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Maximum Power Point Tracking Method For PV Array Under Partially Shaded Condition

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ABSTRACT: *Solar radiation that hits the photovoltaic modules has a variable character depending on the position, the direction of the solar field, the season, and the hour of the day. During the trajectory of a day, a shadow may be decanted on the cell, which may be contemplated, as in the case of a building near the solar field, or unforeseeable as those created by clouds. The breakthrough of PV systems as distributed power generation systems has increased drastically in the last few years. Because of this Maximum Power Point Tracking (MPPT) is becoming more and more substantial as the amount of energy generated by PV systems is increasing. A MPPT technique must be used to track the maximum power point since the MPP depends on solar irradiation and cell temperature. In general, when the impedances of the load and source are matched, the maximum power is transferred to the load from the source only. The generated energy from PV systems must be maximized, as the efficiency of solar panels is low. For that reason to get the maximum power, a PV system is repeatedly equipped with an MPP tracker. Several MPP pursuit techniques have been proposed and implemented in recent years.*

Keywords: *Neural network, Open Circuit Voltage, Short Circuit Current, Fuzzy Logic Control, Perturb and Observe and Incremental Conductance*

I. INTRODUCTION

The use of the recently developed power control mechanisms, called Maximum Power Point Tracking (MPPT) algorithms, has led to increasing the efficiency of operation of the solar modules. Therefore, MPPT is efficient in the field of exploitation of renewable sources of energy [MPPT technics]. Maximum power point tracking is a DC-to-DC converter that optimizes the match between the solar array (PV modules) and the battery bank or utility grid. It converts a higher voltage DC output from solar PV arrays or modules down to the lower voltage needed to charge batteries and vice versa. Maximum Power Point Tracking is an electronic arrangement that routinely finds the voltage (V_{MPP}) or current (I_{MPP}) at which PV modules should operate to achieve maximum power output (P_{MPP}) under partial shading condition. It runs the PV modules in a way that allows the modules to generate all the power they are capable of producing [3]. MPPT is an electronic tracking system, whether digital or analog. There are many approaches to find and track the maximum power point for PV cells. For instance, neural network, open circuit voltage, short circuit current, fuzzy logic control, perturb and observe, and incremental conductance are the most popular methods to track the maximum power point tracking. As a matter of fact, many systems have combined methods, for example, using the open circuit voltage (OV) to find the starting point for the iterative methods such as Perturbation and Observation or Incremental. The levels of irradiance play an important part in changing from one scheme to another. For example, at low levels of irradiance, methods like open circuit voltage and short circuit current could be more suitable as they can be more noise immune. When the cells are connected in a series, the iterative methods can be a preferable solution. When a portion of the string is partial shade, search algorithms are needed [5].In general, the accurate method is better than the fast because fast methods tend to bounce around the maximum power point due to noise present in the power conversion system. Of course, an accurate and fast method would be preferred, but the cost of implementation needs to be considered.

II. NEURAL NETWORK

Neural networks are another technique for implementing MPPT, which is also well adapted for microcontrollers. Neural networks usually have three layers, which are input, hidden, and output layers. The input variable can be PV array parameters such as V_{OC} and I_{SC}. Additionally, it can be atmospheric data like irradiance and temperature. The output is commonly one or several reference signals like a duty cycle signal.

III. OPEN CIRCUIT VOLTAGE

The Open Circuit Voltage (OV) method for MPPT control is based on measured terminal voltage and PV arrays. Generally, the OV technique uses 76% of the open circuit voltage OV as the optimum operating voltage V_{OP}. By measuring the open circuit voltage in real-time, the maximum power point of the PV array can be estimated with the predefined PV I-V curves. It is important to introduce a static switch into the PV array for the OV method. The switch has to be connected in series to open the circuit. When $I_{PV} = 0$, the PV system supplies no power. The features of this approach are a relatively fast response and no oscillations in a steady state [1].

IV. SHORT CIRCUIT CURRENT

The short circuit current method employs a value of I_{SC} to estimate I_{MP}. This method uses a short load pulse to generate a short circuit condition. Indeed, it is important to observe that during the short circuit pulse, V_{PV} equal zero. Consequently, no power is supplied by the PV system and no energy is generated. Therefore, the power conversion circuit must be powered from some other source. To create the short circuit condition, it is necessary to introduce a static switch in parallel with the PV array. In fact, the optimum operating current I_{OP} for maximum output power is proportional to the short circuit current I_{SC} under various conditions of irradiance level G as follows:

$I_{OP}(G) = k.\ I_{SC}(G)$

Where k is a proportional constant. One advantage of this technique is the tolerance for input capacitance compared to the V_{OC} method [2].

V. FUZZY LOGIC CONTROL

A fuzzy logic control (FLC) is used to control the maximum power point tracking for a photovoltaic (PV) system. The FLC technique harnesses the fuzzy logic control to specify the size of incremental current in the current command of MPPT. Hence, the convergence time of the maximum power point (MPP) of the FLC algorithm is better than the Perturb and Observe (P&O) algorithm. That is why the FLC algorithm is used to enhance the performance of the P&O algorithm. Moreover, the FLC can handle nonlinearity and work with imprecise inputs [4].

VI. PERTURB AND OBSERVE

Perturb and observe (P&O) is one of the most straightforward and popular techniques of MPPT. In this technique, only one sensor is used, which is the voltage sensor, to sense the PV array voltage. Therefore, the cost of implementation is reduced and, hence, is easy to implement. The main aim of this method is to boost the system to work in a direction. The P&O algorithms operate by perturbing the array terminal voltage or current. After that, the P&O algorithms compare the PV output power with the previous perturbation cycle. This equation below describes the change of power, which elucidates the strategy of the P&O technique.

Δ□ = □□−□□−1

(□□) = The new point of the power, (□□−1) = The old point of the power

By comparing the new power point with old power point we can get the new maximum power point.If the resulting change in power is positive, then the system is going in the direction of MPP and will keep the direction of the incremental current as the same direction. If the change in power is negative, the system will change the direction of incremental current to the opposite direction, and it is going away from the direction of MPP. This method works well when the radiation and temperature conditions change slowly. However, the P&O method fails to track MPP when the atmospheric condition is rapidly changed. A common problem in P&O algorithms is that the array terminal voltage is perturbed every MPPT cycle. Therefore, to avoid this problem we can use an incremental conduction method [6]-[9].

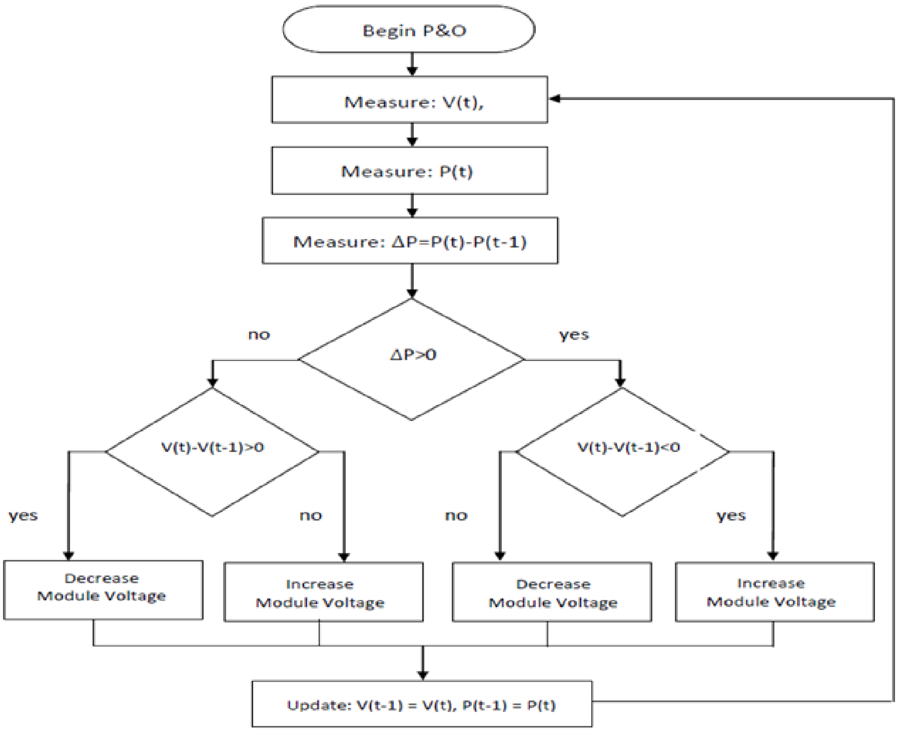

Fig.1: Flowchart of Perturb and Observe (P&O) methods.

VII. INCREMENTAL CONDUCTANCE

The incremental conductance(IC) method employs two sensors, which are voltage and current of the PV array. At MPP, the slope of the PV curve is zero. Indeed, the purpose of the incremental conductance method offers a good performance and takes account of the rapidly changing atmospheric conditions. The incremental conductance method is based on the fact that the slope of the PV array power is zero at the MPP, positive on the left of the MPP, and negative on the right, as given by

$dP/dV = 0$, at MPP
$dP/dV > 0$, left of MPP
$dP/dV < 0$, right of MPP
$\Delta I/\Delta V = -I/V$, at MPP
$\Delta I/\Delta V > -I/V$, left of MPP
$\Delta I/\Delta V < -I/V$, right of MPP

Where V and I represent the PV array output current and voltage, respectively. The left-hand side of equations represents incremental conductance of PV module, and the right-hand side represents the instantaneous conductance cycle. Comparing the incremental conductance ($\Delta I/\Delta V$) to the instantaneous conductance (I/V), as shown in the flowchart in Figure 4.4 used to track the MPP, the operation of the PV array is maintained once the MPP has been reached unless a change in ΔI is noted [7]-[8].

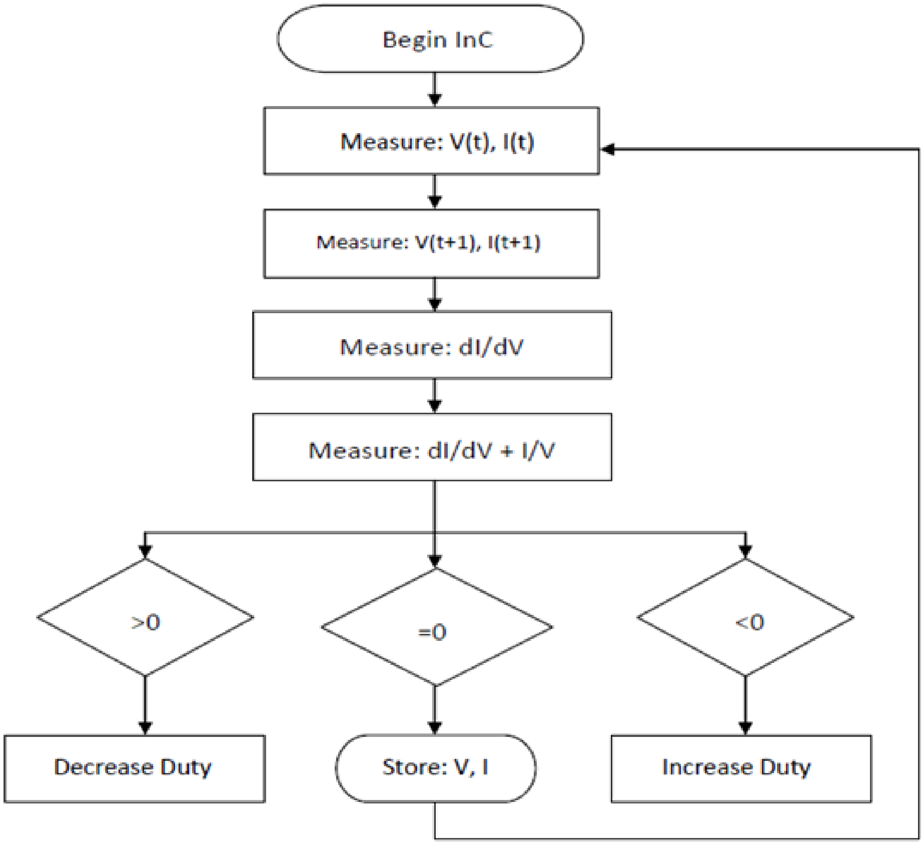

Fig.2: Flowchart of Incremental conductance method.

Table 1: Characteristics of Different MPPT Techniques

MPPT technique	Convergence speed	Implementation Complexity	Periodic tuning	Sensed parameters
Neural Network	Fast	High	Yes	Varies
Open Circuit Voltage	Medium	Low	Yes	Voltage
Short Circuit Current	Medium	Medium	Yes	Current
Fuzzy Logic Control	Fast	High	Yes	Varies
Perturb and Observe	Varies	Low	No	Voltage
Incremental Conductance	Varies	Medium	No	Voltage & Current

VIII. CONCLUSION

There are many ways to find and track the maximum power point for PV cells and groups of cells such as neural network, open circuit voltage, short circuit current, fuzzy logic control, perturb and observe, and incremental conductance. Numerous systems combine methods, such as using open circuit voltage to find the starting point for the iterative methods like Perturb and Observe or Incremental Conductance. In some cases, the level of irradiance plays a major role in choosing the appropriate method. For example, at low levels of irradiance, methods like Open Circuit Voltage and Short Circuit Current may be more suitable. However, for simplicity and effectiveness, P&O was selected for further analysis.

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