An approach to enhance the efficiency of the solar PV panel in partial shading condition: A Review

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Abstract: ***Hot spot heating causes permanent destruction of the solar cell structure. Areas with high impurity contaminants and high concentration of transition metals have the most number of hot spot heating. When the operating current of the overall series string approaches the short circuit current of a bad cell then the overall current becomes limited by the bad cell. The good cell becomes forward bias, which reverse biases the bad cell. This leads to large dissipation of power in the bad cell. Enormous power is dissipated in the bad cell or hot spot that results in destructive effects like glass cracking, melting of solder or degradation of a solar cell. The solar panel works best when there is no shade on them. If there is a partial shadow in any one of the arrays, the efficiency of the solar panel drops to a great extent. The shaded cell becomes reverse biased so maximum power will be dissipated on the shaded cell. The heat developed due to the reverse biased of the shaded region adds to the dissipated power.***

Keywords: Solar PV, partial shading, maximum power extraction, solar irradiance

1. Introduction

In a series connected solar photovoltaic module, the cells are not equally connected. The shaded cells may get reverse biased which acts as a load. If the system is not fully connected, there is a chance of creation of hotspot.

2. Partial shading and bypass diode

Shade impact depends on module type, fill factor, bypass diode placement severity of shade and string configuration [1]. Typically, a crystalline silicon module will contain bypass diodes to prevent damage from reverse bias on partially shaded cells. These diodes are placed across 12 - 18 cells in a group of cells. The bypass diode allows current from non-shaded parts of the module to pass by the shaded part and limits the effect of shading to the only neighboring group of cells protected by the same bypass diode.

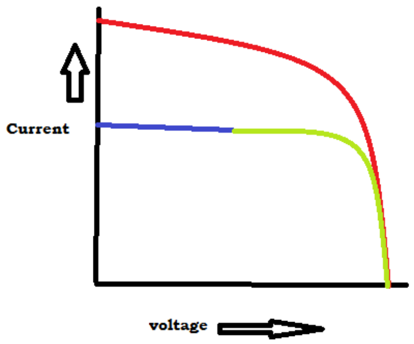

Figure 1: V-I characteristics

Here, the current will be maximum at that point where the green curve intersects the red curve. This graph depends upon the number of cells that are shaded sequentially.

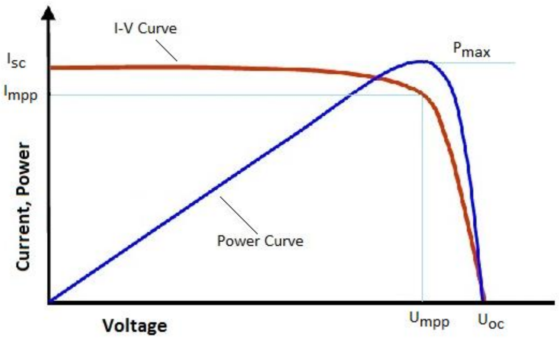

Figure 2: P-V characteristics

The P-V characteristics curve always depends upon the value of G i.e. irradiance [2]. The maximum power point is shown in the graph, which is the peak value i.e. P_{max}.

2.1 Partial shading of a single module

Bypass diodes usually reduce hotspot in solar panel. The bypass diode will ensure the operation of the module [3]. However, the number of bypass diode is limited, so the shading of one single cell will affect the cells in the module.

2.2 Partial shading in two modules

Partial shading can be done in two modules. Here the blue curve shows the p-v Characteristics of solar PV panel which are having different irradiance i.e. G.

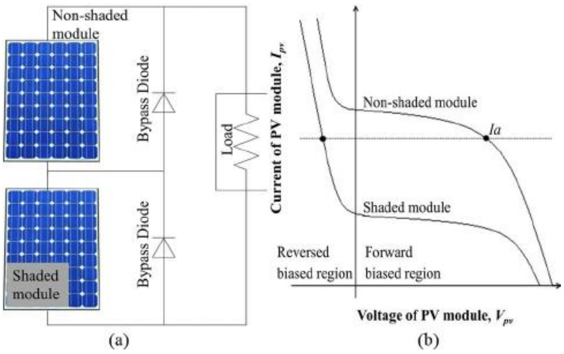

Figure 3: Partial shading in two modules

3. Hotspot in solar panel

Some cells exhibit inhomogeneity of the surface temperature resulting in localized heating [4]. These heating occur when there is one low current solar cell in a string of several high short circuit current solar cells. Hot spot heating causes permanent destruction of solar cell structure. The elemental composition of different regions of solar Cells revealed that the areas with high impurity contaminants have the most number of hot spot heating. In addition, the areas with high concentration of transition metals result in hot spot heating. When the operating current of the overall series string approaches the short circuit current of the bad cells then the overall current becomes limited by the bad cell. The good solar cells now become forward biased. The forward biased across all the cells reverse bias the bad cell. A large number of cells connected in series causes reverse bias across the shaded region, which leads to large dissipation of power in the bad cell [5]. Thus, all the generating capacity of the good cells is dissipated in the bad cell. The enormous power dissipation occurring in a small area results in overheating of the bad cell or "hot spot" which results in destructive effects like glass cracking, melting of solder or degradation of the solar cell.

4. Main causes of hotspot in solar panel

There are many causes of a hot spot. The functional causes of hot spot are-

1) <u>Cell mismatch</u>:- occurs when cells of varying current production are connected in series.
2) <u>Cell damage</u>:- occurs during the production process because the silicon cell will be subjected to many stresses during lamination, handling, and transportation.

The operation of the hot spot is related to solar park design and operation includes:-

1) <u>Partial shading:</u>- There is a drastic effect of shading on a solar panel. The efficiency of the solar panel decreases enormously even for a small partial shading.

2) <u>Rooftop condition</u>:- When cells are completely shaded this may not be sufficient to trigger the bypass diode, resulting in increased temperature which will degrade the panel.

3) <u>Soiling</u>:- Panels can be soiled due to dust, dirt and other contaminants during the lifetime which results in the formation of a hot spot.

In Fig. 4, two parallel-connected solar cells are shown. The green solar cell is in sunlight and the red one is shaded. The generated current from the green and red solar cell is I_1 and I_2. The total current (I_1+I_2) is flowing out from the solar panel. The V-I characteristics of the green and red cell are shown in Fig. 4.

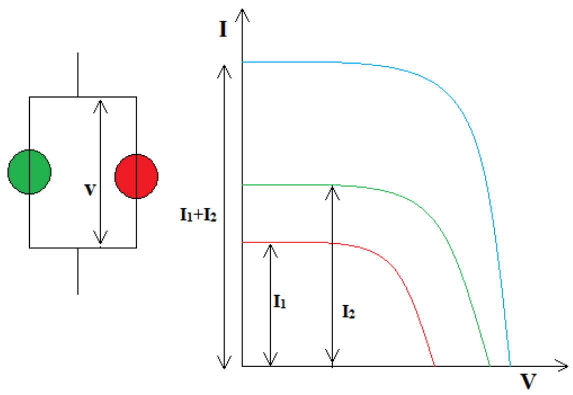

Figure 4: V-I characteristics of a good cell (in sunlight) and bad cell (shaded).

5. Conclusion

When Hotspot generates in a solar panel it permanently damages the solar panel. Because of that, a huge loss is there in the consumer end. Govt. of India (GOI) has a target to generate 100GW by 2022 from solar energy. That is why a number of solar projects are going on across the country. However, along with the solar mission of power enhancement we will have to look towards the different auxiliary problems that arise in the solar panels. Out of all auxiliary problems, hot spot generation is the most severe one. Therefore, it is our utmost requirement to do research to overcome from this problem

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