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Maximum Power Point Tracking Algorithms Under Partial Shading Condition

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ABSTRACT- High and rising fuel consumption has occurred in past times. resulted in enormous growth in renewable energy generation and consumption. As economies Photovoltaic (PV) solar is becoming more popular as the world's interest in cleaner energy grows. is becoming a more viable option. PV energy harvesting and managing has numerous advantages, but it also has certain disadvantages, such as low energy conversion efficiency due to optical and electrical losses. Because of the random component associated with its genesis, the partial shading problem, the first of these losses is typically the most hardest to deal with. As a result, shading countermeasures exist as an important component of power converting unit, so as to reduce negative influence over power efficiency extraction. Despite the fact that each of these processes has its own set of shortcomings, a large range of different techniques have been devised as well as evaluated in literature to far. We proposes a MATLAB simulation to investigate the efficiency of set of numerous high power point tracking approaches over a large range of shading speeds, where PV array layout is created in three different settings under various partial shading conditions.

KEYWORDS- Photovoltaic (PV), Maximum Power Point Tracking (Mppt), Deterministic Algorithms, Stochastic Algorithms

I. INTRODUCTION

Renewable energy sources are becoming more popular, despite a desire and tendency to reduce the world's evident reliance on traditional energy sources. Furthermore, population energy consumption is increasing at an exponential rate, meaning a race against the clock in the growth of energy-producing industries, notably in the renewable energy sector.

Solar energy, more than any other renewable energy source, has the potential to solve the world's mid-to-long-term energy supply problems. It is the most potent origin of survival on Earth, generating an amount of energy equivalent to hundreds of times the whole civilization's global energy needs only on the low stratospheric surface. Building solar energy harvesting devices appears to be the most reasonable answer to core issue of population expansion.

Among every solar energy's essential characteristics, the most important ones to consider are reliability, relative simplicity of storage, and, the fact that it is the cleanest, most universal, and cost-free energy accessible today. It is also environmentally friendly, with low operational and maintenance costs [1], making it appealing not only to grid-connected energy investors, and also to specific natives who want to supplement their energy source system or install a stand-alone PV-based system in homes, because such type of system amortises in a relatively short period of time.

Solar energy may be collected using one of two techniques. Photovoltaic cell-based power plants and solar thermal power plants Despite the fact that the renewable energy boom is still in its early stages, other systems for gathering and storing solar energy are being investigated, like a combustible liquid that captures photons to energise the molecular form, changing it into its isomeric shape and maintaining this energized form for nearly two decades. [2].

In any event, solar plants are and will continue to be popular in the near future. PV cells convert solar light directly into electricity, which has a variety of advantages and benefits [3]. However, because to the complexities of energy fluctuation, optimal energy extraction demands precise control of the complete PV system. As a result, a variety of tactics are employed in order to assure efficient power generation. In recent years, maximum power point tracking, or MPPT, has become the most common. MPPT forecasts as well as records the maximum power point,, in each environmental condition, forcing PV system to run on this MPP.The fundamental purpose of such master's the o investigate gating the behaviour of several MPPT algorithms in response to the external situation which modifies maximum energy that PV systems get, specifically the shadow shape that covers array arrangement in case of solar panels. In addition the shadow dynamism span is set to a very large range so as to show which MPPT strategy is more victorious in terms of speed dynamics.

Here we give a quick summary of the literature, with an emphasis on the numerous MPPT techniques that are increasingly being used today..

We briefly reviewed the functioning of the PV cell as well as the basic mathematical models of PV cells utilized to simulate it. One of these is picked to show produced curve shape as well as behavior in response to the external parameters that have the most impact.

It also explains the most popular PV system configurations dependent on distribution and power converter type. At last, the partial shading problem and physical solution technique were addressed.

II. OBJECTIVES

The primary goal of this paper is to examine a wide range of MPPT techniques.

- To compare how they behave in response to an external scenario that modifies the maximum energy received by PV systems, namely the shadow shape that covers the array configuration of solar panels.
- Define the range of shadow dynamism in a wide range to demonstrate which MPPT technique is more successful based on speed dynamics.

III. LITERATURE REVIEW

As shown in the survey, the velocity profile that reveals the PV array layout has a peculiar maximal, or the system is put in region where sunlight is steady as well as uniform over the entire PV panel region. In subheadings that come, the procedures that are best fit to the partial shaded condition are explained.

This trial-and-error approach monitors real PV power and afterwards perturbs operating point by altering operating voltage at every time cycle. It detects the variance of power from each two time-steps and actuates next perturbation based on such power variation.

If power rises, next perturbation is then in same direction else have the same perturbation sign, however if it drops, the perturbation direction will be changed. This basic action is repeated until the MPP, which is dP/dV = 0, is attained. When the tracker reaches MPP, it vibrates about it, the amplitude of which is determined by the size of the perturbation step.

Many writers have investigated such basic MPPT, in order to improve their delicate spots, as in [4] and often to compare it to another MPPT strategies, like in [5], with first one serving as baseline because it is most commonly used method.

According to published experimental results, the proposed technique can give much faster tracking speed[6].

IV. METHODOLOGY

A. Physic principle

Solar cells, often called as photovoltaic cells are cells which convert sunlight into electrical energy. They rely on photoelectric effect of the material hey'rebuild-upp of, which is defined as ability to emit electrons when photon beam irradiated their photoelectric material region.

The most common material used for cell construction, which can be found within the above-mentioned feature, is silicon, a well-known semiconductor with a mixture of properties present in metal and insulator materials, allowing the photoelectric effect to occur.

The physical structure is very similar to that of semiconductors. It consists of a p-n interface with two dyed slabs that are doped differentially. The favorable feature is the n-type portion. Because it has already been laced with a semiconductor that produces with over free electron in the intermediate orbital layer, such as light, the conjunction yields an additional 'free' electron. A distinct poisoning approach is utilized on the p-type layer, in which the pumping particle has less than octet in the final valence layer, generating a 'hole,' while in other measures, the combination's last given component is without one electron.

As a result, the 2-layer junction forms depletion layer in junction zone, where free electrons fill holes, while n-type zone becomes positive as a result of the loss of free electrons and the p-type zone has become negative as a result of the loss of holes. A minor electrical field is formed between the two sides, blocking the flow of additional free electrons by the n-type area towards the p-type region .

At last, more photon energy must be delivered to the depletion layer in order to generate current. If the energy is such high to break through silicon bandgap barrier, electron-hole pair arises, separated by the silicon bandgap barrier.

Electrons can travel across the circuit while it is closed, resulting in a constant current (Figure 1).

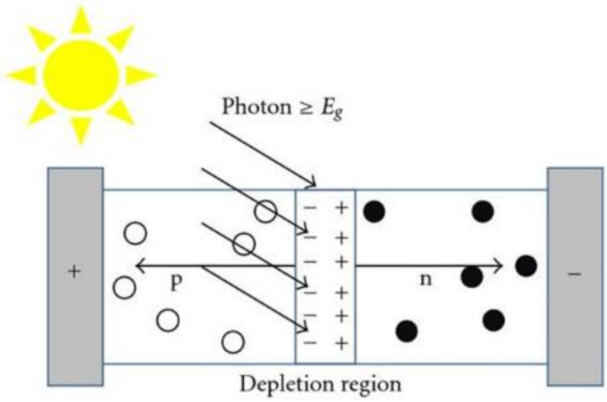

Figure 1: Diode

Although silicon technology is the most frequently used, and it is likely to become even more so as technology improves in this century, there are a variety of doping materials technologies and methods available. Despite the fact that CdTe and CIGS have enhanced their efficiency to transform solar energy at same level over the last 50 years (from 5% to 20% in all scenarios), they still account for less than 10% of total materials utilized in cell manufacturing .

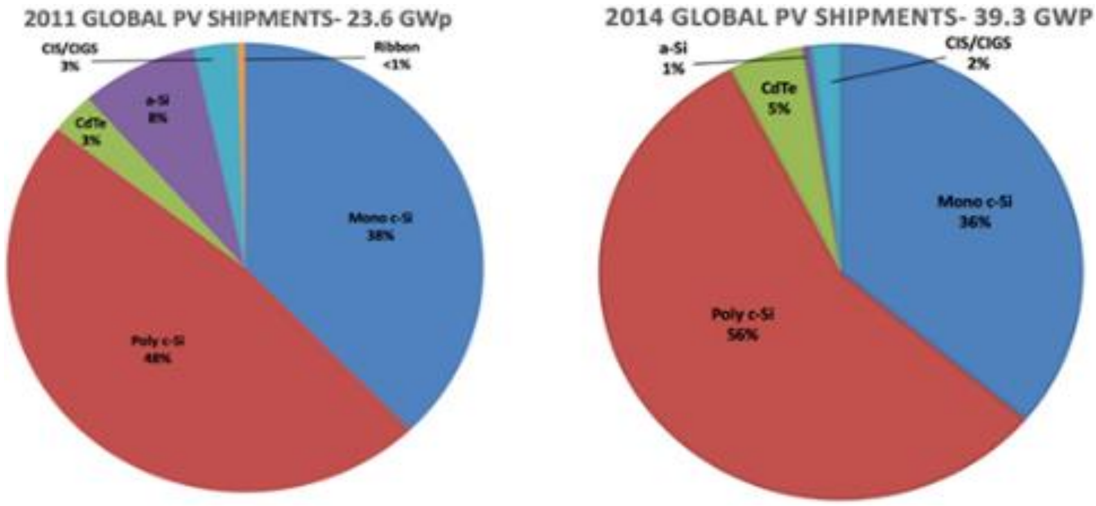

Figure 1: Materials used to build cells

The utility and expense of the material type affect the distribution of these materials' usage and the user's proclivity through time:

- Monocrystalline silicon is the most effective material (Mono c-Si).
- Because polycrystalline silicon has less It has a less perfect microstructure and is less efficient than silicon wafers. Its wafer is composed of single crystals with consistent characteristics and is manufactured using a complicated and costly technique, making this material exceedingly pricey. As a result, its capacities are severely limited; yet, the cost is not excessive.
- The simplest to make is silicon dioxide (a-Si), but it is cheap.
- The efficiency of CIGS stuff is comparable to that of poly c-Si and assembly process is comparatively inexpensive. The main issue is particular chemical toxicity as well as scarcity, as well as the exorbitant prices of the principal raw element required in its production, indium, which is significantly less common on the planet and also used in other things, putting it in great demand.
- CdTe (Cadmium Telluride) somewhat costly material and complicated manufacturing

process. This is very efficient, but due to technological restrictions, it is inappropriate for most projects. However, it may be effective in space projects when cost is not a big factor. As a consequence, the distribution pattern is clear, with Polycrystalline Silicone as well as Monocrystalline Silicone clearly outperforming other products and being more extensively used. In any case, evaluating cutting-edge technology is vital, since renewable energy is becoming more widely recognized and its components are being explored throughout the world[9]. Much more material is being developed right now, and a new one that excels all others in every way might be discovered at any time. Despite the market.

B. Equivalent Model Circuit

In general, and as seen There is still a clear trade in computational complexity across many statistical models in regard to the real world. model in the different mathematical representations of the solar cell model. Models with three to nine parameters are compared in this scenario. The three-parameter model is the simplest to implement, but it's also the worst because it can't accurately represent the real model; and from the other foot, the thirteen model is the most difficult areas, but now it achieves the better representation of the real model because parameters that are used are well defined by manufacturer[7][8].

It seems to be correct., something else to consider. The bigger the number of parameters in the model, the more unpredictability and inaccuracy there will be. The five parameters model is most often utilised in the literature because it has a fair trade-off when related to other mathematical models and it can be used in simulation. The next section will go through the various models in further detail, as well as examine the relevance of the various parameters.

A overview of the various models' approaches, together with their corresponding parameters, can be seen in Table 1.

Table. 1: Overview of the various models' approaches, together with their corresponding parameters

Model	No. of Parameters	Parameters
Ideal single-diode model	3	Iph, Id1, n1
Single-diode RS model	4	Iph, Id1, n1, RS
Single-diode RSh model	5	Iph, Id1, n1, RS, RSh
Two-diode model	7	Iph, Id1, Id2, n1, n2, RS, RSh
Three-diode model	9	Iph, Id1, Id2, Id3, n1, n2, n3, RS, RSh

The 'Parameters' column lists parameters that are used in each of the model.To summarize, Iph denotes the photocurrent, Idi denotes each diode's reverse current, ni denotes each diode's ideality factor, RS denotes. lumped series resistance and RSh denotes shunt resistance

V. SYSTEM ARCHITECTURE

A. Setup Simulation

The PV module is derived from the cells that make up the configuration module in the same way that the PV module is derived from the cells that make up the PV module.

- The first configuration is whole series module array not having a blocking diode because of a a unique series array does not require one. As a consequence, by increasing the voltages on each of 15 I-V module curves from their respective reference step currents, the equivalent I-V curve is determined (figure 2)

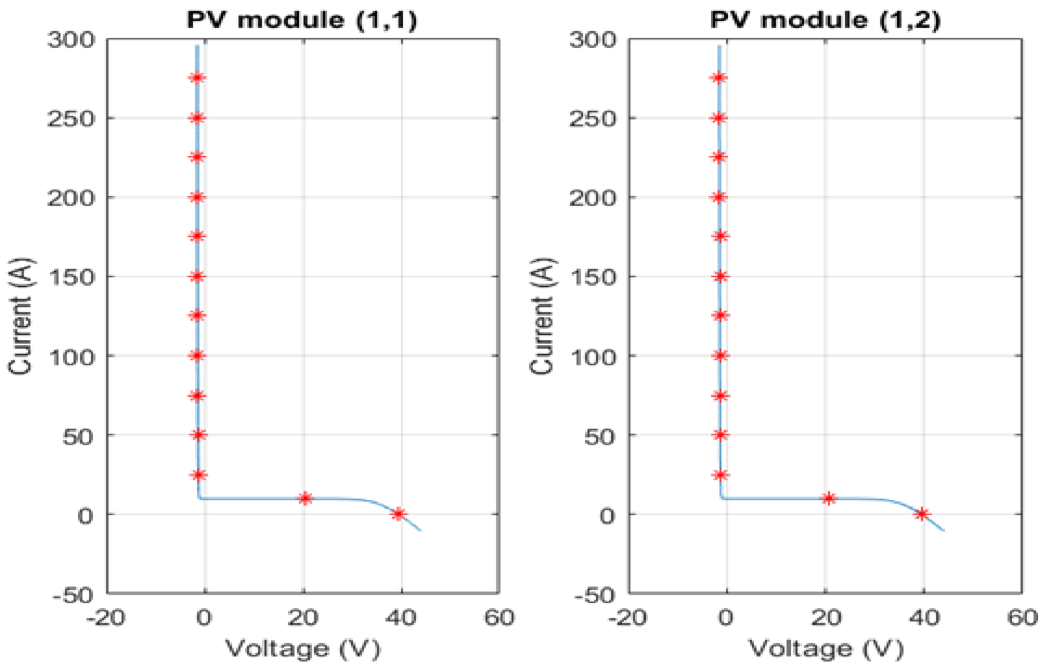

Figure 3: Series, setup 1: Series sum

- The second plus third configurations, which are series-parallel, need 2-stage curve addition. The voltage total for 5 or 3 rows in series, including obstructing diode, is then followed by the sum of current for 3 or 5 columns in parallel, both of which are related to configurations 2 and 3. In the setting 3 situation, Figures 3 and 4 illustrate a graphic picture of this strategy.

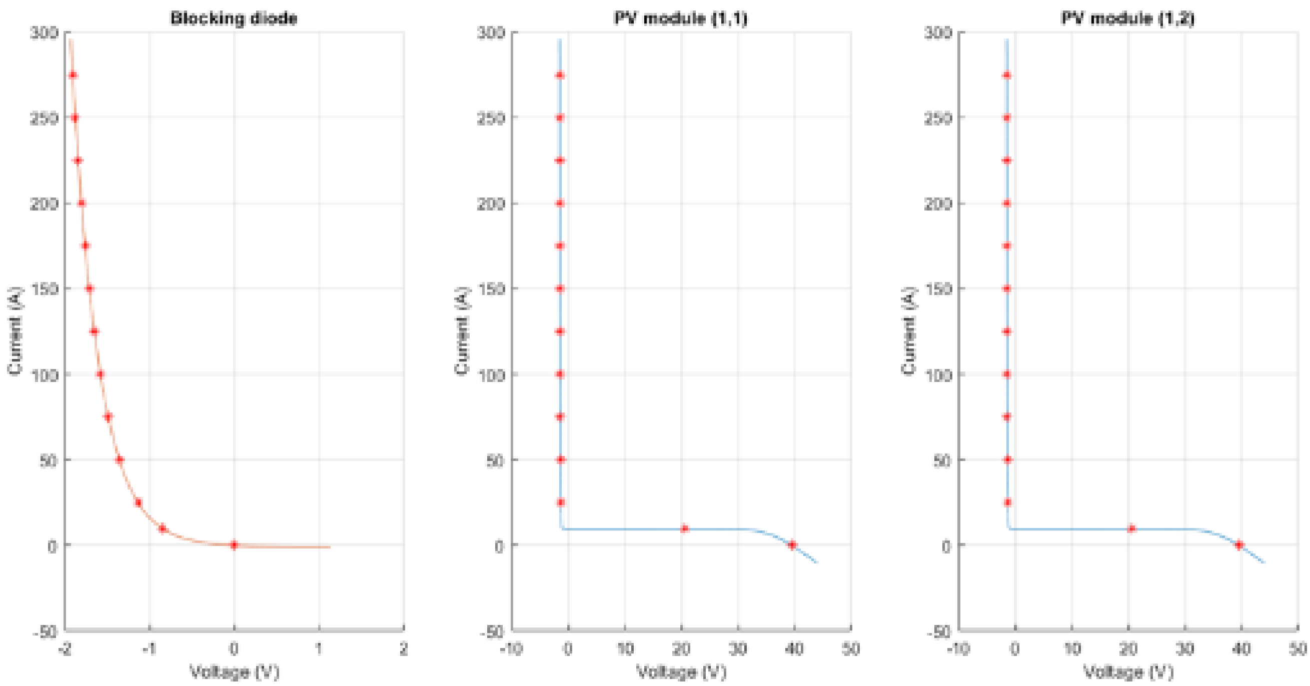

Figure 4: Series-parallel, setup 3; Series sum

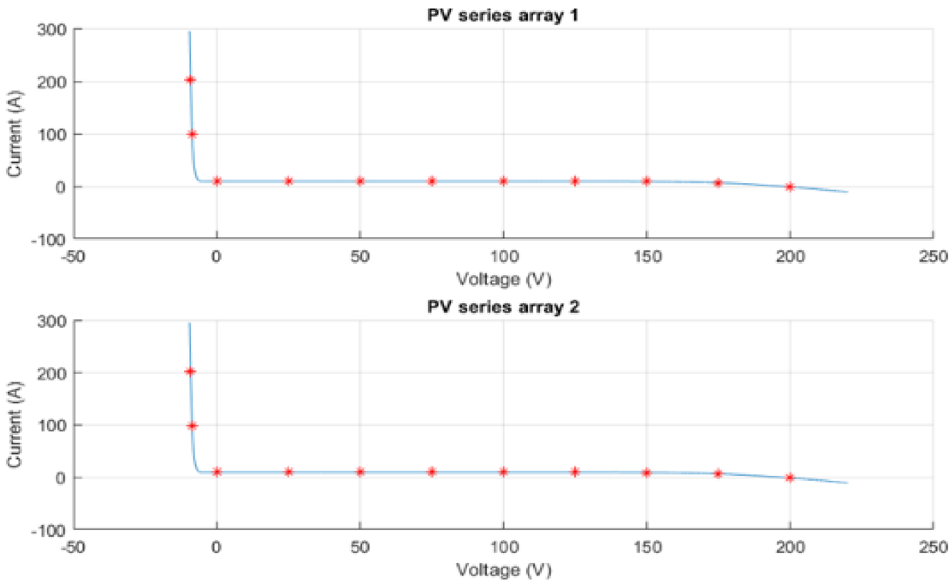

Figure 5: Series-parallel, setup 3: Parallel sum

The I-V and P-V curves for three situations are given after each setup configuration is defined. Figure 4 shows the three I-V and P-V curves from distinct configurations (at 25°C and 1000 W/m2) overlapping to compare their energy production capacities

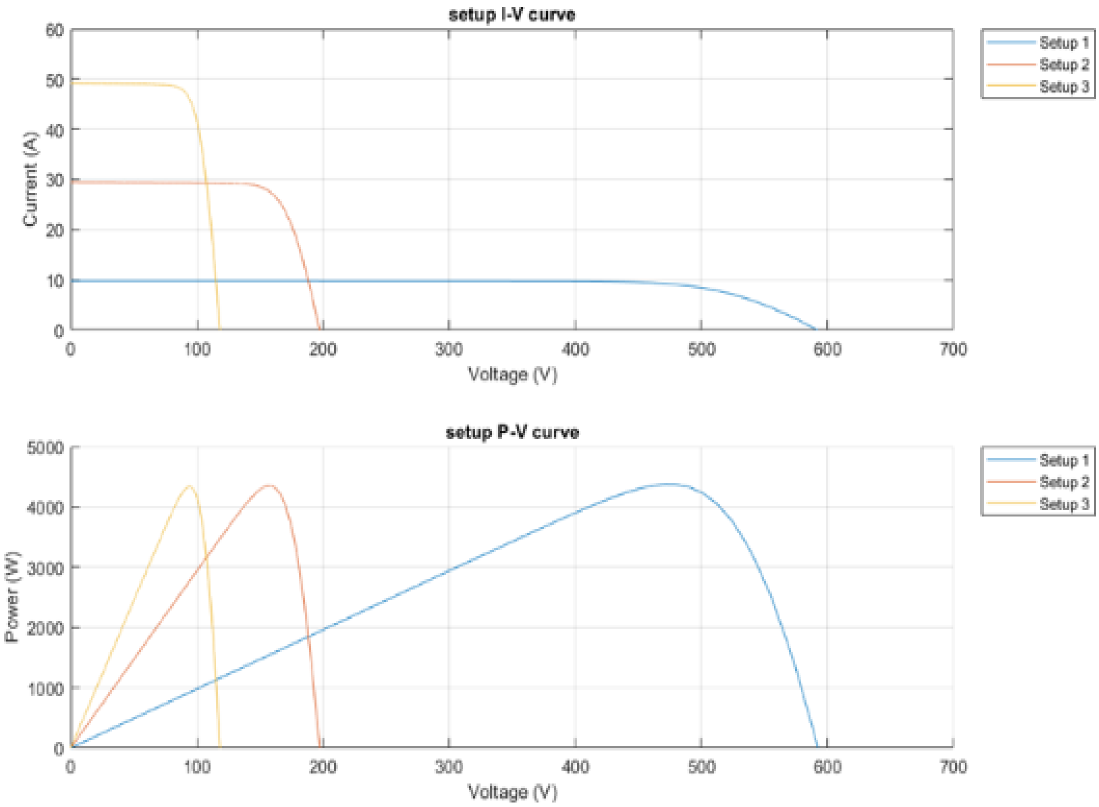

Figure 6: Series-parallel, setup 3; Series sum

The following table 2 summarizes several key factors.

Table 2: Physic constant values

Setup	Voc(V)	Isc(A)	MPP (W)
1	592.5039	9.8317	4.3741 · 103
2	197.5014	29.4944	4.3510 · 103
3	118.5008	49.1564	4.3357 · 103

The ratios of Voc and Isc between the three unique configurations are 1:3, 3:5, and 1:5, respectively, according to logic. On the power front, configuration 2 loses a little bit of power, while setup 3 loses a little more.. It is because of extra condition of blocking diode, that results in extra power loss for system The power in the three layout choices would be similar in the absence of a blocking diode[10].

B. PV System

The next step is to figure out what type of power converter is needed to derivet the energy generated by PV system. In any of the case, next section begins by a broad review of many configurations which may be used in PV system..

C. The partial shading issue

1. Effects on system efficiency

In above sections, we looked at how sun irradiance plus ambient temperature affected I-V and P-V curve forms of PV system. MPP position adjustment requires particular control to compensate for the loss of power system efficiency.

When partial shade is present, a new, much more challenging challenge emerges.. It is ordinary and often inevitable because it may be generated with commonplace factors such as nearby trees, chimneys, or clouds. If partial shading is used, the independent addition curves have mismatched morphologies, resulting in P-V shape with one maximu and also local maxima, due to non-linear nature of I-V and P-V curves

The bypass diodes, which are used to offer an alternate conduit for power via very less irradiated regions and prevent 'hot spot' effect, which deteriorates the shaded cells which absorb power from rest of system, are responsible for these varied forms. As a result, rather of losing a whole branch of power, as previously indicated, many curve shapes will yield several maxima, as seen in figure 6

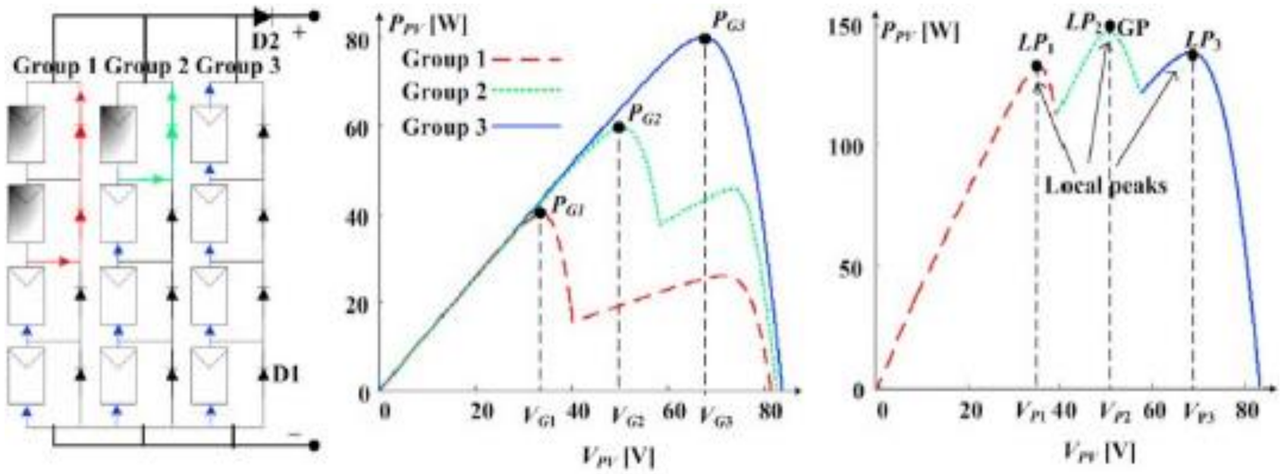

Figure 7: Partial shading effect

Even with changes in irradiation and temperature, some trackers, such as deterministic-based systems, can do an excellent job. However, in the case of a large number of peaks, these sorts of trackers may find an inaccurate maximum, necessitating the adoption of a different approach to avoid these local peaks and also find global one. In the presence of full shadow transient, simulation

The setup as well as shadow configuration for next simulation stage (figure 7),

which involves applying a MATLAB image tool over a matrix representing the experimental field region, is shown below figure 8..

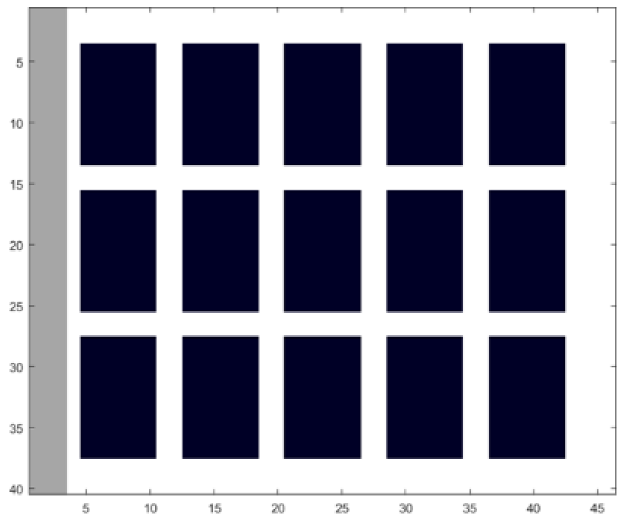

Figure 8: Full shadow transient

The PV modules in the matrix are represented by the navy-blue rectangles, the grey region is the shadow that will ultimately cover all of the PV modules, and the white space is simply an empty zone in between modules.

Every unit is about same size as a single solar cell's longitude side. Each time step, the field coverage speed will be very high to cover approximately 1 PV cell (10 cm/(timestep)). This is since the purpose of such simulation is to examine P-V curve as this develops. As a result, it is stated as high-speed step to prevent saturating plot.

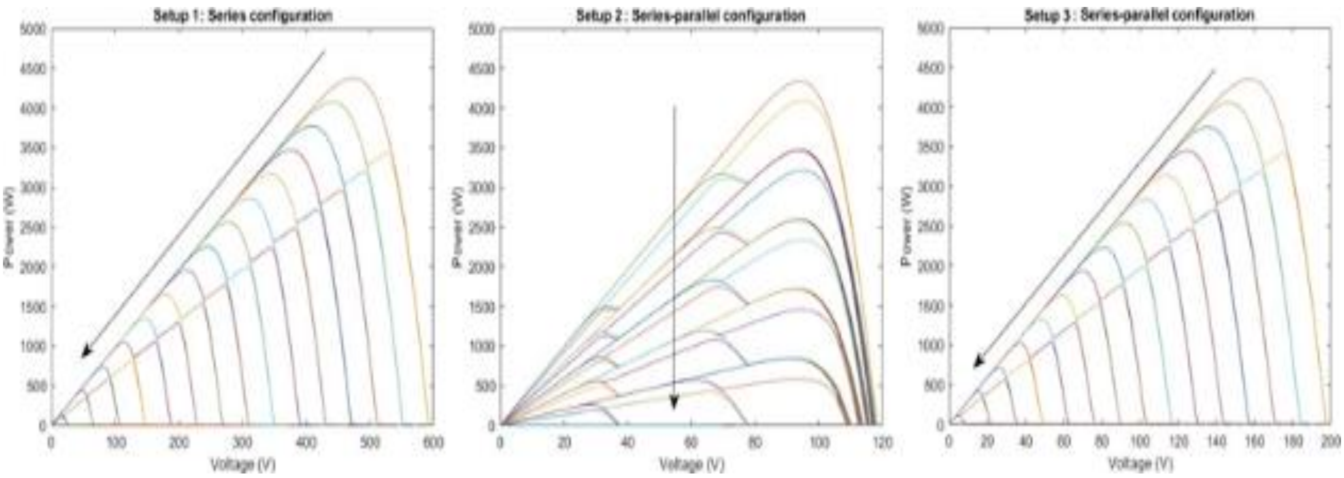

Figure 9: P-V dark flicker slopes

Setups 1 and 3 behave in exactly the same way. Figures 6, 7, and 8 depict the arrangements in a visual manner. The shadow falls in same direction in setups , 3, however setup 2 has an array layout that is perpendicular to shadow advance boundary

D. Scenario Comparison

Regarding algorithm differentiation in diverse circumstances, there are numerous previous considerations to consider.

• The dynamic shading scenario was used to adjust the P-V curve form of the system time by time, step by step. To put it another way, stochastic and deterministic algorithms will perform differently than a static curve shape finding approach. Stochastic algorithms perform poorly in dynamic objective function tracking in general, and their performance deteriorates as the dynamic situation grows more rapid.

The purpose of this study is to see how the algorithm used in a range of dynamic conditions affects the efficiency of a PV array, with the goal of figuring out when stochastic methods are worthless in this PV array configuration. Deterministic algorithms have been shown to become caught at a local maximum, resulting in a large loss in efficiency. It's important to remember, though, that merely being probabilistic makes a stochastic algorithm vulnerable to sliding into a local maximum. The problem is that, while this stochastic strategy beats deterministic approaches in such case, it will not imply that these can totally avoid the partial shading obstacle.

• Although shading conditions have a substantial influence on their performance, deterministic methods which follow a reasonably constant reference, like short-circuit current, open-circuit voltage, and same voltage, do not have same difficulty as perturbing approaches. In such circumstance, geometry of shadow shape is most important thing to examine.

This last lesson focuses on the array configuration and how it may be used to overcome incomplete shading difficulties. Such type of control uses a contrasting method than the MPPT algorithm as it works with real array structure. advocate rearranging the P-V curve and producing a newer power curve using Total-Cross-Tied array.

The previous paper cited employed these simulated shadow patterns in order to analyze varying MPP achieved dependent on PV array reconfiguration. In big form shadow patterns, it has been observed that physical relocation of modules along with a fixed electrical connection (PRM-FEC) leads in a larger MPP point than normal TCT.

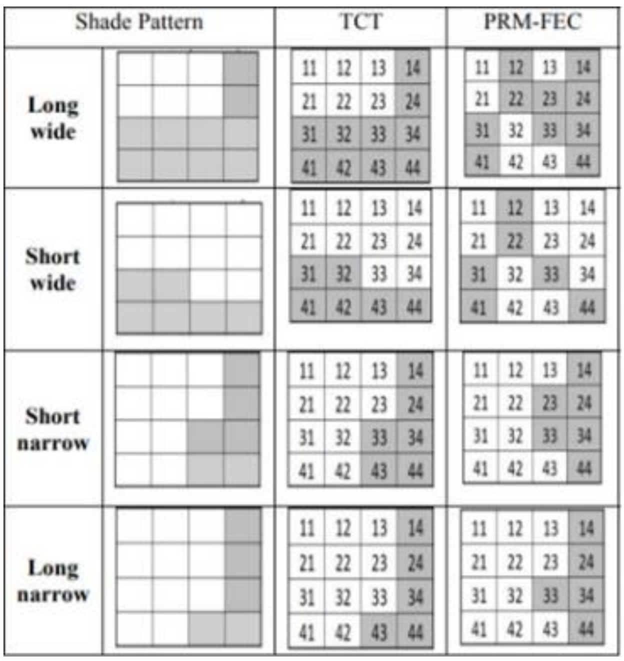

Figure 10: Shadow patterns

Despite the fact that this approach is unrelated to MPPT control, it is intriguing and offers another answer to PV system control problems.

VI. SIMULATION AND RESULTS

We proposes a MATLAB simulation study of an efficiency comparison of a set of several maximum power point tracking techniques over a wide range of shading speeds, where it is designed a PV array configuration in three different setup arrangements under some diverse partial shading scenarios.

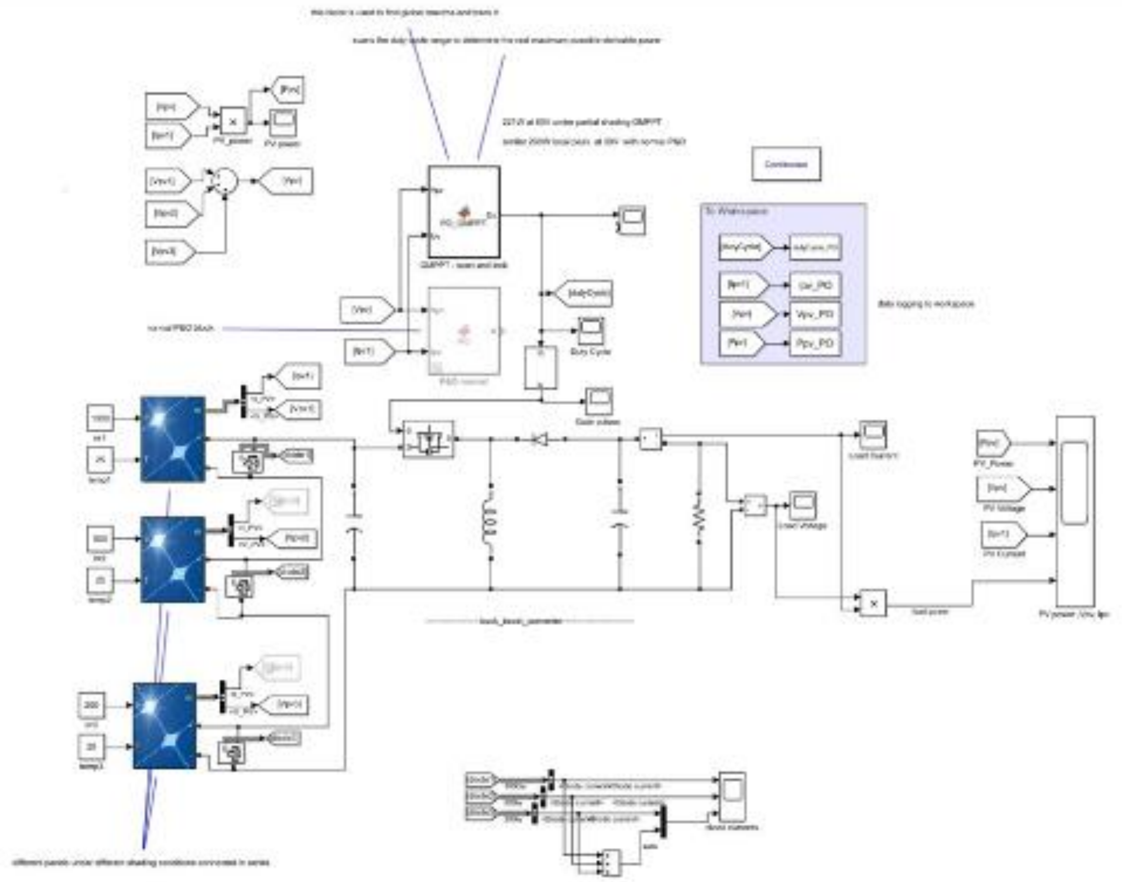

Figure 11: Complete Simulation Model

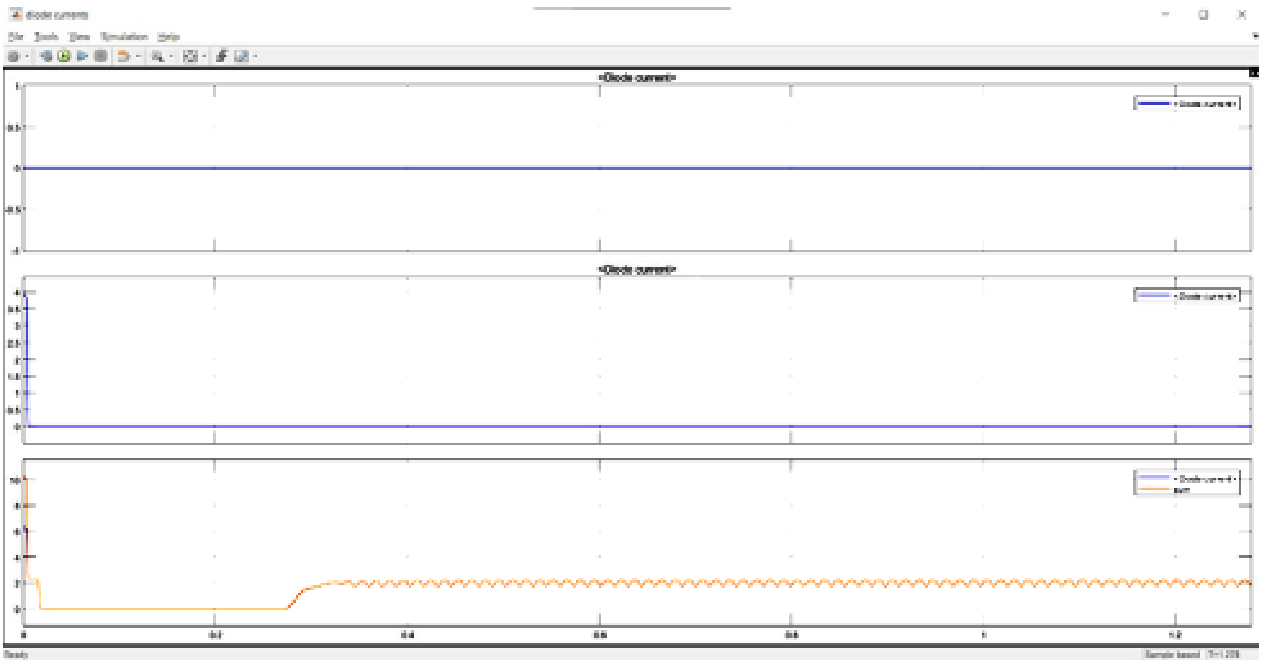

Figure 12: Diode Currents

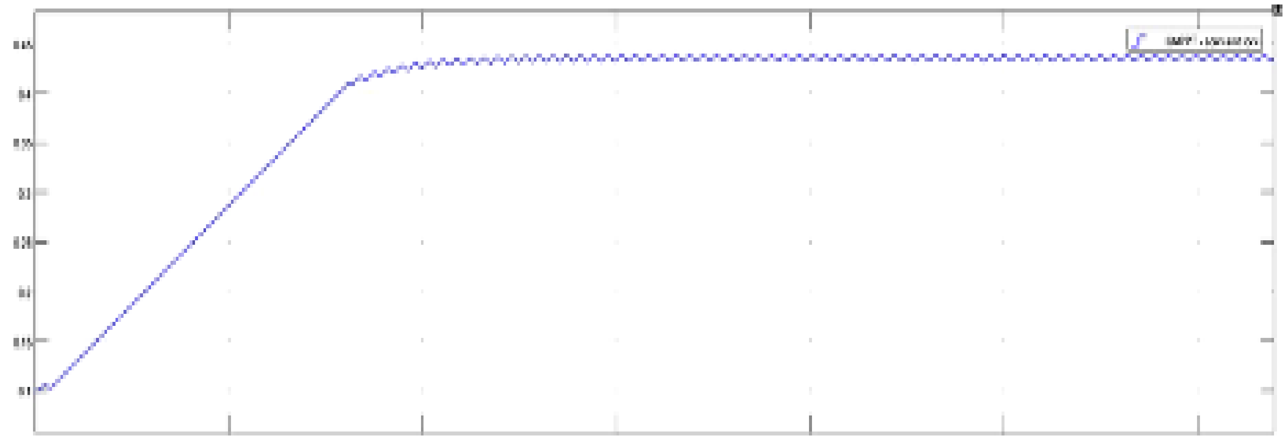

Figure 13: Duty Cycle

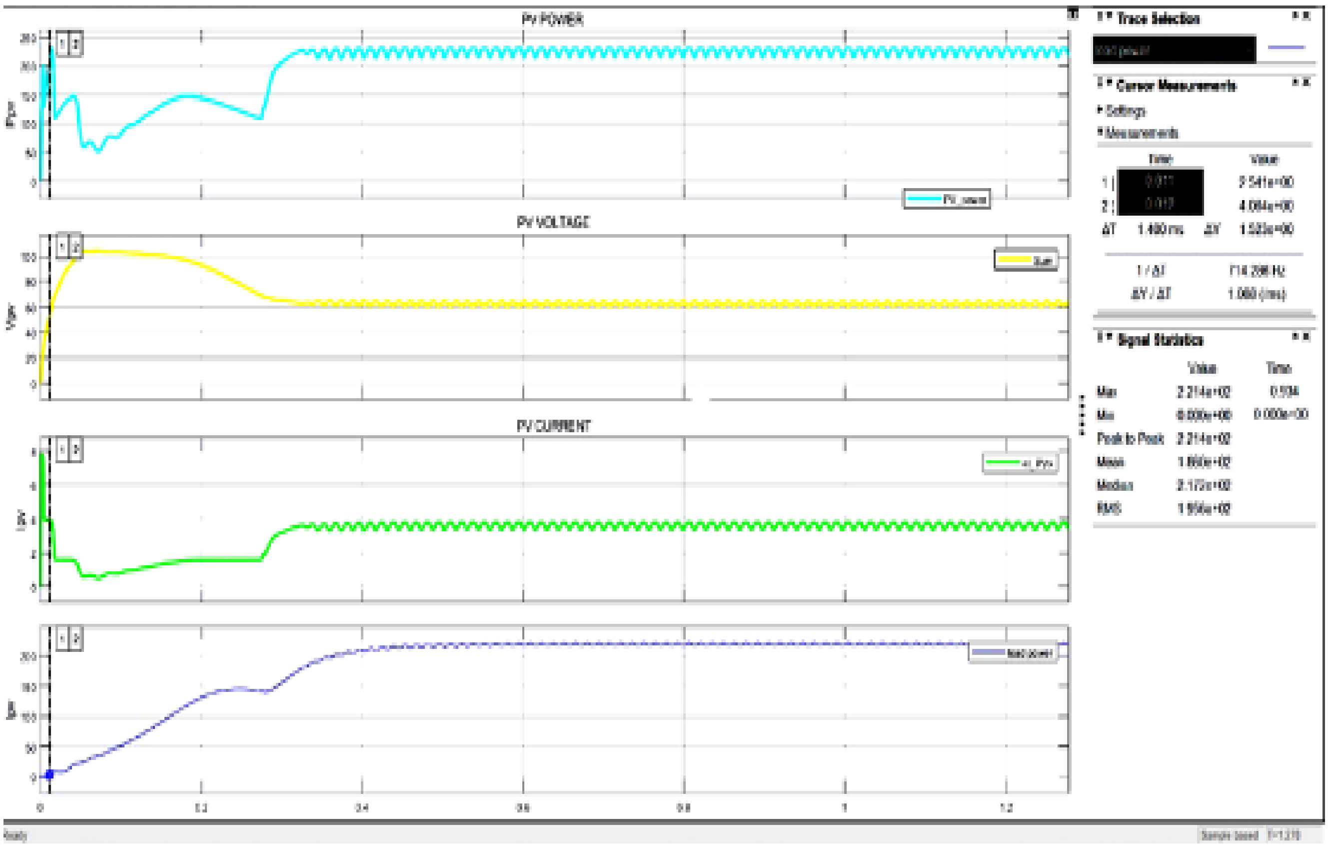

Figure 14: Output

VII. CONCLUSION

We may deduce from the statistics that perturb and observe cannot be employed separately to achieve maximum power point. It's critical to use a global scan that covers the whole duty cycle to find the highest power possible utilizing a search algorithm. Following that, the control is handed to the tracking algorithm, which is in charge. After a few repeats, this scan is completed. allow of tracking the maximum power point ing us to have more tracking control However, this comes with a power loss of up to 0.5 percent. The highest power in our system is 232 watts, and the rms power is 221 watts. As a consequence, the code created for this project is functional, and the model may be used.

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