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STUDY OF THE EFFECTS OF PARTIAL SHADING ON PV ARRAY

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Abstract : - Solar system is the high-quality and trustworthy supply of renewable energy. It is far contamination loose, fewer preservation, reusable and unfailing. The overall performance of photovoltaic (pv) machine is often stricken by radiation, module temperature and array configuration. The understanding of the shading impacts and their courting among the output powers of the pv array may be very essential in an effort to find a well overall performance of the pv system. partial shading is a case whilst the special modules of the array received a different irradiance level. This shadow can be both to expect due to extraordinary situations: neighbour constructing, close by tree or tough to are expecting due to clouds or building. the cause of this paper is to take a look at and illustrate the outcomes of partial shading with bypass diode and without bypass diode on the I(V) and P(V) traits of the photovoltaic panel. This is performed via using simulation using MATLAB/Simulink This paper shows more feature changes compared to shaded and unshaded conditions.

***Index Terms* – Charecteristics of solar cell and panel , Impact of partial shading , Patial shading scenarios.**

I. INTRODUCTION

Solar photovoltaic (PV) technology has emerged as a sustainable and efficient means of harnessing solar energy for electricity generation. As the global demand for clean and renewable energy sources continues to grow, understanding the factors influencing the performance of PV systems becomes crucial. One such factor that significantly affects the efficiency and reliability of PV arrays is partial shading.

Partial shading occurs when certain portions of PV modules are obstructed from sunlight, leading to non-uniform illuminaton across the array. Unlike uniform shading, which uniformly reduces the entire array's output, partial shading introduces complex and dynamic challenges. The non-uniform distribution of sunlight across the array leads to variations in voltage and current, impacting the overall power output [1].

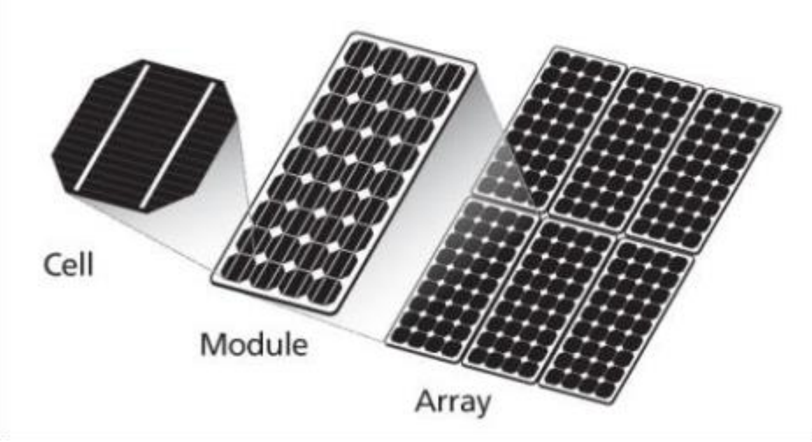


Fig1:- Relationship among cell, module and array

PV Cell**: -** The smallest unit, a solar cell is a semiconductor device that converts light energy (photons) directly into electrical energy (current) through the photovoltaic effect. A typical solar cell produces only about 1-2 watts of electricity, so they need to be connected together to generate usable amounts of power.

PV Module (or Panel): - A solar module (also sometimes called a solar panel) is a collection of interconnected PV cells electrically laminated together and encapsulated in a weatherproof housing for protection. A module typically contains 36 or 72 cells and can produce 200-400 watts of electricity. The frame, electrical connectors, and a bypass diode may also be included in a solar module.

PV Array: - A solar array is the complete power-generating unit, consisting of multiple solar modules connected together electrically in a series, parallel, or combination circuit to produce the desired voltage and current output. The size of a solar array can vary depending on the power needs of the application. A residential solar system might have a few modules, while a large solar power plant could have thousands of modules.

II. CHARECTERISTICS OF SOLAR CELL

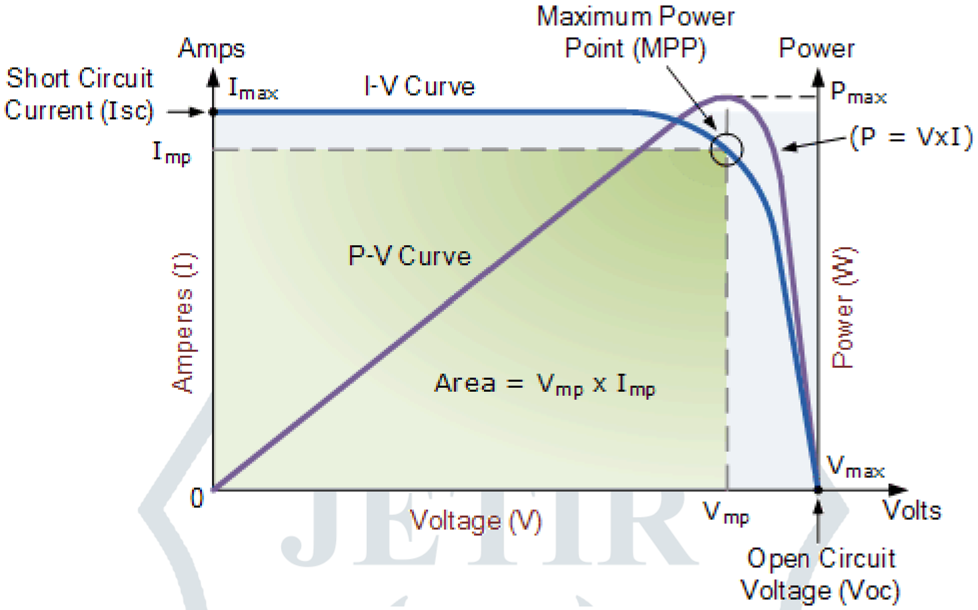


Fig :- Solar Cell I-V Characteristic Curve

The above graph shows the current-voltage (I-V) characteristics of a typical silicon PV cell operating under normal conditions. The power delivered by a single solar cell or panel is the product of its output current and voltage (I x V). If the multiplication is done, point for point, for all voltages from short-circuit to open-circuit conditions, the power curve above is obtained for a given radiation level.

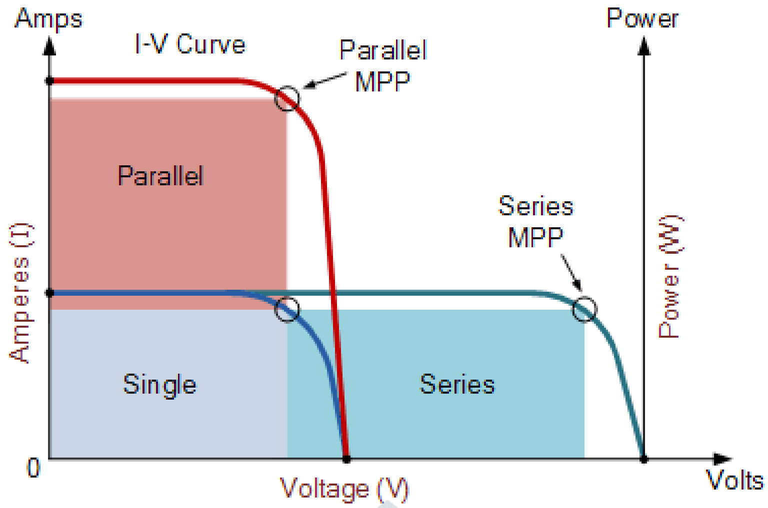
Then the span of the solar cell I-V characteristics curve ranges from the short circuit current (Isc) at zero output volts, to zero current at the full open circuit voltage (Voc). In other words, the maximum voltage available from a cell is at open circuit, and the maximum current at closed circuit. Of course, neither of these two conditions generates any electrical power, but there must be a point somewhere in between were the solar cell generates maximum power.

However, there is one particular combination of current and voltage for which the power reaches its maximum value, at Imp and Vmp. In other words, the point at which the cell generates maximum electrical power and this is shown at the top right area of the green rectangle. This is the “maximum power point” or **MPP**. Therefore, the ideal operation of a photovoltaic cell (or panel) is defined to be at the maximum power point.

The maximum power point (MPP) of a solar cell is positioned near the bend in the I-V characteristics curve. The corresponding values of Vmp and Imp can be estimated from the open circuit voltage and the short circuit current: Vmp ≅ (0.8–0.90) Voc and Imp ≅ (0.85–0.95) Isc. Since solar cell output voltage and current both depend on temperature, the actual output power will vary with changes in ambient temperature.

Thus far we have looked at **Solar Cell I-V Characteristic Curve** for a single solar cell or panel. But a Photovoltaic Array is made up of smaller PV panels interconnected together. Then the I-V curve of a PV array is just a scaledup version of the single solar cell I-V characteristic curve as shown.

III. CHARECTERISTICS OF SOLAR PANEL



Photovoltaic panels can be wired or connected together in either series or parallel combinations, or both to increase the voltage or current capacity of the solar array. If the array panels are connected together in a series combination, then the voltage increases and if connected together in parallel then the current increases.

The electrical power in Watts, generated by these different photovoltaic combinations will still be the product of the voltage times the current, (P = V x I). However, the solar panels are connected together, the upper right-hand corner will always be the maximum power point (MPP) of the array.

IV. IMPACT OF PARTIAL SHADING

Addressing the impact of partial shading on building-integrated energy systems requires careful planning, innovative design solutions, and the integration of advanced technologies to optimize energy generation and overall building performance. This holistic approach ensures that the building not only generates clean energy but also provides a comfortable and sustainable living or working environment.
Partial shading occurs when parts of a solar panel array are blocked from receiving full sunlight. This can be caused by shadows from nearby objects like trees, buildings, chimneys, or even passing clouds. While it might seem like a minor issue, partial shading can significantly impact the performance of your solar array.

Reduced Power Output: The most direct consequence is a decrease in electricity generation. Shaded panels become less productive, and depending on the severity of shading and electrical connections, the entire array's output can suffer.

Hot Spots: When some cells within a panel are shaded while others are exposed to sunlight, the shaded cells can become hot spots. This can damage the panel and further reduce its efficiency.

Multiple Power Peaks: Partial shading can create multiple peaks on the solar array's power-voltage curve. This confuses the Maximum Power Point Tracker (MPPT) system, which might get stuck on a sub-optimal peak, resulting in missed potential power generation.

V. PARTIAL SHADING SCENARIOS

A partial shading scenario describes a situation where a solar panel, or group of panels (array), isn't receiving sunlight uniformly. This can happen due to various reasons, like: Nearby objects: Trees, chimneys, power lines, or even building structures can cast shadows on the panels, causing partial shading.
Dust or debris**:** Buildup of dust, dirt, or bird droppings can block sunlight from reaching parts of the panel.
Seasonal changes**:** As the sun's position changes throughout the year, some panels might experience shading for a part of the day.

The key aspects of a partial shading scenario include:
Shading pattern**:** This refers to the distribution of shade on the panel's surface. It can be a small area, a large block, or even multiple scattered shaded regions. The pattern significantly impacts the severity of power loss.
Shading severity**:** This indicates the intensity of the shade. It's often measured as a percentage of the panel's area that's under shade.

Here are some potential consequences of a partial shading scenario:
Reduced power output**:** Shaded portions of the panel generate less electricity. In some cases, the entire panel's output can be significantly reduced depending on the shading pattern and severity.
Hot spots: When a shaded area sits next to a brightly lit area on the panel, the shaded cells can overheat. This can damage the panel and permanently reduce its efficiency.
Current mismatch**:** Solar panels are usually connected in series. If one panel is shaded, it disrupts the current flow throughout the entire string, reducing the overall power output from the entire series.

VI. WHY PARTIAL SHADING CAUSES POWER LOSS

Series Connection: Solar panels are often wired together in series to achieve the desired voltage output. However, this creates a "weakest link" scenario. When one panel in a series string is shaded, it produces less current than the unshaded panels. Since all panels in the series are forced to operate at the same current level (dictated by the shaded panel), the unshaded panels are unable to function at their maximum potential. This mismatch in current output across the string leads to power loss.

Bypass Diodes**:** To prevent damage in shaded panels, bypass diodes are typically included within them. When a panel is shaded, the bypass diode activates, essentially bypassing the current flow through that panel. While this protects the shaded panel, it also contributes to power loss because the bypassed current doesn't contribute to electricity generation.

VII. CONCLUSION

Partial shading presents a significant challenge for photovoltaic (PV) arrays. When panels are even partially shaded, their power output is hampered due to series connection and the activation of bypass diodes. This can lead to substantial energy loss, reduced overall efficiency, and even potential damage from hot spots.

The study of partial shading effects is crucial for optimizing the performance and longevity of PV systems. By understanding how shading patterns and array configuration influence power loss and hot spot formation, we can implement effective mitigation strategies.These strategies include utilizing optimizers or microinverters for individual panel power management, carefully designing the array layout to minimize shading, and employing solar tracking systems in larger installations.

By acknowledging the impact of partial shading and taking proactive measures, we can ensure that PV arrays operate closer to their full potential, maximizing their contribution to clean and sustainable energy generation.

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