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BOA BASED MPPT FOR PV SYSTEMS

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Abstract

Because of dust, trees, high buildings in the surrounding area, partial shading conditions (PSC) occur in photovoltaic (PV) systems. This condition affects the power output of the PV system. Under PSC there is a global maximum power point (GMPP) besides there are a few local maximum power points (LMPP). This condition makes the maximum power point tracking (MPPT) procedure a challenging task. In order to solve this issue, soft computing techniques such as gray wolf optimization (GWO), particle swarm optimization (PSO) and Gravitational Search Algorithm (GSA) are implemented. However, the performance of MPP trackers still needs to be improved. The main contribution of this paper is improving the tracking speed by implementing BOA to the MPPT of the PV system under PSC. Thus, in real-time applications a promising alternative presented to the literature to improve the performance of the PV systems under variable PSC because of its fast-tracking speed. PV system consists of PV array, boost converter and load are modeled and simulated in MATLAB/Simulink. Finally, the output relates to the inverter for small power applications.

INDEX TERMS: photovoltaic (PV), Maximum power point tracking (MPPT), gray wolf optimization (GWO), Gravitational Search Algorithm (GSA), partial shading conditions (PSC).

1. Introduction

PV panels in an array may receive different intensity of the sunlight. When the panels in a PV array receive the same level of solar radiation, P-V characteristics of the system shows only one MPP. On the other hand, in case of a shading condition, the P-V curve at the output of the system has more than one MPPs. One of these points is called the global MPP (GMPP) and others are called local MPPs (LMPP). In the case of shading, the conventional MPPT algorithms for PV systems have failed because of the existence of LMPP. At this point, there is a need for an MPPT algorithm that can reach GMPP without sticking on LMPP. In order to meet this, need a lot of researches have been made during recent years about mitigation of the impact of partial shading conditions (PSC) on PV systems.

The proposed algorithm compared with PSO and Differential Evolution in order to test its performance. The authors stated that the proposed algorithm showed better performance than the other two algorithms. and it presented an improved PSO algorithm to track MPP of PV systems under PSC and validated the proposed algorithm by experimentally on 110 W PV system. configuration to enhance the performance of the PV system under PSC. The idea is based on the fact that the physical location of PV modules under PSC affects the performance of the system. The system consists of two main components; PV and DC-DC Boost Converter. In this section, these systems will be discussed in detail. Figure 1 shows the block diagram of the system. The PV system generating power depending on environmental parameters such as solar radiation and temperature.

The generated power is transferred to a DC load via DC-DC boost converter. The input voltage and current values of the Boost converter are measured to be used in the MPPT controller. The duty cycle of the gate signal of the MOSFET in the Boost converter is controlled by the MPPT controller to keep the system operate at the MPP. The duty cycle signal is converted to a PWM signal by PWM generator for inverter is not easy as it depends on the technology available, it may require better components, which can increase drastically the cost of the installation. Instead, improving the tracking of the maximum power point (MPP) with new control algorithms is easier, not expensive and can be done even in plants which are already in use by updating their control algorithms, which would lead to an immediate increase in PV power generation and consequently a reduction in its price.

The remainder of the paper is organized as follows: Photovoltaic System described in section II,

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followed by the Algorithms in section III, In Section IV discusses some Simulation Examples V describes the simulation results and section VI ends with some concluding remarks.

II. PHOTOVOLTAIC SYSTEM

The modeling of the Photovoltaic system is done with MATLAB SIMULINK. The system consists of a photovoltaic panel, boost converter, a resistive load and Butterfly optimizer and a single-phase inverter.

OPERATING PRINCIPLE

Solar cells are the basic components of photovoltaic panels. Most are made from silicon even though other materials are also used.

Solar cells take advantage of the photoelectric effect: the ability of some semiconductors to convert electromagnetic radiation directly into electrical current. The charged particles generated by the incident radiation are separated conveniently to create an electrical current by an appropriate design of the structure of the solar cell, as will be explained in brief below. For further details, the reader can consult references [4] and [10].

A solar cell is basically a p-n junction which is made from two different layers of silicon doped with a small quantity of impurity atoms: in the case of the n-layer, atoms with one more valence electron, called donors, and in the case of the p-layer, with one less valence electron, known as acceptors. When the two layers are joined together, near the interface the free electrons of the n-layer are diffused in the p-side, leaving behind an area positively charged by the donors. Similarly, the free holes in the p-layer are diffused in the n-side, leaving behind a region negatively charged by the acceptors. This creates an electrical field between the two sides that is a potential barrier to further flow. This electric field pulls the electrons and holes in opposite directions so the current can flow in one way only: electrons can move from the p-side to the n-side and the holes in the opposite direction. A diagram of the p-n junction showing the effect of the mentioned electric field is illustrated in below figure.

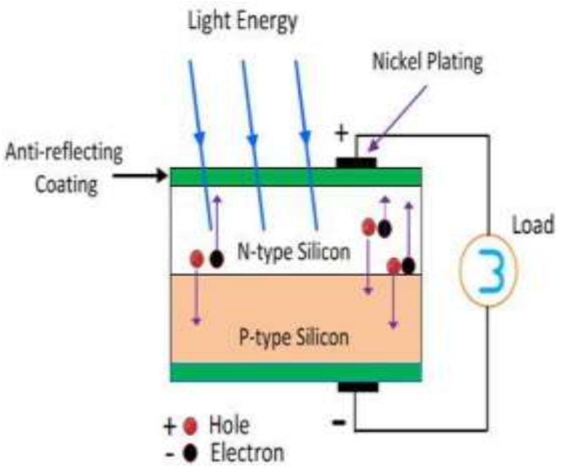

Fig.1: Solar cell

Metallic contacts are added at both sides to collect the electrons and holes so the current can flow. In the case of the n-layer, which is facing the solar irradiance, the contacts are several metallic strips, as they must allow the light to pass to the solar cell, called fingers.

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MPPT Controller

- Maximum power point tracking (MPPT) is a technique used to maximize energy extraction.
- Maximum power point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions.
- Output of boost converter is compared with previous power of the module. Duty cycle is adjusted to track the Max Power Point. It continuous until the power of the PV reaches the max.
- The condition at which Max power is transferred to the load is
  $R_L = R_{\text{solar cell}}$

III. ALGORITHM

A. BUTTERFLY OPTIMIZATION ALGORITHM

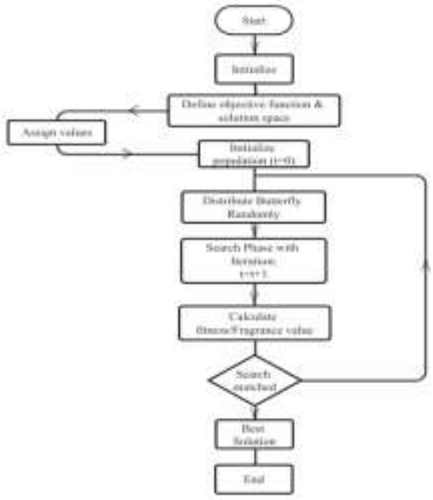

Fig.2: Flow-chat of butterfly algorithm

The entirely empirical approach of the *Butterfly* algorithm requires that:

- The requested setpoint is correctly followed, meaning that the current control (if any) is not saturated and can reach steady state before the result is evaluated.
- There is only one global maximum power point.
- Current control is executed within the main control interrupt (fast control loop) and the MPPT algorithm executed within a secondary control interrupt (slow control loop).

There are three main characteristics of butterflies in this algorithm:

- 1. One butterfly should be able to attract all other butterflies thanks to its fragrance.
- 2. Butterflies change its location randomly or toward the butterfly that has the most intense smell.
- 3. The landscape of the objective function determines the stimulus intensity of butterflies.

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B. FIREFLY ALGORITHM

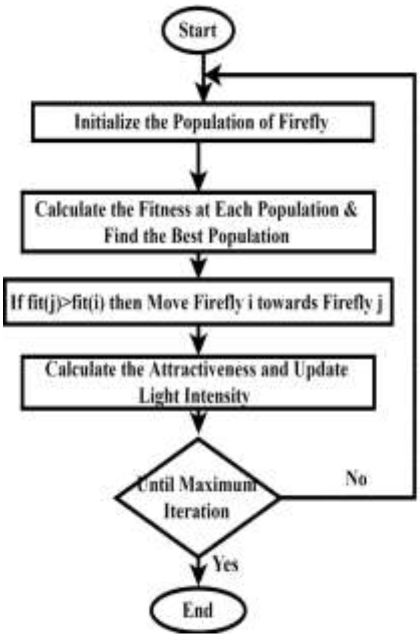

Fig.3: Flow-chat of Firefly algorithm

Fireflies are winged beetles or insects that produce light and blinking at night. The light has no infrared or an ultraviolet frequency which is chemically produced from the lower abdomen is called bioluminescence. They use the flashlight specially to attract mates or prey. The flashlight also used as a protective warning mechanism to remind the fireflies about the potential predators. Firefly algorithm formulated by Yang is a metaheuristic algorithm that is inspired by the flashing behavior of fireflies and the phenomenon of bioluminescent communication. formulated the Firefly Algorithm with the following assumptions:

1) A firefly will be attracted to each other regardless of their sex because they are unisexual.

2) Attractiveness is proportional to their brightness whereas the less bright firefly will be attracted to the brighter firefly. However, the attractiveness decreased when the distance of the two fireflies increased.

3) If the brightness of both fireflies is the same, the fireflies will move randomly. The generations of new solutions are by random walk and attraction of the fireflies. The brightness of the fireflies should be associated with the objective function of the related problem. Their attractiveness makes them capable to subdivide themselves into smaller groups and each subgroup swarm around the local models.

MAXIMUM POWER POINT TRACKING BUTTERFLY-ALGORITHMS

To date, numerous maximum power point tracking algorithms have been proposed, with various trade-offs between performance (tracking speed, accuracy) and complexity (need for sensors, mathematical modeling, computation burden, etc.).

IV. SIMULATION Results

Simulink

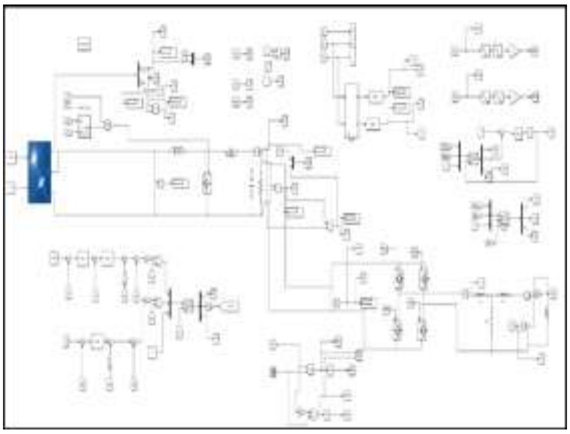

Fig.4: Simulink model of the System with Inverter

Simulation Results –

Output Power = 250.1W

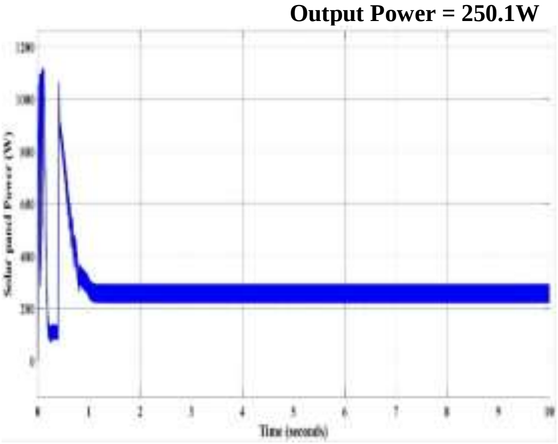

Fig.5: Solar panel output with BOA

Output Power = 246 W

Fig.6: PV system with BOA MPPT unit

Output Power = 241 W

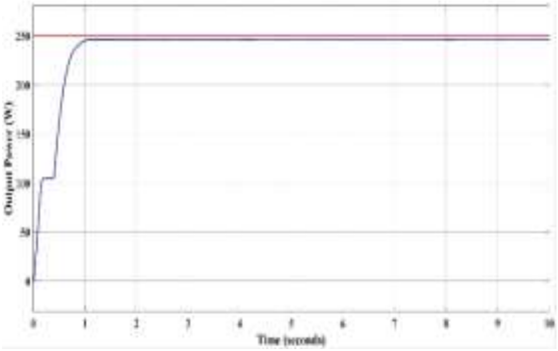

Fig.7: System with FFA MPPT

Output Power = 102.8 W

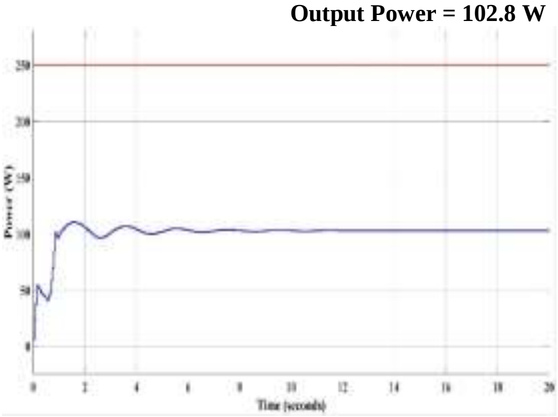

Fig.8: Tracking of maximum power with BOA

Output Power = 246 W

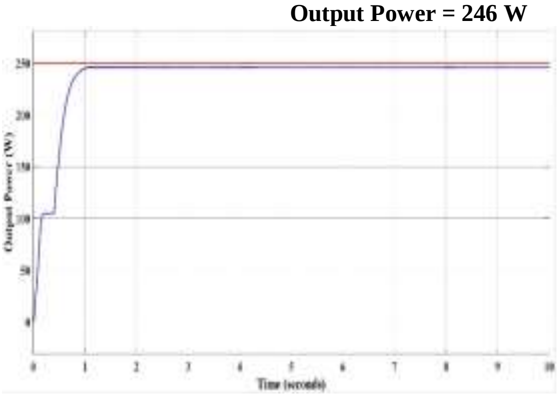

Fig.9: Tracking of maximum power without BOA

Active Power = 851.4 W

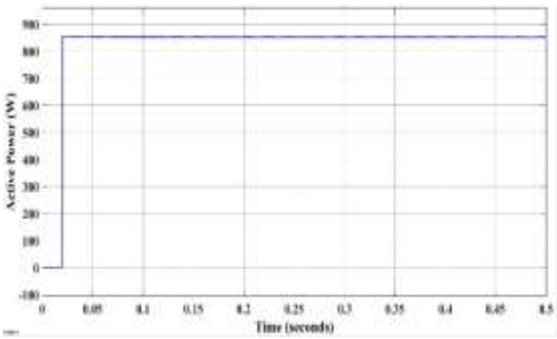

Fig.10: Simulation results active power

Reactive Power = 1.22 VAR

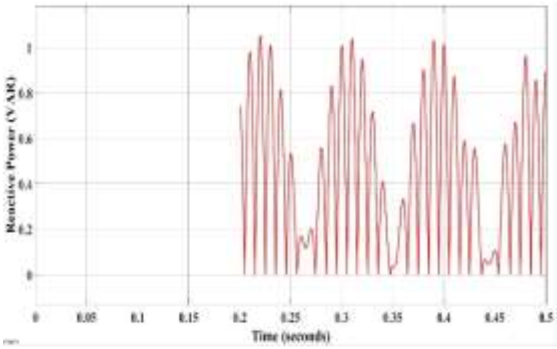

Fig.11: Simulation results reactive power

Table.1: Comparation of Various parameters without and with BOA and FFA

Sl. No	Parameter	Response without BOA		Response with BOA		Response with FFA	
		Solar Panel Output	DC-DC Boost converter Output	Solar Panel Output	DC-DC Boost converter Output	Solar Panel Output	DC-DC Boost converter Output
1	Voltage	*36.26 V*	*71.71 V*	*35.87 V*	***110.9 V***	*35.87 V*	*109.9 V*
2	Current	*2.94 A*	*1.434 A*	*6.971 A*	***2.218 A***	*6.971 A*	*2.218 A*
3	Power	*106.6 W*	*102.8 W*	*250.1 W*	***246 W***	*230 W*	*241 W*
4	Tracking Speed	*18.5 s*	*12.7 s*	*2.3 s*	***1.1 s***	*2.3 s*	*1.1 s*

V. Conclusion

This paper implements Butterfly optimization algorithm (BOA) for the global optimization problem of partially shaded PV arrays that have local peaks and a global peak on its power-voltage curve. Because of its good accuracy and fast-tracking speed, a proper MPPT algorithm for the applications that have to deal with variable PSC is presented. A PV system consists of PV array, boost converter, and the load are simulated in MATLAB/Simulink. BOA is implemented to the MPPT controller of the boost converter. After, taking into account all the results, it can be concluded that the best algorithm is the modified P&O. Its dynamic MPPT efficiency is like that of the modified In Cond, but the P&O algorithm is simpler.

The above conclusions are based on simulations and the reported results in the literature. No experimental validation could be done and that should be the next step to confirm the results from the simulations are also implemented for the MPPT controller in order to make a comparison. A comparative analysis is carried out between these MPP trackers. Three different insolation scenarios are created and three mentioned MPPT algorithm is implemented for these insolation scenarios. The results show that BOA has high accuracy and the best convergence speed among the three MPPT algorithms. It is concluded from the results that for the three insolation scenarios in this study, while all the three algorithms have the same accuracy.

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