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Modified P&O Based Mppt Controller For Photo Voltaic System Under Partial Shading Condition

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Abstract: It is essential to extract the maximum available power from solar system since the energy efficiency of solar cell is about 13%-17% only. There must be converter for efficient electrical tracking. It is achieved by impedance matching between load and solar module. There may be multiple peaks under varying illumination and under partial shading of individual modules. In these case we have to track global maximum power point (GMPP) apart from local maximum power point (LMPP). The conventional techniques either cause energy wastage due to unwanted full PV curve sweeping or complex due to photo sensor and error in calculation. So a new algorithm based on modification of conventional P&O algorithm to track GMPP is trying to establish

Keywords: Maximum power point tracking (MPPT), multiple maxima, partial shading, photovoltaic (PV), Local Maximum Power Point, Global Maximum Power Point.

I.INTRODUCTION

A Photovoltaic (PV) cell is an electrical device which converts the energy of light directly into electricity through PV effect. PV cells have a nonlinear relationship between solar irradiation, temperature, and total resistance, and they exhibit a nonlinear output efficiency characteristic known as the P–V curve. Therefore, it is essential to develop maximum power point tracking (MPPT) techniques in PV systems in order to maximize the output power of PV systems. There have been many MPPT methods reported in the literature, such as hill climbing [1], perturb and observe [2], incremental conductance (INC) [3]. However, when there are multiple local power maxima [4], [5], from partially shading modules or from installation on a curved surface, conventional MPPT techniques do not perform well. These multiple maxima may occur due to presence of bypass diodes [6], which are used to avoid hot spots from forming when some cells in a module or some modules in a array receive less irradiance than others [7]. So it is essential to develop an algorithm which will track the global maximum power point apart from local maximum. Global maximum power point tracking (GMPPT) algorithms can be categorized mainly into two groups. First one is the global (complete) scan of obtained PV output curves [8]–[10]. Followed by, a complex algorithm is used to calculate the GMPP of the curves. Major disadvantage of this method is the inability to determine whether the PV cell is operating under the shading conditions. Because the GMPP is blindly tracked, and the converter system works at low-power points most of the time in the tracking process, energy waste is significant. The second group uses specialized sensors (for the measurement of solar irradiation) to calculate the working status of the PV cells and then simulate the output characteristic curves [11], [12]. This method can be an effective solution to mitigate the effect of partial shading. The simulation results, however, obtained by measuring environmental parameters and the actual case will be entirely different, because the actual characteristic of the solar panels depends on many external factors (e.g., light intensity, temperature aging, dust, and partial shading). In addition, the method increases the PV system cost in practical commercial applications. In this paper, a new method to track the GMPP of PV arrays operating under partial shading conditions is presented. The paper is organized as follows. Section II describes critical observations on the current–voltage (I–V) and power– voltage (P–V) curves of partially shaded arrays. Section III describes the proposed algorithm to track the GMPP. Section IV presents the simulation results. The main conclusion is summarised in Section V.

II. PARTIAL SHADING CONDITIONS

Fig. 1(a) shows a PV array consisting of four PV modules connected in series under uniform insolation conditions. Fig. 2(a) illustrates typical I–V and P–V curves for the PV array under a uniform solar irradiance of 1000 W/m^2 on all the PV modules. The traditional MPPT algorithm can reach this peak and continue oscillating around the MPP. The P&O method, perturbs the solar array voltage in one direction in each sampling period and tests the power change afterward. It is assumed that initially PV array is operating at point A, as shown in Fig. 2(a). An operating voltage of the PV array is perturbed in a given direction (A to B), and an increase in output power is observed (P_B>P_A). This means that point B is closer to the MPP than point A, and the operating voltage must be further perturbed in the same direction (from B to C). On the other hand, if the output power of the PV array decreases (from D to E), the operating point has moved away from the MPP, and therefore, the direction of the operating voltage perturbation should be reversed (from D to C). Through constant perturbation, eventually the operating voltage will reach and continue oscillating around the MPP level.

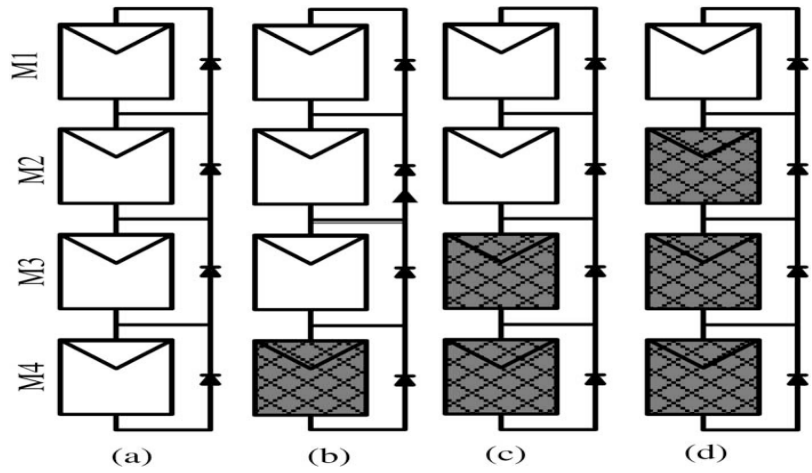

Fig.1 PV array under different partial shading conditions. (a) Sample PV array with insolation of 1000 W/m^2 on the unshaded modules. (b) One shaded module with 400 W/m^2 (c) Two shaded modules with 400 W/m^2 (d) Three shaded modules with 400 W/m^2.

Under the partial shading conditions, if there is one module in a PV string that is less illuminated, the shaded module will dissipate some of the power generated by the rest of the modules. It means that the current available in a series-connected PV array is limited to the current of the shaded module. This can be avoided by using bypass diodes which can be placed in parallel with the each of the PV module. The method of using bypass diodes allows the array current to flow in the correct direction even if one of the strings is completely shadowed. Bypass diodes are widely implemented in commercial solar panels. Because of bypass diodes, multiple maxima appear under the partial shading condition.

The P–V curve of PV array in Fig. 1(b) possesses multiple maxima under the partial shading condition, as shown in Fig. 2. The unshaded modules in the PV array are exposed to 1000 W/m^2 of solar insolation and the shaded module is exposed to 400 W/m^2 of solar insolation. There are two peaks observed in the P–V curve, because of the natural behaviour of the bypass diode and PV array connection inside the module. Point A is the GMPP, while point B the local maximum power point (LMPP). When the area covered by the shadow changes, the P–V curve and the location of GMPP also changes, as shown in Fig. 2(c) and 2(d). Under these conditions, conventional algorithms can only track either of the two MPPs, and cannot distinguish between GMPP and LMPP.

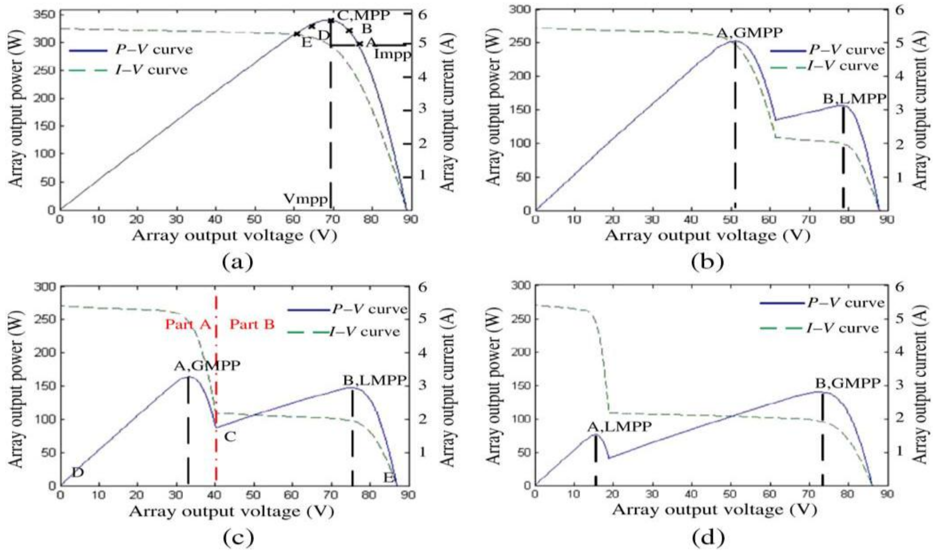

Fig. 2. P–V and I–V characteristics curves of a PV array under different partial shading conditions, as shown in Fig. 1(a)–(d). (a) Unshaded modules. (b) One shaded module with 400W/m^2. (c) Two shaded modules with 400W/m^2. (d) Three shaded modules with 400 W/m^2

If the operating point obtained by the P and O algorithm is LMPP, the output power is significantly lower. Some researchers proposed a global scan method to obtain the PV output curves. Further a complex algorithm is required to calculate the GMPP of the curves. This method is able to obtain the GMPP accurately, but it cannot determine whether the PV cell is operating under shading condition or not, also blindly and constantly scans for the MPP, wasting the output energy. For these reasons, a new improved MPPT method for the PV system under the partial shading condition is proposed in this paper.

III. MODIFIED P AND O METHOD

A. Observations on P-V, I-V characteristics under partial shading condition

From the previous findings on partial shading [13], and multiple maximum due to bypass diodes some common observations can be mad. These observation can be listed as

1) I–V curves under partial shading conditions have multiple steps while the P–V curves are characterized by multiple peaks.

2) The number of peaks is equal to the number of different insolation levels on the PV array, and any peak point may be the GMPP.

3) The voltage obtained from PV modules that receive different solar radiations are different.

4) The voltage of the PV module that is bypassed by a diode is equal to the negative of that diode's forward voltage drop (cut-in voltage).

B. Modified P and O method under partial shading

The flowchart of the modified MPPT algorithm is shown in Fig. 3. Which is used to track the GMPP even under partial shading conditions. The algorithm always starts with a reference voltage (V_{ref}) value set to 85% of open circuit voltage (block 1) as shown in the "Main Program." At the same time, it calculates the number of PV Modules in the array N .Under uniform insolation, there is only one peak in the P–V curve. Therefore, until the partial shading occurs, it will operate at the GMPP by continuously implementing the P&O method (blocks 2 and 3). When MPP is found, it will store the point information, i.e., array power and the voltage (block 4). A timer interrupt program is used to regular checking of the shading condition in proper interval of time (block 5). When a PV module voltage is greater than another one (Vi >Vj) in the same point, it indicate that partial shading has been occurred. When the absolute difference between V_i and V_j is greater than a pre-set constant (used to eliminate sample disturbance and minor differences due to slight changes in insolation), the "Main Program" will calls the "GMPP track subroutine" (block 7). The "GMPP track subroutine" eventually finds the true GMPP and then again gives the control onto the "Main Program," which maintains the operation at this new GMPP.

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The Global MPP track subroutine used to identify the location of the last MPP on the P–V curve (block 8). Whenever the voltage of any PV module is less than zero (V_i<0), it means that the last MPP is the left peak on the P–V curve [Fig. 2(d)], and reference voltage of the right peak is set to about 80% of (block 9). Then, a conventional MPP technique (such as P&O) is applied to track this peak (blocks 10 and 11). If any one of the PV module voltage is not less than zero, the last MPP is the right peak on the P–V curve. It divides the voltage of all PV modules into two groups according to their voltage and calculates M, the number of modules in the array with the smaller voltages (block 12). These modules should be bypassed and will not output any power [Fig. 2(d)], so the reference voltage on the left peak is equal to about 80% of $(1-\frac{M}{N})$ *V_{oc} (block 13).

Afterward, the same MPP technique (conventional P&O) is applied to track this peak (blocks 14 and 15). By comparing the powers of this peak and the previous one, the true GMPP is obtained (blocks 16 and 17). Finally, the reference voltage is set to the voltage corresponds to the true GMPP, and the control is return to the "Main Program," which maintains the operation at this GMPP until the timer interrupt once again.

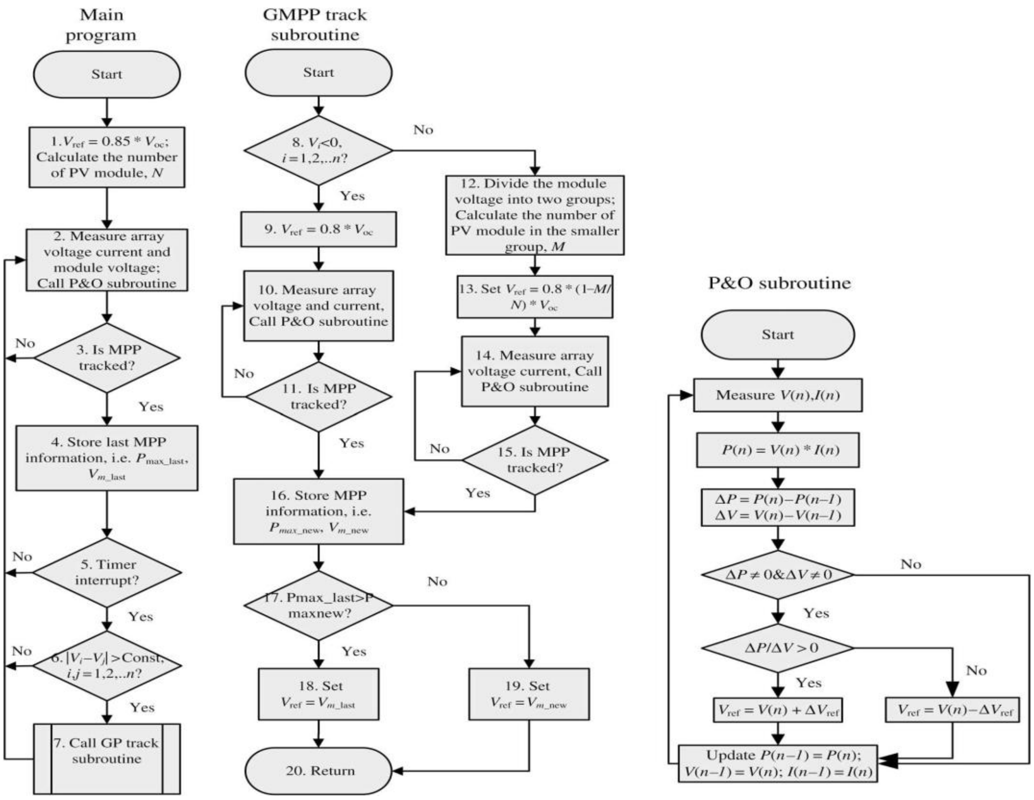

Fig.3 Flowchart of the improved MPPT control.

II. SIMULATION RESULTS OF MODIFIED METHOD

To simulate the performance of the proposed MPPT technique, a series of MATLAB tests was performed. Fig. 4 shows MATLAB- SIMULINK model of boost converter system adopted for the experiment. The PV array consisted of 4 modules of 250 W, and a bypass diode placed is in parallel with each module.

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Voltage of each module is sensed and compared with each other for sensing amount of partial shading periodically. Based on voltage of each module, starting duty ratio of P&O algorithm is properly selected and there onwards conventional P&O algorithm is executed

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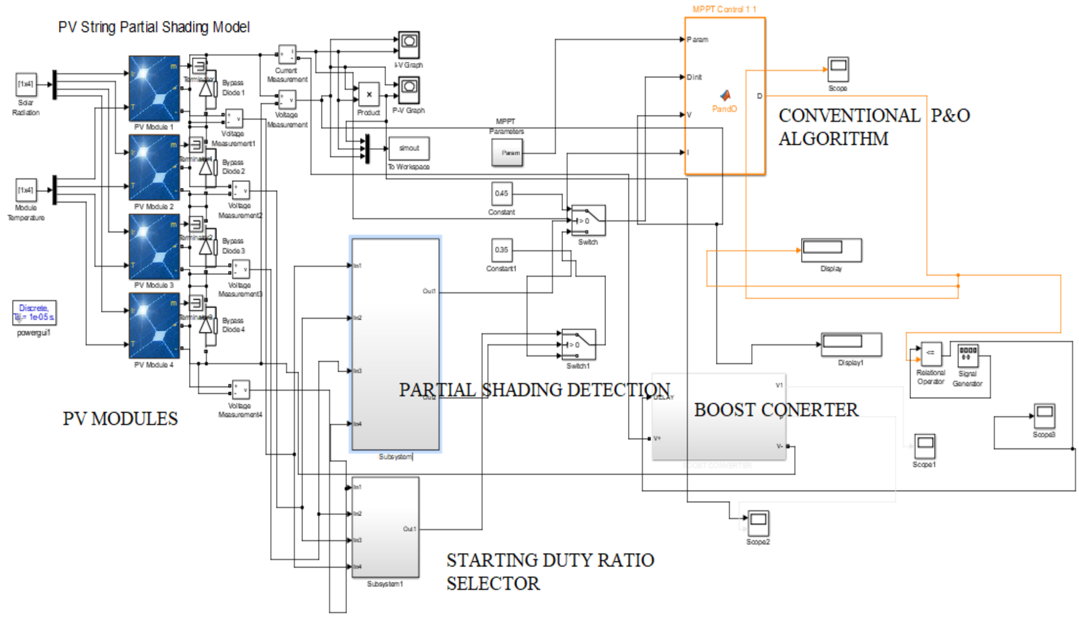

Fig.4 MATLAB SIMULINK model of the improved MPPT control.

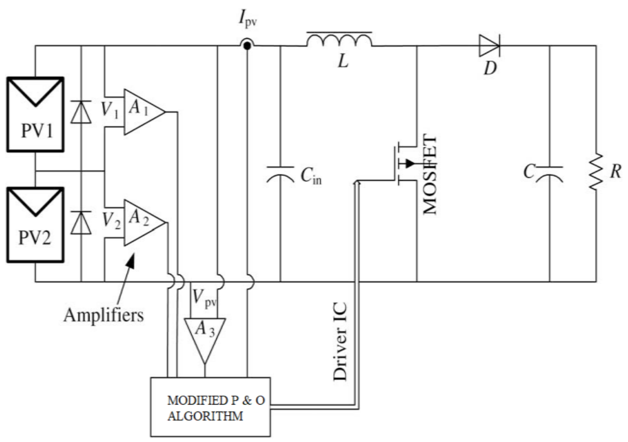

Fig. 5 Circuit schematic of the boost converter used to track GMPP.

To analyse performance of this algorithm temperature of each module is fixed 300K and irradiation level on each module is varied 1000 W/m^2 for unshaded and 400 W/m^2 for shaded module. In the Fig 8(a), 4 modules are irradiated uniformly while one module is shaded in Fig 8(b). On Fig 8(c) and 8(d), 2 and 3 modules are shaded respectively

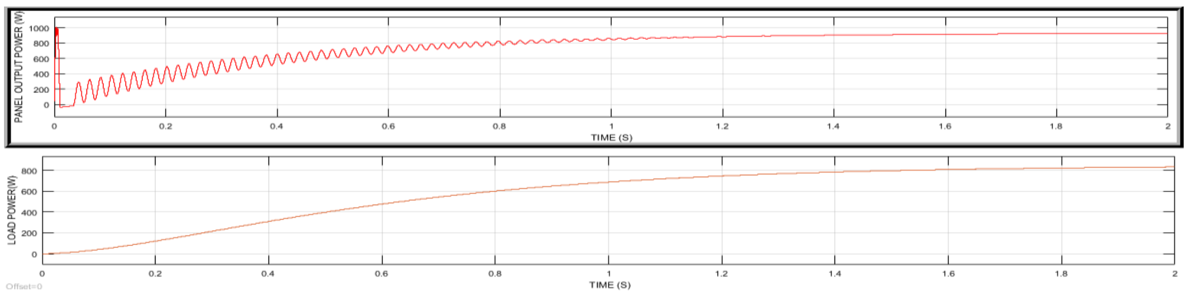

Fig 6(a) Input power and load power of boost converter when all modules are irradiated at 1000 W/m^2

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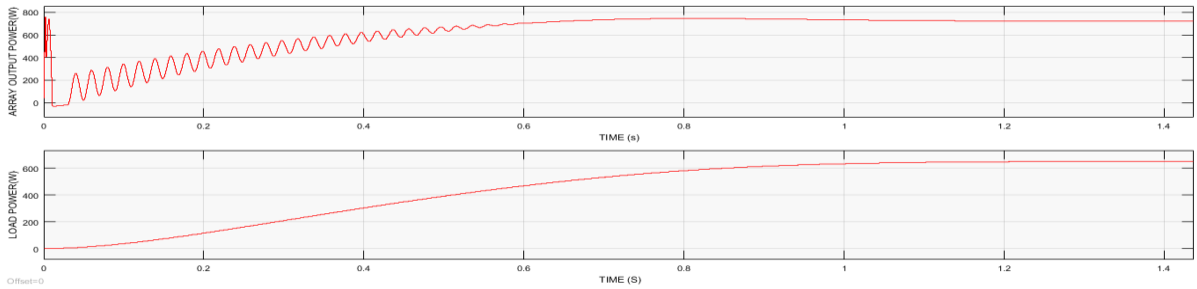

Fig 6(b) Input power and load power of boost converter when 3 modules are irradiated at 1000 W/m^2 and one module at 400W/m^2

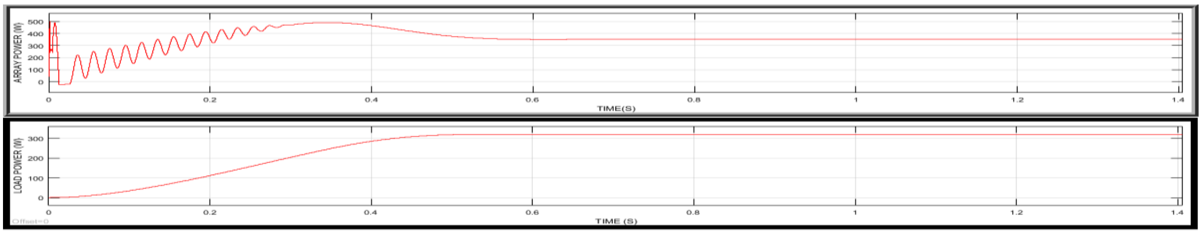

Fig 6(c) Input power and load power of boost converter when 2 modules are irradiated at 1000 W/m^2 and 2 module at 400 W/m^2

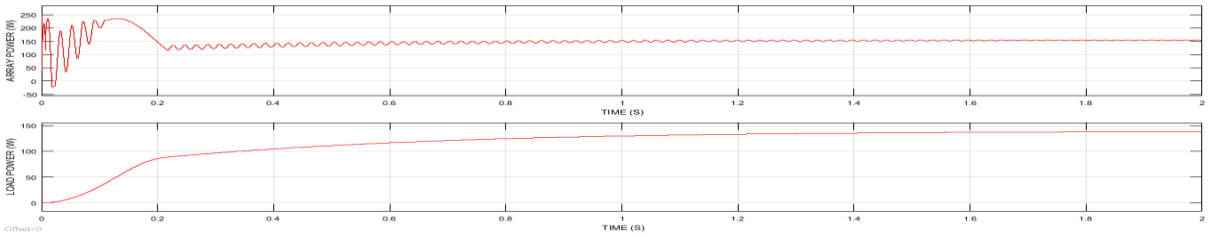

Fig 6(d) Input power and load power of boost converter when 1 module is irradiated at 1000 W/$m^2$and rest of them at 400W/m^2

In the above cases the load power obtained is 920W, 680W, 360W, and 165W for no shaded, one shaded, two shaded and three shaded modules respectively. It can be observed that as the shading reduces power out also deviate from V_{mpp} since bypass diode cut-in voltage shifts the operating voltage slightly away from the V_{mpp} of the entire system. However the power out is still higher than LMPP and better than conventional P&O method during partial shading conditions

III. CONCLUSION

Detection of global maximum is essential under partial shading conditions. This paper presents a new method for tracking Global Maximum Power Point apart from Local Maximum Power Point. It can detect partial shading locate global maximum power point and is able to deliver higher power than conventional P&O under all shading conditions even though bypass diode slightly alter the operating point away from V_{mpp}

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