

# A Study of nature of the Photovoltaic modules under the influence of partial shading effect

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**Abstract**— The behaviour of the solar photovoltaic array will be rapidly changing under the influence of partial shading phenomenon. When two (or) more photovoltaic modules are embedded in series, then the total output voltage and the net output power obtained from the series connected photovoltaic modules will mainly depends upon the solar insolation which is being projected upon each and every module respectively. Small perturbation in solar irradiation levels will lead to large considerable change in the output parameters. This paper mainly focuses on observing the effect of partial shading on photovoltaic modules which are connected in series. The main objective of this paper is to examine about the mismatching phenomenon that occurs while tracking the global maxima point which plays a vital role in extracting maximum power from solar photovoltaic array in an effective manner.

**Keywords**— *Maxima Point, Mismatching, Partial shading, Perturbation, Solar irradiation.*

## I. INTRODUCTION

The short comings of conventional energy based generation methods have made every individual to re-think about the usage of renewable energy based resources such as solar, wind, fuel cell and advanced battery technology, biomass production and other nonconventional type of energy sources. Among the many available non-conventional energy resources, solar based energy production is considered to be the better energy source to meet the present day load demand since it has got high energy density according to authors in [1]. By using the solar photovoltaic (PV) panels, one can easily generate electrical power by capturing the light energy. But, the solar irradiation keeps on changing every moment making it difficult to generate more amount of electrical energy constantly all the time.

The partial shading and ageing effects of PV modules are the main reasons behind the voltage and power fluctuations that are occurring at the load side [2]. When a PV cell (or) module (or) an array is shaded fully or partially as shown in Fig. 1, the PV array will be in reverse biased condition so that, the break down voltage can occur which causes a serious damage to the PV module and

hence a anti-parallel diode is connected in series to bypass the current as depicted in Fig. 2. When the PV modules are connected in a series alignment, then there is a chance of reduction in the output power when any one of the Photovoltaic panel is partially (or) fully shaded.

Several researchers [2-4] have already been worked in investigating the effects of partial shading on PV module structures. Partial shading is considered to be one of the major confronting issues which interrupt the PV system to basically operate at a unique point called Global Maximum Power Point (GMPP) and thus the system efficiency reduces drastically [5].

The modeling aspect of PV array under the partial shaded conditions will surely help the researchers to predict and assess the influences of solar irradiation levels and temperature changes that are being observed by plotting the I-V and P-V curves. Several Maximum Power Point Tracking (MPPT) methods [6-8] can also be developed further and different new topologies could be still configured to improve the overall efficiency of PV system. The knowledge of partial shading effect holds the key aspect in assessing the performance indices of PV array system.

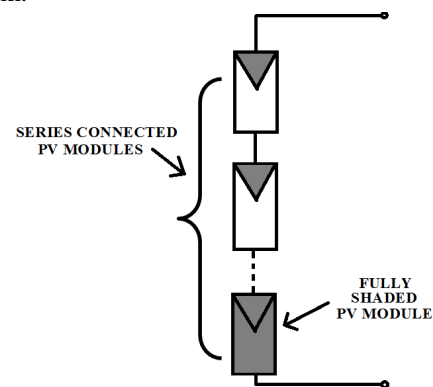


Fig. 1: Series connected PV modules

## II. SERIES CONNECTED PV MODULES

The topology of series connected PV modular structure is shown in Fig. 2. The PV modules are connected in series along with freewheeling diodes in order protect the panels from serious damage ie, from short circuiting of panel.

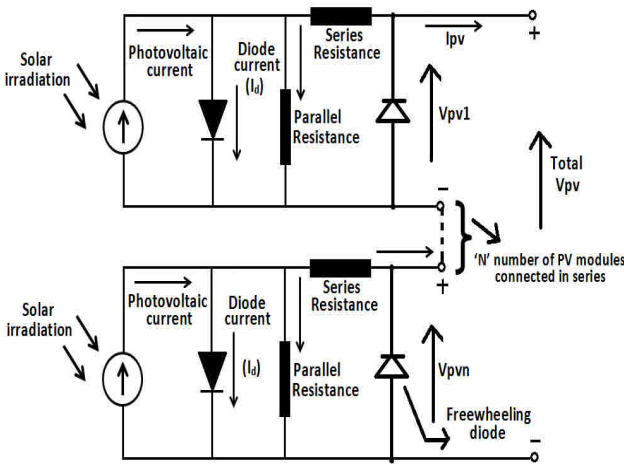


Fig. 2 Series connected PV modular array

A capacitor can also be connected across the output terminals of PV array structure as shown in Fig. 3, which can be used as a dc link. By connecting PV modules in series, the output voltage can be increased further.

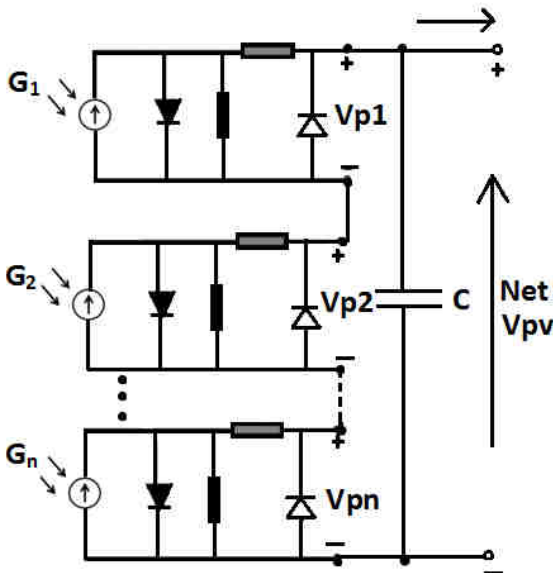


Fig. 3 Series connected PV array with capacitor

### III. CONCEPT OF GMPP

The authors in [5], says that the maximum power point will be having tendency to shift its actual position and operate the system at some other operating power point if there is variation in temperature and solar insolation levels. Many literatures have already been started taking care of irradiation and temperature changes because these two factors plays key role in shifting the maximum power point. So, in order to estimate the exact maximum power point, several tracking algorithms [5,6,7,8,10] have already been developed and implemented. This proves the importance of finding the GMPP and it should be tracked efficiently especially in the partial shaded condition. The PV array efficiency mainly relies on Maximum Power Point Tracking (MPPT) concept. MPPT is the most essential aspect of PV system and probably it could be

considered as a heart of the PV array system. It is well known fact that, temperature is inversely proportional and irradiation is directly proportional to output power [9]. In partial shading condition, it is a tough task to track the actual global power point because of the formation of several other maximum power points inherently. The specifications of PV panel are listed below.

Table 1. PV Panel ratings considered

| Sno | Specifications of typical solar PV panel  |       |
|-----|---|-------|
| 1   | Typical maximum power (Ppv) of panel under standard conditions of 25 <sup>0</sup> /C or 298K. | 60W   |
| 2   | Voltage at maximum power point (Vpv)  | 17.2V |
| 3   | Current at maximum power point (Ipv)  | 3.5 A |
| 4   | Minimum peak output power (Ppv)   | 58W   |
| 5   | Short-circuit current (Isc)   | 3.8 A |
| 6   | Open-circuit voltage of Panel (Voc)   | 21.2V |

### IV. SIMULATION RESULTS

The simulation has been carried out in MATLAB/SIMULINK environment. The PV modules have been modeled and connected in series manner along with a dc link and the output voltage, output current and output power of series connected modules are observed and examined.

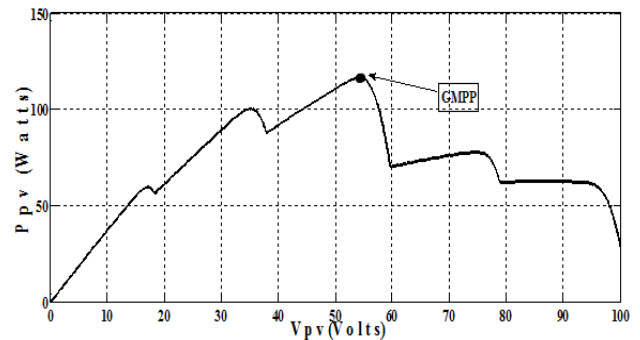


Fig. 4 Plot of PV output voltage versus PV output power

The waveforms clearly represents that, under partial shading condition, there would be formation of several maximum power points instead of one Global point. Fig. 4 represents the plot between the PV output voltage and PV output power which consists of several local maximum power points and one GMPP

respectively.

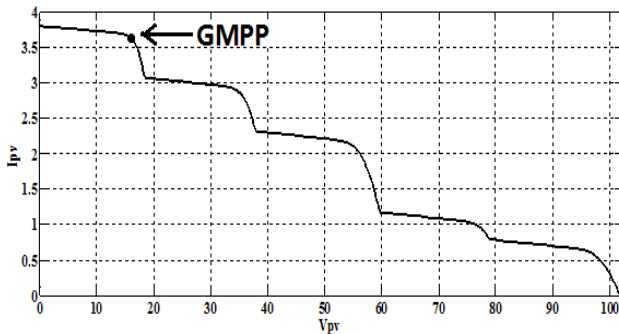


Fig. 5 Plot of PV output voltage versus PV output current  
Similarly, Fig. 5 represents the plot between the PV output voltage and PV output current which also consists of several local maximum power points and one GMPP. The total number of PV modules connected in series is '5' and different insulations are assigned like 1000Watt/m<sup>2</sup>, 200Watt/m<sup>2</sup>, 600Watt/m<sup>2</sup>, 800Watt/m<sup>2</sup> and 300Watt/m<sup>2</sup> respectively.

## V. CONCLUSION

This paper emphasizes on the concept of partial shading effect which mainly affecting the performance of PV array. Clearly, from simulation results, one can easily assess that the output waveform will be having many more fluctuations in terms of occurrence of many local maximum power points. But there exists only a single actual maximum power point called GMPP which is shown in Fig. 4 and Fig. 5 respectively. This work could be extended further in developing suitable MPPT methods to track the exact GMPP.

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