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PV cell Array for Maximum Power Point

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Abstract**--**In the recent years various algorithms have been proposed by researchers to extract the maximum power out of the solar cell/array, called maximum power point tracking (MPPT) algorithms. Out of these incremental conductance (INC) algorithm is most widely used due to its easy implementation and high accuracy. These algorithms also work for non ideal conditions such as long time partial shading condition (PSC).

In this paper, a modified INC MPPT algorithm has been proposed, which also works to solve the problem of small time partial shading by comparing the previous and present duty ratios (D) of boost converter.

Index Terms**—**Incremental conductance (INC), maximum power point (MPP), maximum power point tracking (MPPT), partial shading conditions (PSC), duty cycle (D).

I. Introduction

A PHOTOVOLTAIC (PV) array under uniform irradiance exhibits a current-voltage characteristic with a unique point, called the maximum power point (MPP), where the array produces maximum output power, which depends on panel's temperature and on irradiance conditions. MPPT techniques are used in photovoltaic (PV) systems to maximize the PV array output power by tracking continuously the maximum power point (MPP) [1].

Mostly used MPPT algorithms are following:

- Perturb and observe (P&O) algorithm.
- Incremental conductance (INC) algorithm.
- Constant Voltage (CV) algorithm.

Perturb and observe (P&O) maximum power point tracking (MPPT) algorithm is the most commonly used method due to its ease of implementation, but at steady state, the operating point oscillates around the MPP giving rise to the waste of some amount of available energy [1]-[3]. The P&O algorithm can be confused during those time intervals characterized by rapidly changing atmospheric conditions. Fig.1 Starting from an operating point A, if atmospheric conditions stay approximately constant, a perturbation ΔV in the PV voltage V, will bring the operating point to B and the perturbation will be reversed due to a decrease in power. If the irradiance increases and shifts the power curve from P_1 to P_2 within one sampling period, the operating point will move from A to C [3].

$$\frac{dI}{dV} + \frac{I}{V} \text{€} \ 0 \text{, right of MPP} \quad (3)$$

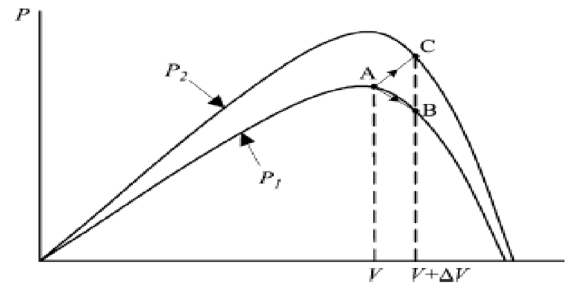

Fig. 1. Divergence of P&O from MPP.

The incremental conductance algorithm seeks to overcome the limitations of the P&O algorithm. Incremental conductance can determine that the MPPT has reached the MPP and stop perturbing the operating point. Incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy. Increased complexity when compared to perturb and observe method. This increases computational time and slows down the sampling frequency of the array voltage and current [4].

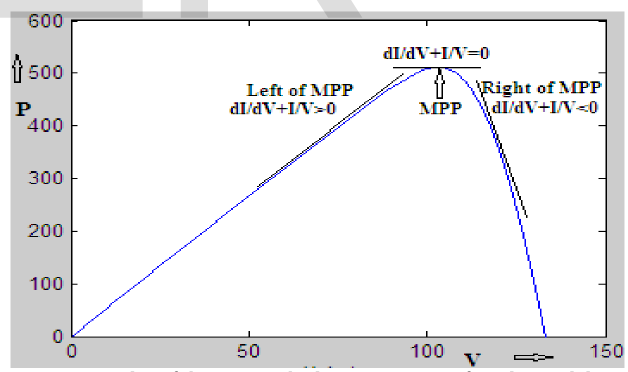

Fig. 2. Basic idea of the INC method on a PV curve of a solar module.

$$\frac{dI}{dV} + \frac{I}{V} = 0 \text{, at MPP} \quad (1)$$

$$\frac{dI}{dV} + \frac{I}{V} \Sigma \ 0 \text{, left of MPP} \quad (2)$$

where I and V are the PV array output current and voltage, respectively [5].

Constant Voltage algorithm makes use of the fact that the MPP voltage changes only slightly with varying irradiances. The ratio of V_{MP}/V_{OC} depends on the solar cell parameters, but a commonly used value is 76% [2, 4].

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TABLE I
OVERALL MPPT EFFICIENCIES FOR DIFFERENT ALGORITHM

	P&O	INC	CV
Array	96.5 %	98.2 %	88.1 %
Simulator	97.2%	98.5 %	92.7 %

From above table INC is most efficient algorithm.

A. Different Type of INC Algorithm

Basic of incremental conductance (INC) algorithms [3]-[5, 10] at MPP

$$\frac{dI}{dV}+\frac{I}{V}=0 \quad (1)$$

In [6] the condition for the Maximum Power Point (MPP) operation can be established from the solar cell voltage and the converter switching duty ratio alone. The method can also be readily applied to any load type where power increases monotonically with voltage. The experimental results show that the proposed MPPT algorithm has secured a 1.5-ms response time due to insolation changes. Another INC MPPT algorithm with a variable step size, reported in [6] adjusts automatically a step size to the solar array operating point, thus improving the MPPT speed and accuracy compared with the conventional method with a fixed step size [7, 8]. The INC MPPT algorithm is used for tracking MPP of PV system is capable of tracking MPPs accurately and rapidly without steady-state oscillation, and also, its dynamic performance is satisfactory [9, 10].

B. Effects on the PV Array Under PSC

Nonideal conditions refer to some specific situations where solar cells reach their limits and cannot provide specified power. Common nonideal conditions include partial shading, low solar radiation, dust collection, and photovoltaic ageing [11]. It is not easy to avoid shading in residential installations because of the change in sunlight direction throughout the day. Furthermore, obstacles, such as trees, poles, towers, birds, and buildings, etc., can cause partial shading. Minor shading can cause a major reduction in solar power output of the PV array. A PV array is composed of several PV modules connected in series-parallel to get the desired voltage and current. To protect modules from hot-spot (Shadowing is the normal event in a photovoltaic system, causing thermal disequilibrium which produces excess heat at the shadowed cell) problem, the bypass diodes are connected in parallel with each PV module and the blocking diode is connected in series with each string, which is a group of series connected PV module, to protect the modules from the effect of potential difference between series connected strings. When the solar irradiance on PV array is identical, only one MPP is existed on the P-V characteristic curve of PV array. However, because of the bypass diodes and the blocking diodes, numerous local maximum power points (multiple local maxima) can exist under partially shaded condition. The performance of MPPT is analyzed according to the position of real MPP [12].

Fig. 3 shows a PV array composed of 3×2 modules and its Characteristic curves under PSC. There are two local MPPs on the P-V curve; however, only one of them is the real MPP.

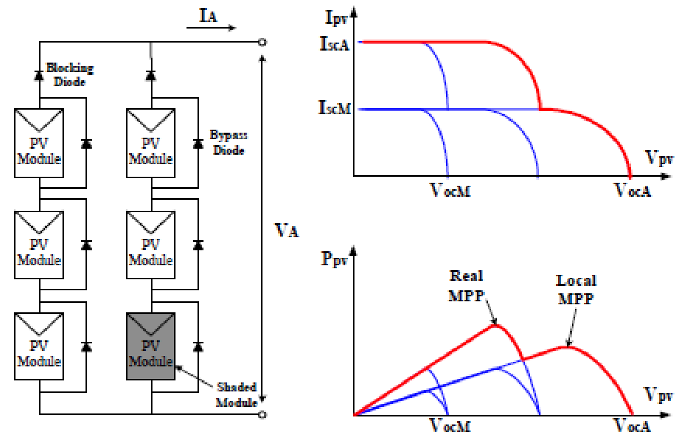

Fig. 3. Output characteristic curve of 3x2 PV array under PSC.

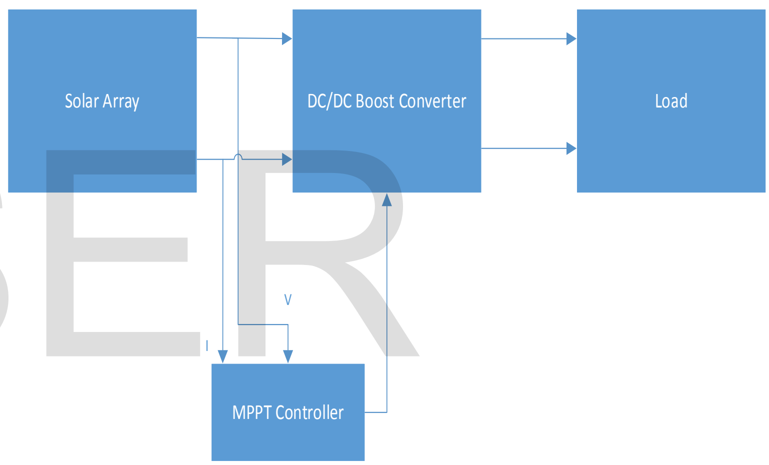

Fig-4

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II. PROPOSED INC MPPT ALGORITHM

Fig. 5. The flow chart of the modified INC MPPT method.

Minor shading by birds, small clouds and airplanes can cause a major reduction in solar power output of the photovoltaic array. If shading is for very small duration .

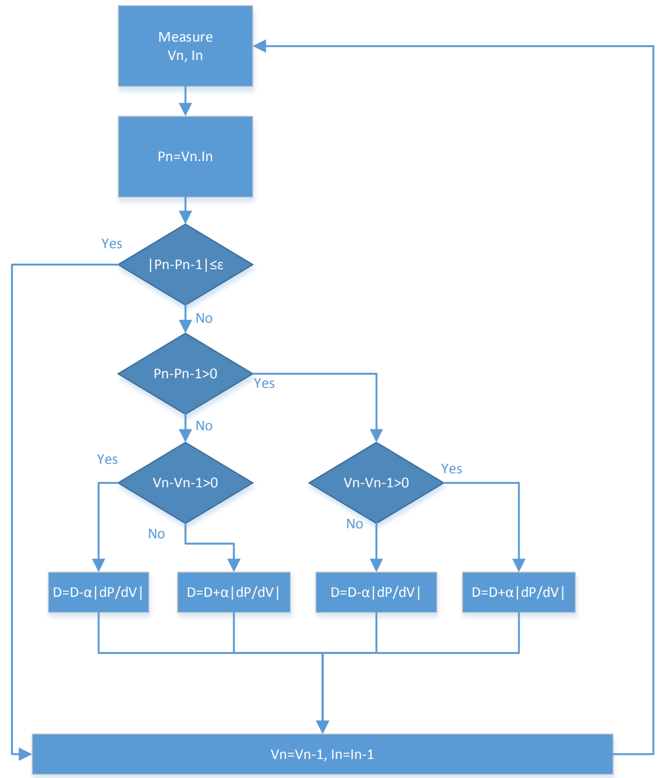
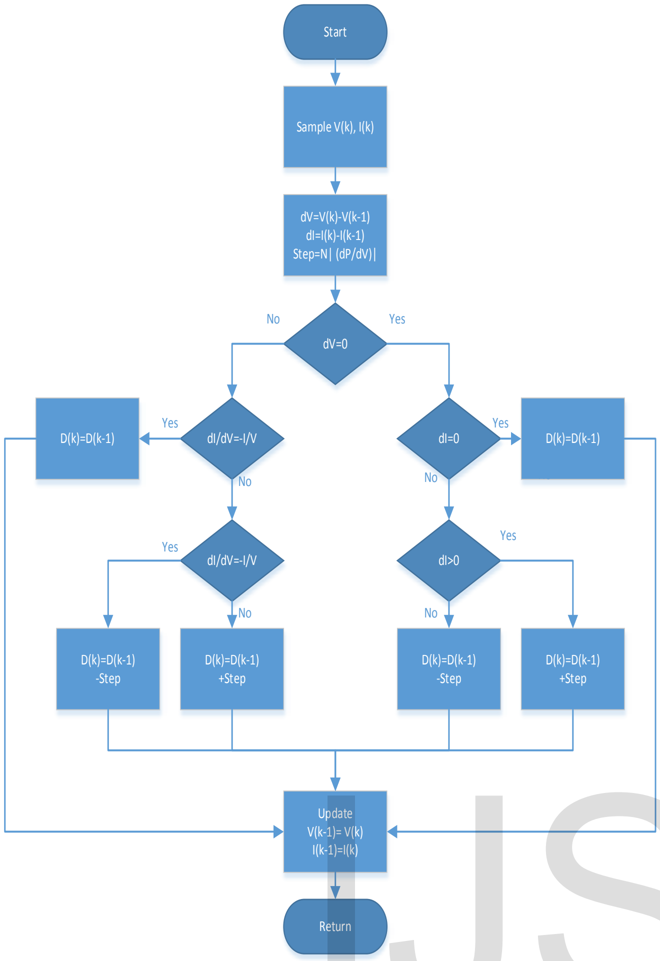


Fig -6 -Flow chart for P & O


Start
Sample V(k), I(k)
dV=V(k)-V(k-1)
dI=I(k)-I(k-1)
Step=N| (dP/dV)|
No
Yes
dV=0
D(k)=D(k-1)
Yes
dI/dV=-I/V
No
dI=0
Yes
D(k)=D(k-1)
No
Yes
dI/dV=-I/V
No
dI>0
Yes
No
D(k)=D(k-1)
-Step
D(k)=D(k-1)
+Step
D(k)=D(k-1)
-Step
D(k)=D(k-1)
+Step
Update
V(k-1)= V(k)
I(k-1)=I(k)
Return