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Maximum power point tracking algorithms for photovoltaic system – A review

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ABSTRACT

This paper provides a comprehensive review on various maximum power point tracking (MPPT) algorithms based on Perturb and Observe, Incremental Conductance, Soft Computing and other techniques along with the real time hardware implementation of photovoltaic (PV) system. In this review, the complete procedure, the implementation methodology and their effects in the PV output were discussed in detail for each algorithm. Further, MPPT algorithms for PV systems with partial shading condition were reviewed and reported. This paper is intended to serve as a suitable reference for future work in PV based power generation and its related research.

Contents

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1. Introduction

In the recent years the demand for power generation increases rapidly and on the other hand the availability of the conventional resources (like coal and petroleum) degrades drastically which makes a challenging future for the power production. Moreover the conventional resources based power generation has the effect of greenhouse emission. Due to these reasons renewable energy based power generation has increased manifold. Among all type of renewable energy technologies, PV based energy is a good choice as it is available universally, free of cost, atmospheric friendly, and has less operational and maintenance costs [1,2]. The necessity of photovoltaic (PV) generation systems is getting increased for both stand alone and grid connected system. Therefore, to make the PV generation efficient, a capable maximum power point tracking (MPPT) technique is required to predict and to track the MPP at all environmental circumstances and then force the PV system to run at that MPP point [3–6].

Various MPPT techniques had been proposed by researches to improve the efficiency of PV systems in recent years such as distributed MPPT, adaptive P&O, variable step size P&O, modified INC, Fuzzy Logic Controller (FLC), Neural Network (NN) and Particle Swarm Optimization (PSO) based P&O. These methods vary in convergence speed, oscillations around the MPP, algorithm complexity, cost and electronic equipment requirements [7–10]. Few researchers discusses the hardware implementation of the MPPT also in various methods such as FPGA, PIC microcontroller, DSP, Analog circuitry etc.,

In this review, an attempt has been made to compare the systems on the basis of their MPPT techniques, converter types, complexity and hardware implementation. This literature review shows distinct advantages than the similar works published [2,11–13] and gives current advancements in the techniques as well implementation methodologies. The schematic block diagram for stand alone and grid connected PV system is shown in Fig. 1.

From Fig. 1, it can be noted that the MPPT technique is to find the voltage V_{mpp} or current I_{mpp} at which a PV array should operate so as to obtain the maximum power output P_{mpp} under a given temperature and irradiance.

The paper is organized as follows. In Section 2, modeling of PV panel is discussed. In Section 3, various real time MPPT techniques from the literature survey are reviewed. In Section 4, the manuscript concludes with a discussion on different methods based on their implementation in real time to detect the local and global maximum.

2. Modeling of PV

PV cells have p–n junction similar to a diode. It generates the electrical power by using photons. It has capacity to absorb the solar irradiance and mobilize the photons to electrons until it converges [14–16]. When a load is connected to the PV cell the charges flows through it as a direct current until the irradiance gets stop [17,18].

The cells are connected in series and/or parallel to achieve the corresponding voltage and current. If the cells are connected in series then it produces the large output voltage whereas if the connection is in parallel it produces large output current. The modeling of the solar cell is defined by voltage–current relationship of PV system as follows [19].

$$I = I_{pv} - I_s\left(\exp\frac{q(V+R_sI)}{N_skTa} - 1\right) - \frac{V+R_sI}{R_p} \quad (1)$$

where:

I_{pv}: PV current (A).

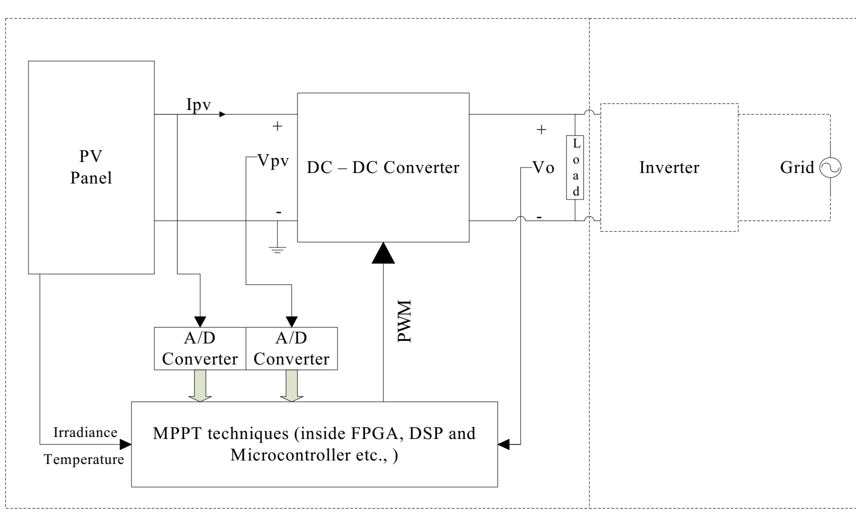

Fig. 1. Schematic block diagram for stand-alone and grid connected PV system.