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Modified PSO based MPPT algorithm for solar panels under partial shading condition

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ABSTRACT

The MPPT controller approach is completely responsible for the solar system's efficiency. Popular techniques such as P&O and IC, on the other hand, fail to achieve the global minima point under various irradiance conditions. This is most common when there is only a little amount of snow on the ground. As a result, a number of techniques have been created and compared to the suggested Practical Swarm Optimization (PSO), a heuristic approach. The four such MPPT algorithms such as P&O, I&C, and PSO are experimented and the PSO algorithm resulted in better power tracking capability under shedding condition.

Keywords: PV system, partial shedding, MPPT, PSO, I&C, P&O

1.INTRODUCTION

Energy participation is critical for the globe, which is reliant on resources such as nuclear and fossil fuels. However, they raise the danger of environmental damage, drawing attention to the need for an alternative, non-conventional energy source.

Photovoltaic solar system systems (PV) are the most common renewable energy source because they are clean, safe, and can be deployed with no fuel costs, no maintenance, and no noise or pollution. The MPPT controller approach is completely responsible for the solar system's efficiency. Popular techniques such as Pertub and Observe (P&O) and incremental conductance (I&C) fail to achieve the global minima point at various irradiance levels. Although the PO method is a more straightforward approach to MPPT, it tends to cause oscillations around the global minima point, which fails under quickly changing environmental (temperature and irradiance) circumstances [1].

The I&C algorithm, on the other hand, performs better in such settings despite being significantly more critical in nature [1-2]. Other strategies, such as constant voltage or constant current approaches, are likewise simple to implement, but they do not effectively track the maximum point [1-2]. The beta approach, on the other hand, has a decent ability to track MPP circumstances but is computationally demanding and requires careful selection of the beta-factor [2]. For partially shedded situations, the entire method fails. As a result, several techniques have been devised, which are further debated and scattered throughout the literature.

While certain MPPT approaches are appropriate for small scale solar systems, they fail in big systems owing to partial shedding. As a result, none of the MPPT techniques mentioned above are adequate for achieving the global MPP under partial shade conditions. Under such conditions, numerous techniques [11, 16] are the global tracking method; however they are not very efficient and have a higher computational cost. In this paper, the particle swarm optimization (PSO) technique, Which is a well-known heuristic approach, is used. It is a Population-based optimization strategy that is based on the social behavior of birds flocking and fish schooling and is inspired by nature. Each individual is referred to as a particle in this scenario, and they each offer a possible solution. A population-based heuristic PSO for partially shaded as well as under variable temperature and insolation circumstances is proven in the current literature. The environmental characteristics are taken into account by the PSO-based maximum power point (MPP) tracker, which then calculates the current and voltage corresponding to the solar panel's maximum power. PO, IC, and PSO implementations and results are shown and compared.

2. PV MODELING WITH DC-DC CONVERTER

A VI graph, which properly displays the relevance of the solar panel's electrical characteristic, may be used to better visualize the solar panel's characteristics. The parameter Pmax, on the other hand, is critical for determining the solar panel's total performance and efficiency. The solar cell generates current or electricity with the assistance of semiconductors by extracting power from the sun.

A solar system, often known as a photovoltaic (PV) system, is a device that transforms solar irradiance (light from the sun) into energy using semiconductors. While the sun's irradiance is absorbed by the solar model's semiconductor, electrons are normally free, and so electricity is generated. The panel is extensively used in the photovoltaic process.

Solar cells are usually stacked one on top of the other On a frame or module. However, numerous frames may be combined to form an array, which can then be scaled to meet the user's power requirements.

The I-V characteristics curve represents the connection between the electrical parameters, i.e. the current and voltage generated for a single PV cell, as the major performance of the solar cell. The irradiance, or the intensity of solar radiation that strikes the solar cell, affects the solar-generated DC current (I), and the PV panel's temperature rises as a result, lowering the Voltage (V).

PV panels provide direct current (DC), therefore they may be used with any electronic equipment. However, some electrical appliances and industrial applications may require a DC to AC converter.

The IV curve of a solar panel is important because it characterizes the solar panel's performance over variable voltage and how the solar panel reacts to its current with a constant loading state. The resultant power curve is particularly crucial since it contains a maximum peak known as MPP.

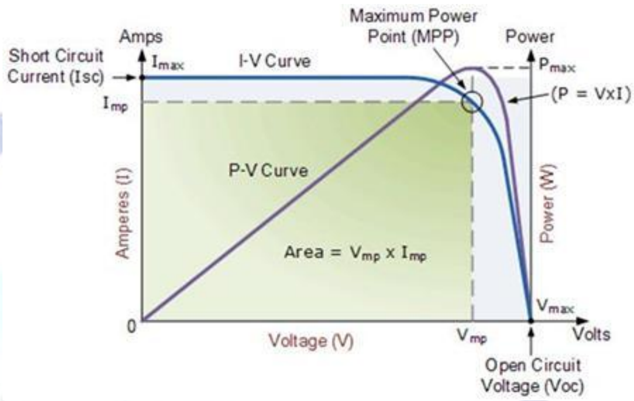

Figure 1: VI characteristics

The VI curve of a solar cell may be seen in the above picture 1. The IV curve of a solar panel is used to describe How the solar panel reacts to its current under constant loading conditions while operating at different voltages. The resultant power curve is particularly crucial since it contains a maximum peak known as MPP.

In the case of solar panels, the model produces various Operational voltage and current owing to the varying configurations. While the voltage and current must be limited or controlled based on the load demand. A DC-DC converter must execute adequate control of these electrical characteristics.

This type of converter changes one voltage level to another while ensuring that the power level remains constant. This is a perfect scenario, however in practice, each DC-DC converter has losses, which are made up of conduction and switching losses. The converter is explained in more detail after a brief description.

3. BOOST CONVERTER

The boost converter, like the buck converter, has all of these components, but they are organised differently (Fig.2). In the case of boost, the switch Q1 works at a high frequency, and the output voltage is adjusted to match the duty cycle fluctuation.

When the switch Q1 is turned on, current flows from the source to the L words and then to the Q1. The energy is stored in the form of a magnetic field in the inductor. Because no current flows via D1, the load current is carried by the charge in C1. When switch Q1 is turned

off, the L counteracts the decline in current by abruptly changing EMF. This adds voltage to the inductor,
boosting the source voltage, and the current now flows from the source via L, D1, and the load, eventually reaching C1. The step up voltage, which is usually the outcome of a boost operation, may be written as

$$\frac{Vin}{Vout} = \frac{1}{1-D} \tag{1}$$

where the reciprocal duty ratio 1–D represents the fraction of the duty cycle, and Q1 is turned off while it is turned on. As a consequence, the resultant ratio can be expressed as

$$\frac{Vin}{Vout} = \frac{T}{Toff} \tag{2}$$

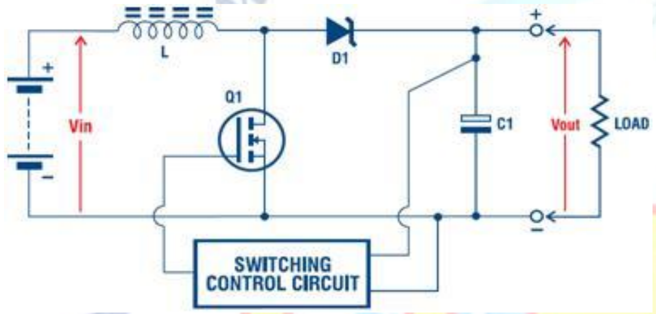

Fig.2. The basic circuit for a Boost type of DC-DC converter

The 2:1 step-up ratio, for example, may be achieved with a duty ratio of 50% (Ton = Toff), but the 3:1 step-up requires a duty cycle of 66 percent.

Furthermore, if the converter is optimal, i.e. 100 percent efficient, the output current to input current ratio is reciprocal order to have maximum possible power, the turbine should always operate at λopt.

This is possible by controlling the rotational speed of the turbine so that it always rotates at the optimum speed of rotation.

$$\frac{Iin}{Iout} = \frac{Vout}{Vin} \tag{3}$$

As a result, by increasing the voltage by a factor of two, the input current will be twice as large as the output current. The converter with losses, on the other hand, will have bigger values in a practical sense.

4. PARTIAL SHADED CONDITION AND MPPT

Shedding is an issue that bigger solar array setups have to deal with. There can be an impact of difference in solar irradiance to various panels when hundreds of solar panels are arranged in a bigger geographical region. As a result, the panels operate at varying MPPs, which are not consistent across the array. This causes a mismatch in the solar panels' output power level, resulting in several MPP peaks.

A. Shedding effect

Shedding is an issue that bigger solar array setups have to deal with. There can be an impact of difference in solar irradiance to various panels when hundreds of solar panel are arranged in a bigger geographical region. As a result, the panels operate at varying MPPs, which are not consistent across the array. This causes a mismatch in the solar panels' output power level, resulting in several MPP peaks. Below is a comparable visual representation with its performance (figure 3). In reality, changing irradiance falls on the solar panel owing to varying weather conditions and the chain formed solar panels (either in parallel or in series). The Fig. reffig 3 depicts such a demonstration, which results in energy loss owing to the included solar panels' various energy levels of operation.

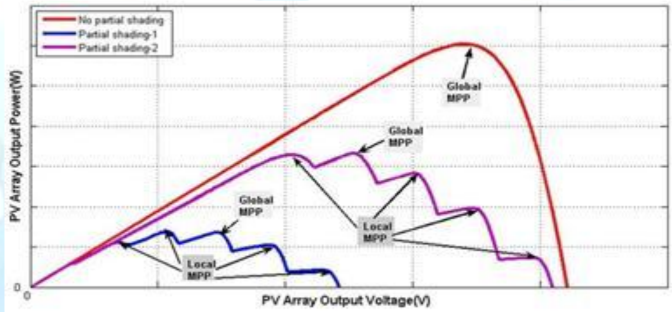

Fig.3. PV characteristics of partial shedding on Solar panel

This is a common problem with solar installations, whether they are in the city or at home. In addition, grid-related challenges are imposed, and many investigations are being conducted in this area. Other designs for a central inverter integration for grid connection with solar panels can be created in parallel.

The biggest disadvantage stems from the MPP algorithms' faulty modeling, which might result in variable output power levels. This is a result of incident irradiance having a varying effect on panels at various places. The integrated PV converter module makes full use of the available irradiance levels and optimizes power by altering the PWM source and modifying the DC-DC converter output. However, due to the nonlinear feature of the solar panel power curve, doing the same is extremely challenging. In order to avoid partial shade,
appropriate alignment and arrangement of the solar panels is essential. The only option left is to use an

efficient algorithm if one exists. In addition, the right mix of converters may allow the integrated modules to work with the global MPP point.

5. PSO ALGORITHM

Dr. Eberhart and Dr. Kennedy presented particle swarm optimization (PSO) as a meta heuristic optimization approach in 1995. The social behavior of birds flocking or fish schooling was the major inspiration for this. PSO's nature is quite similar to that of evolutionary computation techniques. Genetic Algorithms (GA) is one such similarity, however it is very nonlinear in nature. In general, the system is started with a population of different solutions and then searches for (and perhaps discovers) the optimal solution by updating generations as a global best outcome. In contrast to GA, the PSO lacks evolutionary processes such as crossover and mutation. The PSO has prospective solutions, which are particles, which are updated in the search space using other particles depending on the current optimal particles. The technique is summarized and explained further. In compared to the GA, the PSO has the benefit of being easy to implement and requiring only a few hyper parameters to be regulated. Several applications have demonstrated the value of heuristic techniques, despite the fact that they may lack clear mathematical basis

The algorithm keeps track of three global over varyings:

- A condition or a target value

TABLE I

SOLAR PANNEL PAPRAMETER

Tata power solar systems TP250MBZ	
Voc(V)	36.8
Isc(A)	8.83
Vmp(V)	30
Imp(A)	8.3
Temp.Coeffecient Voc(%/deg C)	-0.33
Temp.Coeffecient Isc(%/deg C)	0.0638

- The global best (gBest) value indicates which particle's data is closest to the Target at the moment.
- If the Target isn't located, this number indicates when the algorithm should end.

Each particle consists of:

- Data that may be used to come up with a solution A Velocity number that indicates how quickly the Data can change.
- A personal best (pBest) number showing the particle's Data's closest approach to the Target.

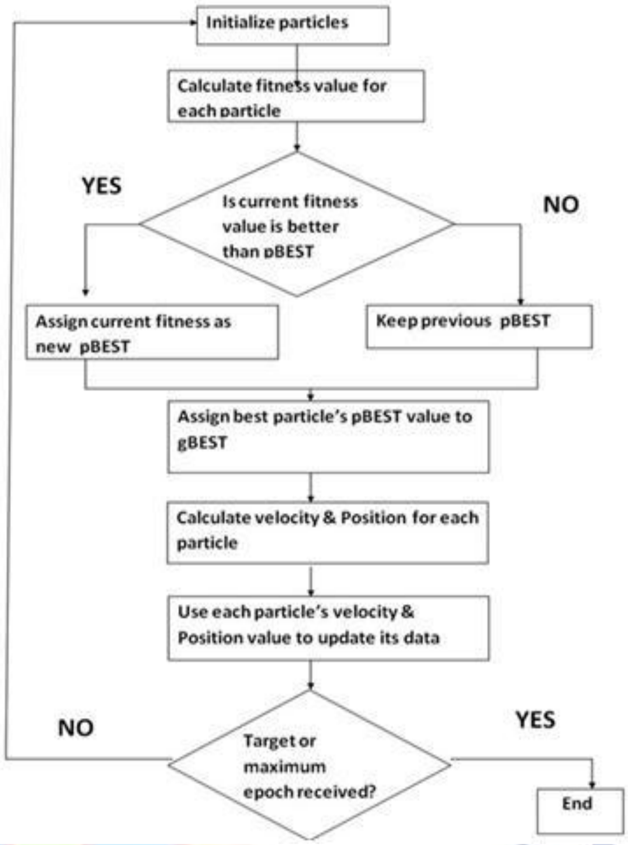

Fig. 4. Flow chart of PSO algorithm

6.SIMULATION RESULTS

Tables 1 and 2 show the simulation settings for the solar panel, the load, and the DC-DC.

A. Partially shedded Solar panel and its simulation results

As described before multiple solar panel with non-uniform irradiance is modelled and its V-I characteristics are presented in figure 6

TABLE II

DC-DC CONVERTER AND LOAD PARAMETERS

DC-DC converter	
L1(H) 1.15E-03	1.15E-03
C(F)	4.68E-04
RL(Ω)	53

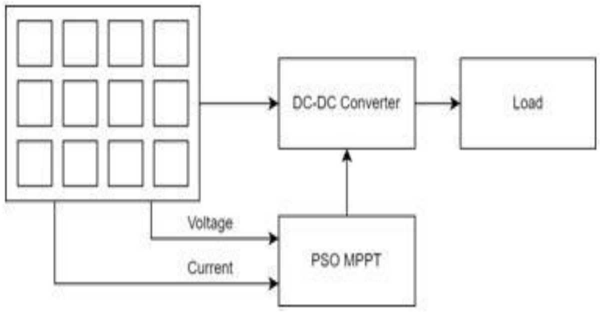

Fig. 5.Block diagram of proposed model

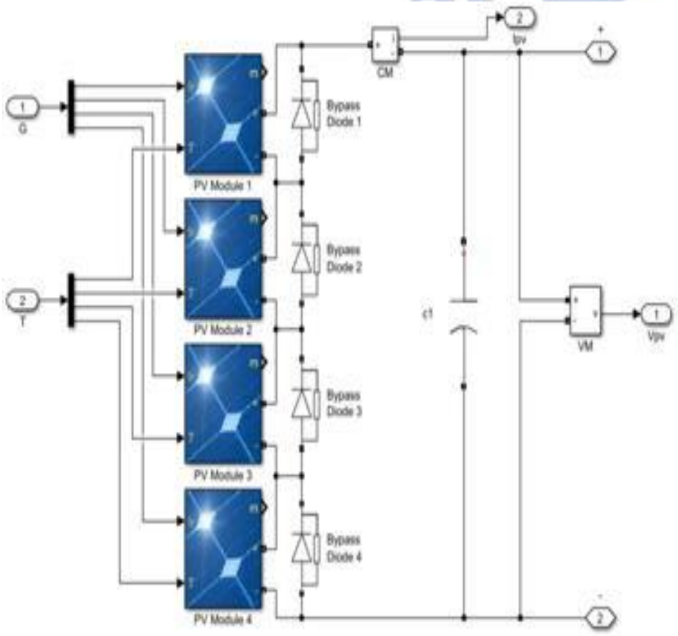

Fig.6. Partially shedded PV panel setup

The figures 7 and 8 clearly shows the VI and PV characteristics of a multiple solar panel with non-uniform illuminance respectively.

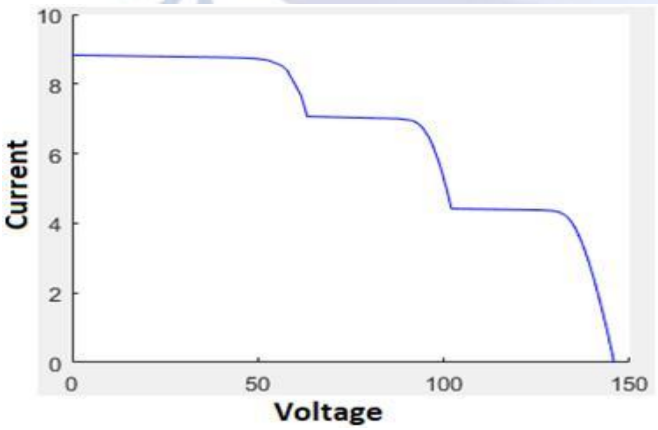

Fig. 7. Partially shedded PV panel VI characteristics

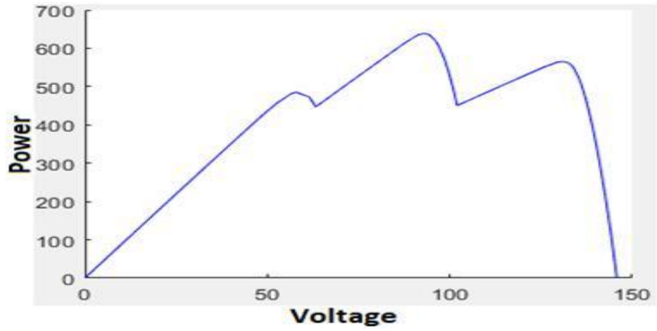

Fig.8. Partially shedded PV panel PV characteristics

A comparative analysis of the four different algorithms are presented in figure.

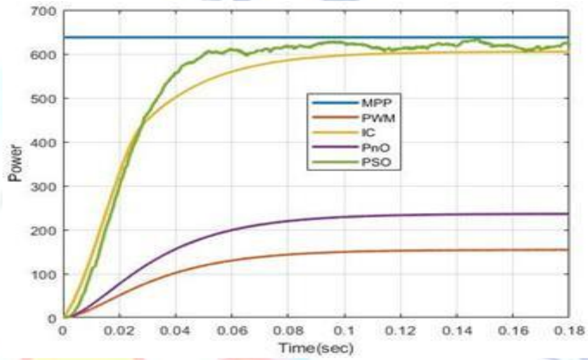

Fig. 9. Comparing the algorithms under uniform irradiance

7.CONCLUSION

The analysis and design of solar panels is now being carried out in order to determine their respective VI characteristics under partially shedded situations. The relevance of optimization algorithms is revealed by the findings of the characteristics, which cannot be solved by other state-of-the-art methodologies such as P&O and IC. The same can be concluded based on the acquired results (figures).The solar panel characteristics cannot be pre-assumed due to the unknown nature of the irradiance. As a result, heuristic techniques like PSO may be the best-fit solution to the situation at hand. A similar implementation is carried out, with positive outcomes. This clearly suggests that, in comparison to previous techniques, the proposed PSO-based MPPT is capable of extracting a significant share of power. However, further research and implementation of alternative heuristic methodologies might be considered as a future project expansion.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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