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Analyse the Effects of Partial Shading Conditions on Solar Photovoltaic Panels

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Abstract— In a solar photovoltaic array, the shadow may cover its PV cells. In partial shading conditions, the PV characteristic gets more complicated with multiple numbers of peaks. The aim of this model is to analyses the different partial shading situations and also their effects on the operation. This is done by simulation in MATLAB/Simulink2015a software. In this, three PV panels of 250 watt are connected in series for analysing the output. Different irradiances with specified temperature environment are provided to the panel to form the I-V and P-V curve. Due to shading, the output of the panels gets decreased if there is increment in the shaded portion and due to this in a PV strings there will be a current mismatch while in the parallel strings there will be a voltage mismatch. To stop the damage from the other side i.e., from reverse bias, we use bypass diodes. These diodes are placed parallel to each PV cell so that voltage does not become negative and we obtain a good amount of output in case of partial shading also.
Keywords— Partial shading, Photovoltaic cells, Maximum power point tracking (MPPT)

I. INTRODUCTION

The extreme large consumption of the energy resources in this modern era has led to encourage the gigantic disasters and tragedies in the future. Thus, it has become mandatory for all to go with the renewable resources. From all the renewable resources solar energy is always chosen as a far better option because it is very eco-friendly, sustainable, can be used free to exploit and it is perfectly used for resolving the issues of electricity in the rural areas. Partial shading is a situation in which some part of the PV module or array gets shaded while remaining gets irradiated. It can be arisen due to nearby buildings, trees, chimneys etc.

The shading on the panels stops the complete absorption of the radiation which ultimately leads to the reduction of the output. Some module defects like cracks present on the module will also affect the output energy. When the PV modules gets shaded, a large amount of energy get lost because short circuit will be caused in the shaded modules which forces the voltage to get reduced to very low level. In a one part of shaded cells get heat up which increases the cell temperature which ultimately damages the whole PV system. If we put bypass diode parallel to the PV modules then it helps to avoid partial shading effect. It is mostly recommended to put one bypass diode with each solar cell but it will increase the capital cost for the PV plant. So instead of that we put a bypass diode with a group of cells so that capital cost will not get increased. Though the installation cost of the PV system may get high but it will definitely minimize the energy loss due to shading.

In the situation of the uniform solar radiation, there is always a single maximum power point (MPP) but if we use bypass diodes in our circuit then there will be many maximum power points (MPPs) at a single output curve. Among them only one MPP is chosen as Global Maximum Power Point (GMPP) while rest of all is treated as local maximum power points (LMPPs). One MPPT in each PV array can also be a solution to reduce the partial shading effects but again, it increases the capital cost of the system.

II. LITERATURE REVIEW

This particular experiment was designed and carried out to determine the magnitude of sun irradiance dropping upon a photovoltaic sun area. The experimental outcomes reveal that the second as well as succeeding rows received much less sun irradiance compared to the very first row [5]. This paper uses a fundamental method for estimating what cells within the portion are shaded with the screen that costs less than complex as well as altering ecological circumstances [15]. In this paper, there's a total evaluation of the consequences of overlapped bypass diodes on the overall performance on the PV component hasn't been still systematically disclosed [16]. This experimental work targeted to learn the effect of front side partial shading together with the rear side irradiance inhomogeneity elements on the overall performance of bifacial PV modules [14]. This paper provides the Futoshiki puzzle design for the setup of the modules of a PV array below partial shading quality, making sure the development on the electrical power development with regard to absolutely crossed exhausted (TCT) system [20]. In this paper, analytical program is utilized for locating the greatest power purpose (MPP) which get the largest energy type as an attribute on the board voltage for changing the local weather problems. Two resistor solar power cellular edition (TRM) is applied to approximate every place and every largest energy issue just for the partially shaded board [18]. In this paper, the few works are completed for giving the inadequacy of 0.8Voc (open circuit voltage) layout anytime the amount of the modules within the string elevates. Mathematical and graphical techniques are used to reveal that the peaks do not constantly show up within the 0.8Voc [11]. In this experiment bypass diodes are used as a typical attribute of sun cellular arrays to enhance the array functionality beneath the partial shading scenarios (PSS). A shading design and style detection algorithm would be the initial suggested to calculate the variety of shaded modules within a PV string [17]. In this specific paper the talk regarding how precisely to look at non-perhaps irradiance suggest on PV design and style [19]. In this paper, we are able to fix the problem of output sturdiness of un-shaded PV modules cut down by the outcome of shaded PV Module precisely just how.

III.METHODOLOGY

A. Partial Shading

A situation in which non-shaded modules receive a proper amount of irradiation while the shaded modules receive very low irradiation then such situation is known as partial shading. Sometimes it may be difficult to track the maximum power point (MPP) in the partial shading conditions because of clouds. These clouds are obviously not uniform and due to this they continuously form certain spots on the module whereas rest of the part of the module will get uniformly irradiation. The I–V and P–V characteristics in partial shading condition are shown in Fig. 1 below. In the Fig. 1(a) two modules are connected in series with different irradiance and their curve is shown in this figure. In Fig. 1 (b) two stair type curves of I-V characteristics are formed because of the partial shading and due to that two maxima points are also formed on the P-V curve in the Fig. 1 (b).

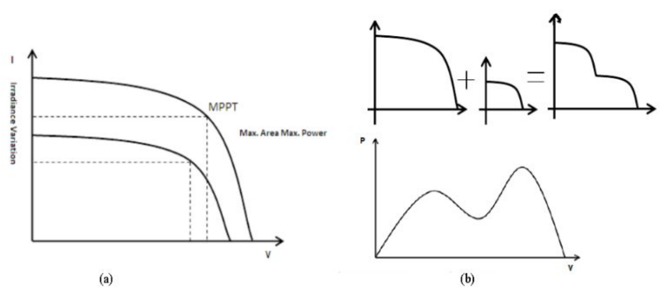

Fig.1 PV cell I-V and P-V characteristics in different temperature and irradiation levels

The MPPT must have to give accurate tracking of the GMP so that it will not get trapped at any local maxima point and if it will be then there must be a loss of output power which ultimately decreases the efficiency of the system. In the partial shading conditions, direct and diffuse irradiation components are assumed separately. The direct beam of irradiation forms a clear block of shadow which decreases the output up to very low level whereas the diffused beam of irradiation gets scattered or dispersed due to clouds, dust particles in the air etc and due to this, irregular patterns of shadow are formed which also decreases the output power up to very low level. Shadow which can be occurred on the second row of the panel system due to the first row of the system is also included in the diffused beam of irradiance.

Solar panel systems can also be used in various ways to reduce losses from shading. Some of them are:

1) Bypass Diodes: As its name signifies “Bypass diode” that means this device is used to bypass the current from the shaded array or module so that output power cannot be reduced to very low rate. But the limitation of this device is that it cannot takes out benefit from the shaded array which is bypassed by this diode. For 20 cells there is requirement of a bypass diode and if we want to increase the efficiency of the system then we have to connect single bypass diode with each solar cell.

2) Arrangements of Strings: Strings that are connected in parallel with the inverter are connected in series with PV arrays. If there is a shaded module then the power output can be reduced significantly. However, in a single string it is not easy to reduce the output of the parallel string and that’s why it is divided into two types i.e., shaded and un-shaded modules. That’s why in the market, arrays which do not receive shade are grouped into one string whereas the arrays which receive shades are grouped in another string.

3) Micro Inverters: The conversion of DC -AC of a single PV module can be done by putting each small micro inverter to each PV module. Here each micro inverter will work on the principle of maximum power point tracking (MPPT) so that operation of other modules will not get disturbed and by this efficiency of the PV arrays will also not get affected.

4) DC Optimizers: By keep changing the voltage and current at the output side of a single PV array, performance can be maintained and that’s how output power can be increased up to certain extent. DC optimizer will boost up the output current of a shaded array by producing electricity with a low current by decreasing its voltage so that equal amount of current will be flown through un-shaded panels. Thus, it shows that equal amount of power is produced by all the panels.

B. The Maximum Power Point Tracking (MPPT)

The main aim of the maximum power point tracking (MPPT) system is to extract maximum power from the solar PV arrays in the bad environmental situations. There are many methods by which MPPT can be achieved but the main two methods are Perturb & Observe method (P&O) and Incremental Conductance method (Inc. Cond). The main principle used for finding MPP is the counter matching of the current and voltage of the converter with MPP. The block diagram of a PV system with an MPPT controller is shown in Fig. 2.

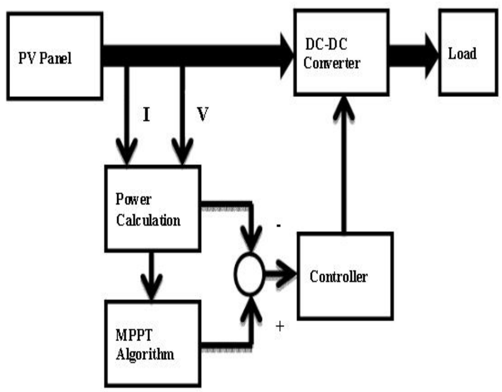

Fig.2 Block diagram of the solar module with the MPPT controller

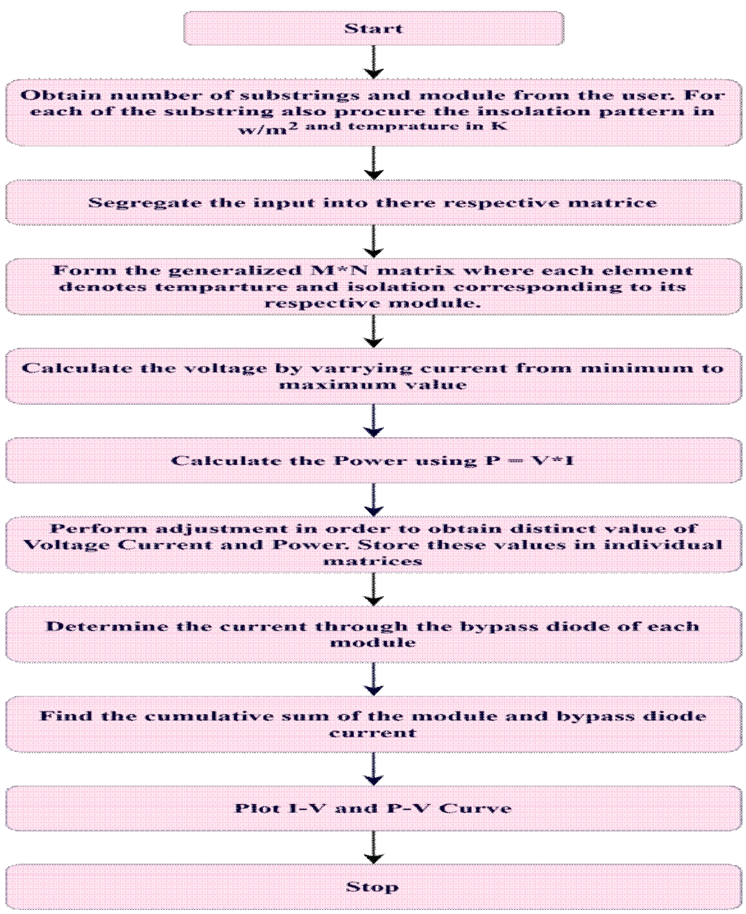

Fig.3 Partial shading methodology flow chart

By the help of MPPT technique firstly voltage and current levels are measured by the sensors. Then the reference values of current and voltage are finalized. These values are then compared with the converter to find the maximum power point. If these values get matched with the reference values then we have to find the maximum power point (MPP) successfully but if these values are not same then again counter will work and converter will again try to find the maximum value of current and voltage. With the help of duty cycle, the difference between values can be removed up to some extent. The block diagram of the solar module with the MPPT controller is shown in Fig. 2.

The methodology flow chart is shown in Fig. 3. This flowchart explains the procedure of analysing of partial shading solar PV cells. First of all, we have to find the values of output power, current and voltage. After that we have to find maximum power point (MPP) by the help of maximum power point tracking (MPPT) methods so that we can easily plot I-V curve and P-V curve. After plotting curves, we can easily analyse the output of the solar PV cells in the partial shading conditions (PSC).

IV. SYSTEM MODELLING & SIMULATION RESULTS

This modelling is done in MATLAB 2015a software as shown in Fig. 4. In MATLAB circuit diagram is made in Simulink. This model has 250-watt PV module which consists of 60 cells which are connected in series. This model shows the partial shading scenarios (PSC). There are 3 modules which consist of 20 cells each. Different irradiance is given to every module i.e., 1000 W/m2 for cells 1-20, 300W/m2 for cells 21-40 and 600W/m2 for cells 41-60. All the modules work in a specified environment of 25°C.

After that, Bypass diodes are put in parallel with the modules to save the system from huge output power loss. Bypass diode bypasses the current from the shaded or damaged cells so that shaded cell does not absorb the energy instead of producing. Here three bypass diodes are used in which each diode is placed for each module individually. Then voltmeter and ammeter are also placed in the circuit. Voltmeter is placed parallel with the circuit to measure the amount of voltage produced by the PV modules whereas ammeter is placed in series with the circuit to measure the amount of current produced by the PV modules. After that variable DC voltage source is connected which acts as a battery storage. Variable DC voltage source is connected in series with the modules to store the output power. Then to plot the I-V and P-V characteristics curve, two scopes are connected to ammeter and voltmeter at the last with the help of Go to tag. Here one scope shows the I-V characteristics while the second scope shows the P-V curve characteristics.

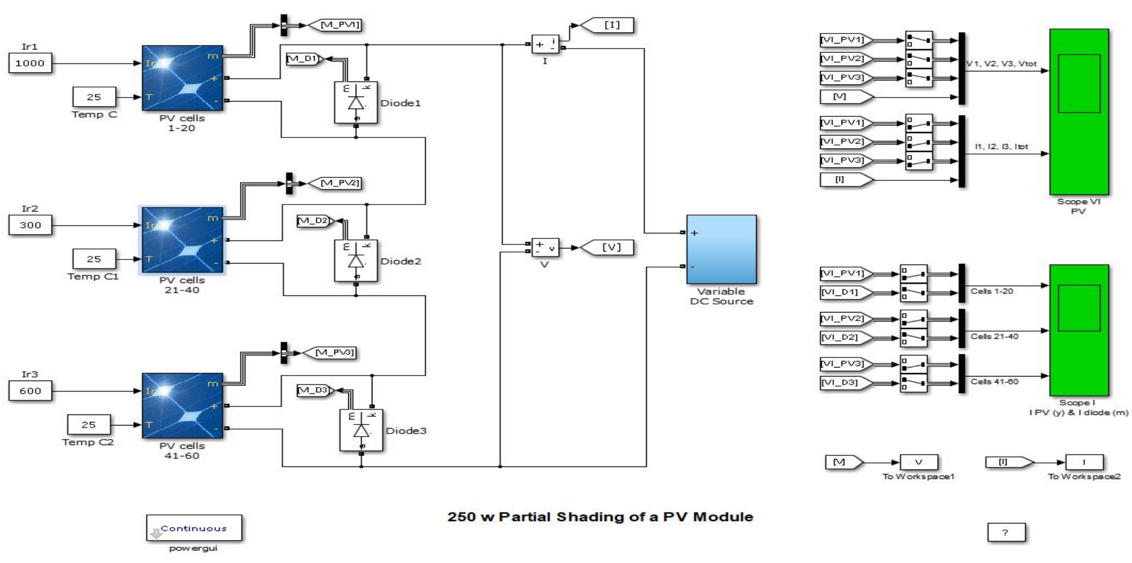

Fig.4 Circuit diagram of a 250 W partial shading of a PV Module

Fig. 5 shows the expected graph of a single string which consists of 20 cells. In this the panel of 1 KW/m2 irradiance shows the maximum output in both graphs i.e., of I-V and P-V curve [8]. The second curve of 0.5 KW/m2 irradiance panel gives some less amount of output than 1 KW/m2 irradiance panel while the third curve of 0.1KW/m2 irradiance panel shows the least amount of output as compared with other two irradiances panels.

When the partial shading condition will occur, then short circuit current (Isc) will be unequal in the series connected cells and in parallel connected cells the open circuit voltage (Voc) will be different. Due to partial shading in series connected cells, we use a bypass diode in parallel to the PV module which never allows the voltage to get negative.

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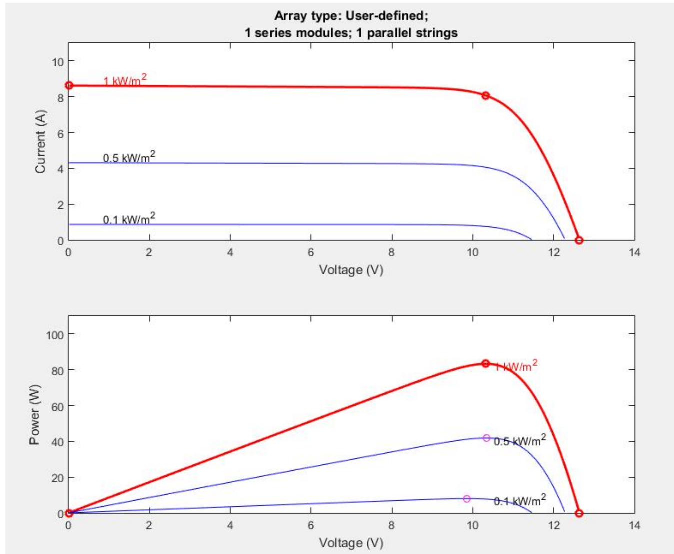

Fig.5 I-V and P-V Characteristics of a module containing 20 cells

In the I-V graph Fig.6, firstly curve is at its peak point and will be constant for some time. When different irradiance will occur due to the short circuit current (Isc), output power will change frequently whereas in the P-V graph, firstly curve start increasing linearly and then after attaining its maximum peak point the graph starts declining to the bottom. In this graph also different irradiances have different maximum power point. This is because of different short circuit current (Isc) but here the open circuit voltage (Voc) is little different in the case of series connected cell.

When we compare the standard irradiance i.e., 1000W/㎡ with other irradiance of partial shading conditions in the I-V curve i.e., 0.5W/㎡ and 0.1W/㎡, we found that the short circuit current is also different at different irradiance. This led to the decrement of overall short circuit current and due to this power also get decreased that's why maximum power point (MPP) occurs at different levels. In I-V graph first bend of curve, let the open circuit voltage is Voc1 and the current is I1. Now at the second bend of the curve, open circuit voltage [9] will be (Voc1+Voc2) and the current will be I2 and this process continues. That's why at the third bend of the curve, the open circuit voltage will be the sum of all i.e. (Voc1+Voc2+Voc3) and the current will become zero. For these points we get multiple maximum power point (MPP) because of different open circuit voltage (Voc) and different short circuit current (Isc) [10].

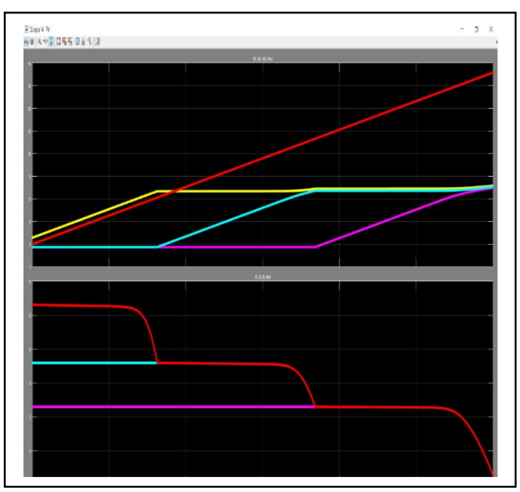

Figure 6. Scope P-V Characteristics Output

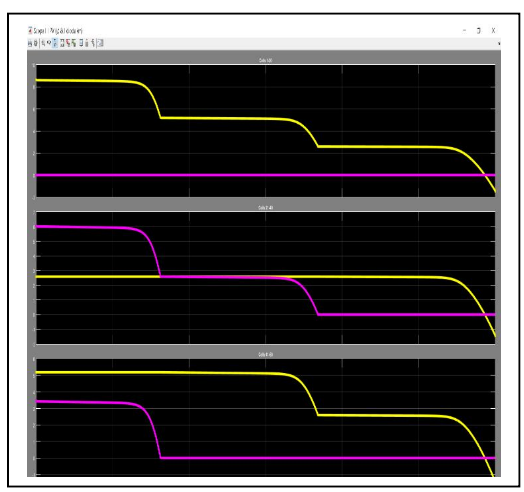

Figure 7. Scope I-V Characteristics Output

V. CONCLUSIONS

In this Research work, the main focus is that how to overcome from the problem of partial shading effect on the PV array. Here Simulink model is of 250W PV module. In the PV power system, the total performance [15, 18] of the series connected PV strings will be negative because of the significantly current mismatch. So that's why low power version connectors are applied with the string in the PV system in order to maximize the output power. Here with the help of the P-V and I-V characteristics we get different output at different solar irradiance for this we use the MPPT controllers. For the MPPT control, controller of each sub-module tracks the power of each sub-module for obtaining the maximum output power.

The sensitivity or the effect of the partial shading can vary with the condition of the partial shading as it can be classified into many types like heavy shading, low shading and many more. It also depends on the configurations that are used to connect all the PV modules in the PV system. The bypass diode is also very essential in improving the output power of the PV system under different partial shaded conditions. Bypass diode bypasses the current from the shaded cells as it helps us to stop getting voltage negative and thus output power can be maintained. This study will allow us to gain some more knowledge on the effect of the shadow of solar PV panel. More ways can be determined in future for extracting maximum power from the partially shaded PV module. This model will be further used in future projects for designing the model in which maximum power point tracking (MPPT) algorithms are used for increasing the tracking efficiency under partial shading scenarios (PSC).

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