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ABSTRACT

There has been a great deal of interest in renewable energy sources for electricity generation, particularly for photovoltaic and wind generators. These energy resources have enormous potential and can meet the current global demand for energy. Despite the obvious advantages of renewable energy sources, they have significant disadvantages, such as the discontinuity of their generation, due to their heavy dependence on weather and climate change, which affects their effectiveness in the conversion of renewable energy. Faced with this conflict, it is essential to optimize the performance of renewable systems in order to increase their efficiency. Several unconventional approaches to optimization have been developed in the literature. In this chapter, the management of a hybrid renewable energy system is optimized by intelligent approach based on particle swarm optimization comprising a shaded photovoltaic generator and a wind generator.

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1. INTRODUCTION

The energy consumption has extensively augmented due to the considerable industrial development. Dealing with this problem a major interest is oriented to the use of renewable energy sources (Zhu & Azar, 2015; Azar & Zhu, 2015; Azar & Vaidyanathan, 2015a,b,c). Firstly, wind power generation is considered the most economically viable alternative within the portfolio of renewable energy resources. It is one of the most promising renewable energy resources for producing electricity due to its cost competitiveness compared to other conventional types of energy resources (Suvire & Mercado, 2012). On the other hand, solar energy has an increasing importance in the field of electrical applications, since it is considered to be an inexhaustible and widely available source (Lalouni et al., 2009). In fact, photovoltaic (PV) generators have been applied in various fields such as electrification of isolated sites, installation in buildings and direct connection to medium and low voltage networks (Billel et al., 2017, 2016; Ghoul-delbourk et al., 2016). To optimize the utilization of large arrays of PV modules, maximum power point tracker (MPPT) is normally employed in conjunction with the power converter (DC-DC converter and/or inverter). Due to the varying environmental condition, as temperature and solar insolation, the PV characteristic curve exhibits a maximum power point (MPP) that varies nonlinearly with these conditions, thus posing a challenge for the tracking method. Various MPP tracking methods have been proposed (Lyden & Haque, 2015; Saravanan & Babu, 2016; Liu et al., 2016). Most commonly used techniques of MPPT are perturb and observation (P&O), incremental conductance (IC), hill-climbing method (HC); Constant Voltage and Current, Parasitic Capacitance along with some digital signal processing (DSP) based methods (Joshi & Arora, 2017; Ramli et al., 2017; Liu et al., 2015).

While the above alternative energy systems are considered as promising power sources, they have a main drawback given their strong dependence on the weather and climate conditions affecting their efficiency during energy conversion (Ramli et al., 2017; Joshi & Arora, 2017). Also, when partially shaded conditions (PSC) occurs, the power voltage characteristic curve of the PV modules becomes complex, exhibiting multiple peak values. Therefore, traditional MPPT methods are not suitable for use in PSC (Liu et al., 2015; Jordehi, 2016). A Combination of sources to form a single renewable energy system called as hybrid renewable energy system (HRES), is considered as a suitable solution for this conflict (Wang & Singh, 2009). HRESs are usually more reliable and less costly than other type of renewable systems that rely on a single source of energy. It is true that, from an economic point of view, the results appear quite convincing as to the profitability of the above-mentioned hybrid system, but this does not exclude the fact that the combination of the two sources constitutes a rather complex system from a technological point of view. In this framework, several researchers have investigated the design, optimization, operation and control of HRES. Recent years, many important developments related to the design of nonlinear systems for many practical applications have been proposed such as optimal control, nonlinear feedback control, adaptive control, sliding mode control, nonlinear dynamics, chaos control, chaos synchronization control, fuzzy logic control, fuzzy adaptive control, fractional order control, and robust control and their integrations (Azar & Vaidyanathan, 2016; Boulkroune et al, 2016a,b; Azar et al., 2017a,b,c,d; Azar 2010a,b, 2012; Meghni et al, 2017a,b,c; Mekki et al., 2015; Vaidyanathan & Azar, 2015a,b,c,d, 2016a,b,c,d,e,f,g, 2017a,b,c; Grassi et al., 2017; Ouannas et al., 2016a,b, 2017a,b,c,d,e,f,g,h,i,j; Singh et al., 2017; Vaidyanathan et al, 2015a,b,c; Wang et al., 2017; Soliman et al., 2017; Tolba et al., 2017).

Various aspects and problems must be taken into account when the major concern is about the optimization of a hybrid solar/wind energy system (Celik, 2002). Evaluating the general performance of hybrid photovoltaic/wind energy system and generating acceptable power quality are some of these