A Comparative Study on Maximum Power Point Tracking Techniques of Photovoltaic Systems

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ABSTRACT

This article concerns maximizing the energy reproduced from the photovoltaic (PV) system, ensured by using an efficient Maximum Power Point Tracking (MPPT) process. The process should be fast, rigorous and simple for implementation because the PV characteristics are extremely affected by fast changing conditions and Partial Shading (PS). PV systems are popularly known to have many peaks (one Global Peak (GP) and several local peaks). Therefore, the MPPT algorithm should be able to accurately detect the unique GP as the maximum power point (MPP), and avoid any other peak to mitigate the effect of (PS). Usually, with no shading, nearly all the conventional methods can easily reach the MPP with high efficiency. Nonetheless, they fail to extract the GP when PS occurs. To overcome this problem, Evolutionary Algorithms (AEs), namely the Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) are simulated and compared to the conventional methods (Perturb & Observe) under the same software.

KEYWORDS

Evolutionary Algorithms, Genetic Algorithm, Maximum Power Point Tracking, Partial Shading Conditions, Particle Swarm Optimization, Perturb & Observe, Photovoltaic System

INTRODUCTION

Maximum power point (MPPT) is an integral part of grid connected photovoltaic (PV) systems. Nowadays, many studies have been devoted in order to enhance the performance of PV systems through developing new or improving already existed MPPT methods.

Normally, the conventional MPPT methods that includes Perturb and Observe (P&O), Incremental Conductance (IncCond), and Hill Climbing (HC) techniques, are able to track the maximum power point (MPP) and usually can achieve 99% or higher tracking efficiency (Ahmed, 2008; Esram, 2007; Hohm, 2000; Sera, 2006). The P&O is the most used for its simplicity. The system is continuously perturbed in order to reach the MPP (Zegaoui et al., 2011). Tough, the mission becomes more problematic when the PV array experiences partial shading (PS) conditions and extracting the maximum becomes a challenging task because of the non-linearity of the Power-Voltage (P-V) curve,

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which exhibits multiple local peaks. In fact, the half or more of the PV array receive different amount of insulation because of partially cloudy conditions caused by towers, clouds, trees, neighboring, etc. (Wasnezuk, 1983; Chowdhury, 2010; White, 2016). Thus, it is imperative to use a suitable MPPT technique which tracks the unique global peak (GP) of the shaded PV array effectively, fast and smoothly (Koutroulis & Blaabjerg, 2015). In the latter case, conventional MPPT techniques become ineffective and inaccurate because they cannot discriminate between global and local peak and they can be trapped on the first local peak which reduces the effectiveness of the whole system (Liu, 2012; Shaiek, 2013; Quaschning, 2008). Thus, the main target of this work is the study of those difficulties and limitations of the conventional methods such as P&O and introducing a more suitable method based on Evolutionary techniques (ET) mainly the Genetic Algorithm (GA) and the dynamic Particle Swarm Optimization (PSO).

The partial shade raises the power consumption and the maximum power of the partially shaded PV modules is minimized. To overcome these issue, a bypass diode is often included in parallel with each serial connection of PV cells which makes the P-V characteristic develop multiple maxima. Figure 1 shows the difference between the MPPs in a totally sunny module and a shaded one where the global and the local MPPs are indicated.

There is a large amount of publications targeting this issue, through developing new or enhancing already existed MPPT techniques and a particular type of MPPT gaining visibility in the literature is soft-computing based MPPT algorithms, such as PSO (Huynh, 2013; Ji, 2011). It has proven good performance and reduced steady-state oscillations under various shading shapes. Another work that combines PSO with a conventional method, IncCond, is reported in (Ji et al., 2011). In the above case, PSO is activated only under PS. Otherwise, the conventional MPPT tracks the MPP. This technique guarantees convergence to the global MPP but the use of six particles increases the tracking time and complexity. (Alajmi, 2013; Chin, 2011) combine fuzzy logic MPPT with P&O. The whole P-V curve is scanned and the global MPP is stored by the fuzzy logic while perturbing and observing with exhibiting a fast converging speed and small steady-state oscillations. Genetic Algorithm (GA) was proposed to show that P&O and IncCond are trapped at the local peak when GA reaches the global MPP successfully in (Hadjii, 2011; Shaiek, 2013). A focus has been devoted to Ant Colony Optimization (ACO) to develop the global MPPT in (Jiang, Maskell & Patra, 2013) using the archive of solution. ACO is performed with four parameters which are the size of solution archive, number of ants in an iteration, locality of search space and convergence speed constant. A Golden Section Optimization (GSO) technique is proposed. It is a new and simple maximum power point tracking algorithm. It is the first time that GSO is performed to track the MPP under fast changing conditions and under partial shading, as proposed in (Kheldoun, Bradai, Boukenoui, & Mellit, 2016).

Within this context, three MPPT techniques (P&O, GA and PSO) were simulated and compared under Matlab/SimPower Systems software. Indeed, this library provides electronic components with dynamic characteristics. This alternative requires a judicious choice of the sampling and chopping

Figure 1. Example of the power-voltage characteristics of a PV array
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