Transient Stability Enhancement for 20 MW PV Power Plant via Incremental Conductance Controller

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ABSTRACT

The inherited uncertainties in the Photovoltaic array (PV) system make it one of the most difficult nonlinear problems in the control theory. In this research work, a practical case study for 20 MW Egyptian PV solar power plant with battery backup system connected to the medium voltage distribution network is presented. This power plant installed in Komombo, Aswan, Egypt. The battery is used to provide the necessary power for the station's monitoring and control devices during the absence of the sun. Also, the battery system improves the steady state and dynamic behavior of PV array system. Proportional-Integral (PI) and Fractional Order Proportional-Integral (FOPI) with Incremental Conductance MPPT algorithm (IC) are used for extracting maximum power from PV power plant. The optimal gains of PI and FOPI based MPPT controllers are attained using Grey Wolf Optimizer (GWO). Various types of disturbances are applied to the system to test the robustness of the systems based on the tuned controllers. The performance is promising.

KEYWORDS

Battery, Fractional Order Proportional-Integral, Grey Wolf Optimizer, Incremental Conductance, Proportional-Integral, Transient Stability Enhancement

INTRODUCTION

The shortage of fossil fuels and the continuous increase of the population in Egypt result in repeated power cuts over the past few years (Ebrahim et al., 2016). Therefore, the new Egyptian trend is to increase the sharing percentage of renewable energy sources to overcome the electricity shortage following economic and political problems (Mohamed et al., 2014). This new trend is assessed by an enormous potential of Egypt due to its special location between the Sunbelt countries (Adel, et al., 2015). Egypt has a great asset of renewable energy which paves the way for more current researches to exploit them economically (Mohamed et al., 2012).

Egypt, one of the countries which lie inside the Sunbelt region and enjoy with 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 average solar radiation (Adel et al., 2015). The only drawback to solar energy technology is the high cost of production unit produced from solar energy compared to conventional sources (Abdel et al., 2017). 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 (Azar & Serrano, 2015a).

The installed capacity of Solar Energy Source (SES) in Egypt was about 1% of the total electricity production from Renewable Energy (RE) sources in March 2017 (Meghni et al., 2016b). The world solar power capacity has expanded rapidly to 305 GW by the end of 2016 with a global growth rate of 52% which was higher than in 2015 (26%). Solar energy production was around 25% of the global renewable generation capacity, and growing rapidly (Azar & Vaidyanathan, 2016). Photovoltaic (PV) is one of the latest technology 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 (Azar, 2015).

PV is renewable and clean energy source because it has no contaminated waste, noise, radiation and does not even need to the fuel. However, the initial cost is high compared with other energy sources (Ebrahim et al., 2016). 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 (Meghni et al., 2016a). The biggest problem with PV system utilization is the impact of the sun radiation and continuous temperature change (Mohammad & Alireza, 2016). Therefore, it is crucial to run PV at Maximum Power Point (MPP) to extract the highest power (Montoya et al., 2016).

Nowadays Maximum Power Point Tracking (MPPT) system is considered the central part of any PV system to achieve the highest power at all time under the change in weather conditions (Bounecbha et al., 2016). In the last decades, there are many artificial intelligence-based techniques were employed for solving different engineering problems (Meghni et al., 2016b; Mekki et al., 2015). There are many MPPT algorithms discussed in scientific research such as Incremental Conductance (IC) (Srinivas, et al., 2016), Fuzzy Logic Control (FLC), Artificial Neural Networks (ANN) (Zhu & Azar, 2015), Fractional Open-Circuit Voltage (FOCV), Sliding Mode Control (SMC), Particle Swarm Optimization (PSO), Perturb and Observe (P&O), Fractional Short-Circuit Current (FSCC).

Figure 1. Egypt average solar radiation
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