Improved Perturb and Observe Algorithm for Maximum Power Point Tracking in a Photovoltaic System

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Abstract

This paper presents a novel method for improving the algorithm of perturb and observe (P&O) to ensure the Maximum Power Point tracking (MPPT) in photovoltaic systems. Indeed, the P&O algorithm is one of the most widely applied MPPT methods in PV systems, which depend on the environmental factors, such as solar irradiance and ambient temperature. In this paper, an improved modified step size algorithm based on P&O algorithm is proposed to improve the tracking response of the maximum power point in comparison to the conventional fixed step size P&O algorithm. The theoretical analysis and the principle design of the proposed algorithm are investigated, and its feasibility is validated and compared to the conventional P&O algorithms. The simulation results confirm that the presented algorithm can effectively improve the MPPT response and its accuracy simultaneously when compared with the conventional fixed step size P&O MPPT algorithm.
Keywords: MPPT, Perturb and Observe Algorithm, Step size, Photovoltaic, Boost converter

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1. Introduction

At present, the generation of electric power from photovoltaic (PV) panel becomes very popular and is attracting more attention all over the word as a promising alternative source of energy due to the free availability of solar energy, the cleanness of energy production and the reasonable exploitation costs[1-2].

However, the generated energy from photovoltaic systems (PVs) is unstable due to the efficiency of solar panels that depends on several parameters, such as the temperature, the sun illumination and the sudden changes of weather [3-5].

On the other side, the I-V characteristic curve of a solar cell presents a nonlinear current-voltage relationship that affects its performance. In order to extract the maximum power generated by the panels under operating conditions on real time, a controller is required. Indeed, several controllers based on maximum power point tracking MPPT algorithms have been proposed, developed and implemented to achieve the requirement of the maximum power extraction from PV systems [6-7]. It can be said that the performances of all these algorithms are depending on several aspects such as the convergence speed, the complexity and the obtained efficiency.

In this context, to overcome the main disadvantages faced within the previously mentioned algorithms various MPPT algorithm shave been developed, such as the fractional short circuit current (FSCC) and the fractional open circuit voltage (FOCV) [8-9].

However, these algorithms require periodic disconnections or PV module short-circuits to measure the open circuit voltage or short circuit current, this leads to energy loss and consequently lower efficiency is met.

On the other side, the incremental MPPT algorithms have been proposed such as the incremental conductance algorithm "INC" and the perturb and observe algorithm "P&O" which are very popular actually and have been widely used in practice because of their simplicity and ease of implementation [6] and [10].

Moreover, the developed nonlinear MPPT techniques, such as the ripple correlation control (RCC) [11], the fuzzy logic (FL) [12-13], the neural networks (NN) [14] and the hybrid algorithm based on combining the neural network with fuzzy logic (NN-FL) [15], are so far the only complex algorithms that can be adapted to the nonlinear behaviour of the PV system at different operating conditions.

However, in spite of this advantage they have some drawbacks. For the same purpose, the particle swarm optimization (PSO) [16-17], and the sliding mode [18-19] techniques have been used in some of the recent MPPT control techniques available in the literature. Overviews of the various MPPT techniques are discussed in previous papers [20-23].

In this paper, an accurate technique for MPP tracking based on P&O algorithm is proposed. The main target of this proposed algorithm is to satisfy the search dynamics and to increase the system efficiency at the same time, where, the main idea is to ensure a fast MPP tracking while keeping improved performance of the main features such as the accuracy, the real time detection and tracking of the MPP, the tracking stability and reduced the complexity of the algorithm and its time computation.

2. PV Module Characteristics

The basic device of a photovoltaic (PV) system is the PV cell that directly converts the sunlight to the electrical power. Whereas, the PV module is the association of a PV