Chapter 19
Modeling, Analysis, and Control of Wide Distributed Large-Scale PV Power Plant Using Recent Optimization Techniques

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ABSTRACT

Atom search optimization algorithm (ASOA) has recently been explored to develop a novel algorithm for distributed optimization and control. This chapter proposes the ASOA-based design of maximum power point tracking controllers (MPPTCs) for controlling the boost converter voltage to harvest the maximum power and enhance the damping of oscillations in the output power of the photovoltaic power plants. The proposed ASOA-based MPPTCs are PI and fractional-order PI controllers. ASOA is utilized to search for optimal controller parameters by minimizing a candidate time-domain based objective function. The performance of the proposed ASOA-based MPPTCs has been compared to the MPPTCs optimized by grey wolf optimizer (GWO) to demonstrate the superior efficiency of the ASOA-based MPPTCs. Simulation results emphasis on the better performance of the proposed MPPTCs compared to MPPTCs and GWO-based PI- FOPI controllers over a wide range of operating conditions.

INTRODUCTION

Like many other countries, Egypt faces increasing challenges in the provision of energy services. Therefore, presenting a comprehensive strategy for growth in the energy sector to cope with local market requirements becomes crucial. The primary strategy objectives are how to achieve energy efficiency and

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sustainability at competitive costs by reducing carbon emissions under the availability of energy resources constraints. Also, how to improve the quality of the existing networks, as well as the extent to which this strategy, economic efficiency, and environmental sustainability. Egypt is one of the countries which lie inside the Sunbelt region and enjoy the high direct solar radiation. So, the Egyptian market has become a promising market in the field of solar energy especially, after the availability of modern technologies enabling customers to rely on solar energy within the electricity network or outside it (Hanane Yatimi, et al., 2018), (Nayara Teixeira Santos, et al., 2020). Egypt has a great asset to renewable energy, which paves the way for more current researches to exploit them economically (NREA, 2019). Egypt, one of the countries which lie inside the Sunbelt region and enjoy the high direct solar radiation. As well as solar energy falling on the deserts of Egypt is enough to cover the world's consumption of electricity. Figure (1) presents Egypt's average solar radiation (NREA, 2005). The only drawback to solar energy technology is the high cost of production units produced from solar energy compared to conventional sources. However, nanotechnology has recently achieved a significant reduction in the cost of generating electricity from the sun, and it deduces importance directing scientific research in Egypt, especially to improve the economics of solar energy (Egyptian State Information service,2019). Photovoltaic (PV) is one of the latest technologies used in electrical power generation to convert sunlight directly into electricity; it uses a semiconductor material such as silicon, which is extracted from pure sand (World Energy Council), (Hanane Yatimi, et al., 2018). PV is a renewable and clean energy source because it has no contaminated waste, noise, radiation and does not even need the fuel. However, the initial cost is high compared with other energy sources (Renewable Energy policy network for the twenty-first century, 2017). The main benefit of PV is that there are no moving parts exposed to malfunction. For this, PV works over satellite with high efficiency and no need for maintenance or repairs or fuel (Regional center for Renewable Energy and Energy Efficiency, 2019), (Seyed Hossein, et al., 2018).

The biggest problem with PV system utilization is the weather uncertainties such as solar radiation variation, continuous temperature change, and partial shading (Brian J. Galli, et al., 2020). Therefore, it is crucial to run PV at Maximum Power Point (MPP) to extract the highest power (Mohamed. A. Ebrahim et al., 2017). Nowadays Maximum Power Point Tracking (MPPT) system is considered the central part of any PV system to achieve the maximum power at all times under the change in weather conditions (Jalel Ghabim et al., 2018). There are many MPPT algorithms discussed in scientific research such as Incremental Conductance (IC), Fuzzy Logic Control (FLC), Artificial Neural Networks (ANN), Fractional Open-Circuit Voltage (FOCV), Sliding Mode Control (SMC), Particle Swarm Optimization (PSO), Perturb and Observe (P&O), Fractional Short-Circuit Current (FSCC) (Hadjer Bounechba, et al., 2016). However, these algorithms are differing from each other according to sensors number, easy or complexity implementation and cost. The best algorithm is selected according to its accuracy, fast-tracking performance and minimum error due to changing the countries weather conditions. IC is introduced in this research work due to its ease of implementations and low-cost. Most of the researchers presented the IC-based MPPT algorithms based on I-controller as a classical MPPT algorithm (Hadjer Bounechba, et al., 2016). However, this work offers two modified MPPT algorithms based on Proportional-Integral control (PI), Fractional Order Proportional-Integral control (FOPI), The main problem of FOPI and PI controllers is how to attain the optimum value of the gains to achieve the best result (Mousa, M.E, et al., 2017).

For this purpose, two recent optimization techniques, namely; Atom search optimization (ASO) and Grey Wolf Optimizer (GWO) are used to achieve the optimal gains of PI and FOPI controllers

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