International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 6, September-October 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

# Particle Swarm Optimization (PSO) Algorithm Based MPPT for PV System Operating under Partial Shading Condition

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ABSTRACT

With ever-increasing demand, solar energy has emerged as one of the most significant renewable energy sources; consequently, operating photovoltaic panels to maximize efficiency is vital. However, solar panels have difficulties, such as the Partial Shading Condition, which has a substantial influence on the efficiency of the PV system. MPPT plays a critical role in improving the power of PV systems. PV trajectories will be diverse and exceedingly complicated due to the numerous peaks accessible during PSC. Traditional MPPT approaches will fail to achieve the Global Maximum Power Point and instead will linger at the Local Maximum Peak Point, decreasing the PV module's efficiency and performance. The Particle Swarm Optimization technique is used in this work to determine the GM PP by measuring peak power. In terms of Maximum Power Point, this approach offers a high degree of reliability, robustness, and proficiency. MATLAB/Simulink is used to verify the suggested approach.

***KEYWORDS:*** *Photovoltaic, Maximum Power Point MPP, Maximum Power Point Tracking MPPT, Global PowerPoint GMP, Particle Swarm Optimization (PSO), DC-DC Boost Converter, and Local Maximum Power Point are some of the terms used to describe partial shading conditions*

***How to cite this paper:*** Sarad Kumar | Pramod Kumar Rathore "Particle Swarm Optimization (PSO) Algorithm Based MPPT for PV System Operating under Partial Shading Condition" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-6, October 2022, pp.1870-1875, URL: www.ijtsrd.com/papers/ijtsrd52182.pdf

IJTSRD52182



## 1. INTRODUCTION

With ever-increasing power usage, electricity expenses must be addressed, which may be reduced by employing PV panels. Furthermore, renewable energy from the sun may be the ideal method to generate power bills, allowing producers to sell excess electricity to local electricity providers through PV panels. As demand grows, PV technology will become more efficient and provide more advantages in the near future. Because solar panels have a greater initial cost, it is preferred that the maximum quantity of electricity be recovered from the PV panels. PV production is purposefully dependent on the strength of solar light and temperature. Because these limits alter over time, is mandatory to propose a MPPT way for tracing the highest power from the PV One of the most significant considerations for getting the most electricity out of a PV system is partial shading. This circumstance occurs as a result of impediments such as buildings, trees, clouds, and towers. The partial shading scenario causes a hotspot to form in the solar module. In order to avoid self-heating, the array has bypass diodes that are coupled across. The partial shading situation will result in a loss of power from the PV module due to the bypass diodes employed, the placement of the PV array, and the shading patterns. The bypass diodes will produce complicated forms and several peaks in the PV trajectory. The standard algorithm becomes confused between the Global and Local Maxima points and is unable to discriminate between the two, reducing the efficiency of maximum power extraction. For PV systems, the P&O and INC maximum power point tracking approaches are often utilized. The allocated voltage is either deducted or added on a regular basis in the P&O algorithm while examining the latest power pattern value of MPP. In the INC method to MPP, we differentiate two values, power against voltage, and maintain the resulting value equal to zero. When partial shade occurs, traditional algorithms may identify just the Local Maximum Peak Power, reducing overall power. In addition, the researchers are working on the ANN and direct search algorithm fuzzy logic control [3-7]. However, these technologies are time-consuming, complicated in hardware design, and very costly. Swarm intelligence and evolutionary algorithms have been presented by researchers as naturally encouraged solutions for coping with multi-dimensional and multimodal challenges [8], [9]. The MPPT system employs genetic algorithms, however they take a long time to execute since the position of restrictions is determined through trial and error. Swarm intelligence is also employed in optimization, such as ant optimization and particle swarm optimization. ANO helps in the tracking of GMPP, however it takes a long time and is user dependant. [10],[11],[12]. This research employs the Particles Swarm Optimization approach to follow the maximum power point in order to locate GMPP while simultaneously grappling with the complex and non-linearity concerns of PV Modules. This PSO method delivers great resilience, reliability, and efficiency in achieving PV system GMP.

## 2. STAND -ALONE SOLAR POWER SYSTEM

A PV module, a dc/dc boost converter, the maximum power point tracking algorithm, and a load comprise the solar PV system. Radiation (R) strikes the PV module. It produces a voltage (V) and current (I) that is supplied into the load [3]. Because of variations in atmospheric conditions, the voltage power characteristic of a photovoltaic (PV) array is nonlinear and time changing. When the amount of solar energy and temperature change, the output power of the The PV module is also altered. To achieve optimal efficiency, the PV module must be operated at the highest point of the PV characteristic. The most severe power point is dependent on temperature and irradiance, both of which are indirect in nature. The most powerful point following control framework is used, as well as work viability on non-straight variations in factors such as temperature and radiations [4]. A MPPT is used to extract the most power from a solar PV module and transmit it to a load. A dc/dc converter (boost converter) transfers the maximum power from the solar PV module to the load. A dc/dc converter serves as a conduit between the load and the module. Figure 1 depicts a dc/dc converter with a maximum power point tracking method and a load. By varying the duty cycle, the load impedance as viewed by the source is adjusted and matched at the time of maximum power transfer with the source. As a result, MPPT procedures are required to keep the PV array running at its MPP [3]. In this research, the two most prevalent MPPT techniques (Perturb and Observe (P&O) methods and artificial neural network (ANN) approaches, as well as a dc-dc converter, will be compared.

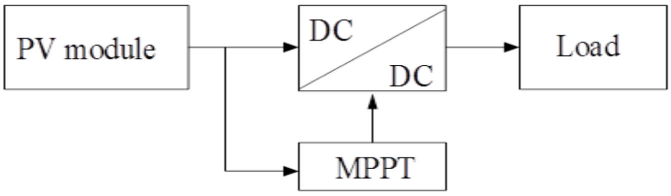


**Fig. 1 Block Diagram of PV System with MPPT**

## 3. MAXIMUM POWER POINT TRACKING

The most extreme Power Point Tracking (MPPT) device is useful in PV applications. The key factors that influence the electric power generated by a photovoltaic framework are solar radiation and temperature. The voltage at which a PV module can produce the highest power is referred to as the' most extreme power point' (pinnacle control voltage). The fundamental rule of MPPT is in charge of isolating the most possible power from the solar and feeding it to the heap via a dc to dc converter that steps up/down the voltage to the desired size [5]. There are several strategies for maximizing power in PowerPoint. Two MPPT methods are among these in this research, ANN and perturb and observe (P&O) have been chosen for comparison.

### 3.1. Meta heuristic MPPT algorithm for Partial shaded solar PV system

#### 3.1.1. Partial Shaded PV Model

The total of 60 solar PV cells is split into three models, each with 20 cells. The open circuit voltage is 12.64 volts, the voltage at maximum power is 10.32 volts, the short circuit current is 8.62 A, and the current at maximum power point is 8.07 and the maximum power point is 83.2824Watts for the 20 cell type. This three models are linked in series, and each features a bypass diode. Figure 1 depicts the simulink model of the three series-connected solar PV system.

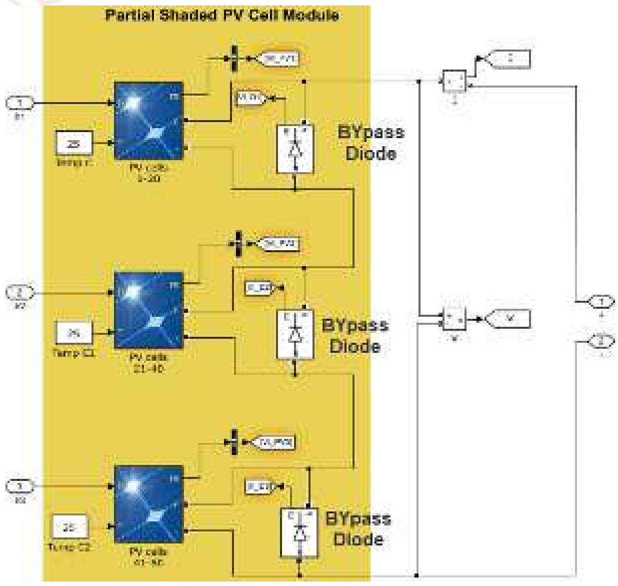


**Figure 1 Series Connected three PV model**

Figure 2 depicts the current-voltage and power-voltage characteristics of the solar PV model under normal test conditions.

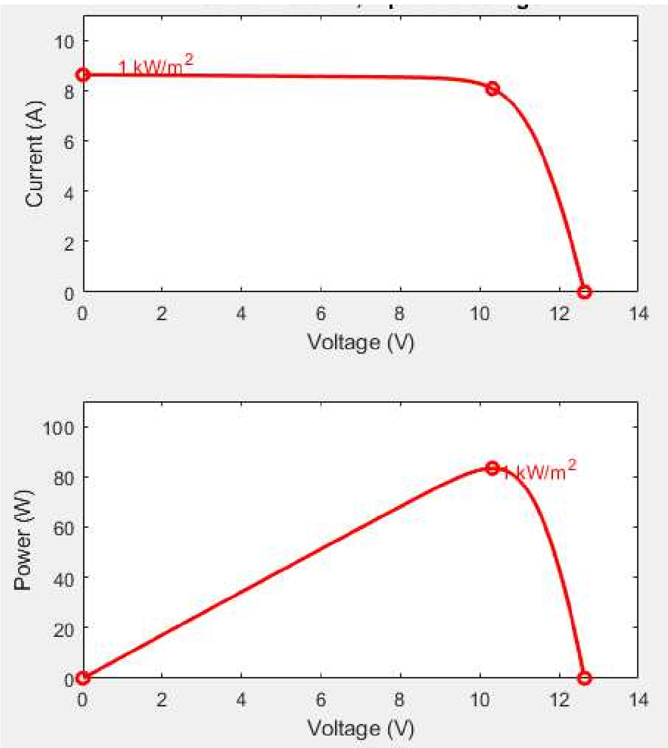


**Figure 2 I-V and P-V characteristics of single solar PV model**

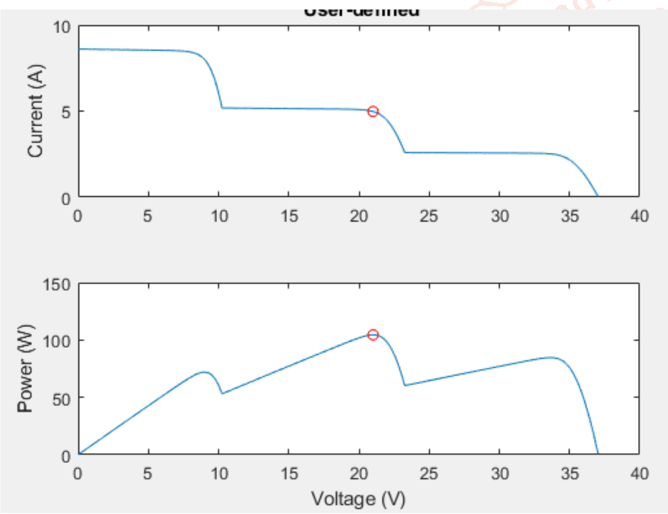


**Figure 3 I-V and P-V characteristics of partial shaded solar PV model**

The partly shadowed state of the solar PV model is achieved by setting the irradiance of each model to a different number, such as 1000 W/m2 for panel 1, 300 W/m2 for panel 2, and 600 W/m2 for panel 3. Figure 3 depicts the IV and PV characteristics of the partially shadowed situations. 104.5 Watts is the maximum power point. The maximum power point tracking method should be used to obtain this point from the solar PV panel. PSO, Cuckoo search algorithm, flower pollination algorithm, and grey wolf algorithm are used in this application. To extract the most power from the partially shaded solar PV model, a boost converter is connected between the solar PV model and the load. Figure 4 shows the boost converter simulink model.

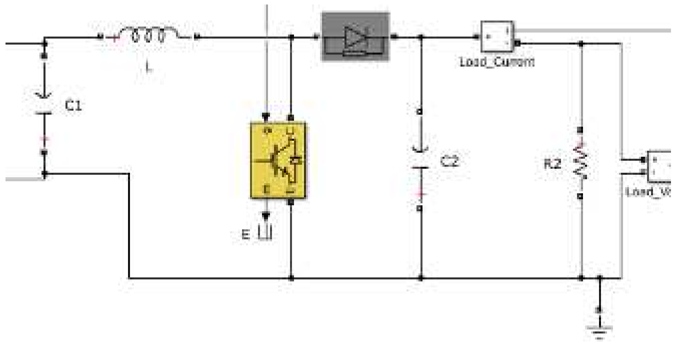


**Figure 4 Simulink model of DC-DC boost converter**

## 3.2. Particle swarm optimization

PSO, a novel swarm intelligence optimization method published by Kennedy and Eberhart in 1995 [28], has grown quickly over the last 20 years. It is patterned by the I of bird flocks. Its benefits include easy implementation and quick convergence, and it is ideally suited for determining the global optimum solution in a nonlinear, discontinuous, non-differentiable curve. This approach employs many cooperating particles in an n-dimensional space. Each particle has its own location Pi (distributed at random) and velocity Vi (Vi = 0 at the start). A particle's location is impacted by its best position so far, Pbest, as well as the best position of all particles so far, Gbest. Particle velocity and position are computed by

$$V_i^{k+1} - \omega V_i^k + C_1 r_1 (P_{besti} - p_i^k) + C_2 r_2 (G_{best} - p_i^k)$$

$$p_i^{k+1} = p_i^k + v_i^{k+1}$$

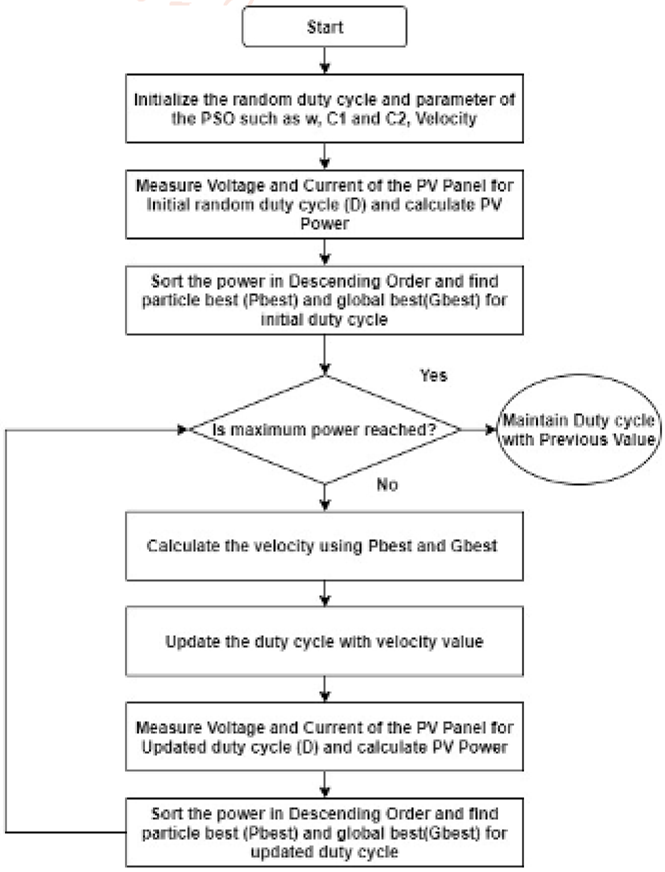


**Figure 4 PSO – Particle swarm optimization Algorithm Flow Chart**

## 4. SIMULATION AND RESULTS

This paper describes a technique for maximum power point tracking (MPPT) that uses particle swarm optimization (PSO) with variable step size to avoid steady-state oscillations. This will eliminate the effect of partial shadowing on the efficiency of photovoltaic (PV) systems. A DC-DC boost converter is used to maximize the power output of the solar panels. The examination of Maximum Power Point Tracking Algorithms follows the modeling of the Stand-Alone PV System. Maximum Power Point Tracking and PSO simulation models Algorithm are executed Version R2021A of MATLAB/Simulink The next sections exhibit the simulation results of Maximum Power Point Tracking using PSO Algorithm.

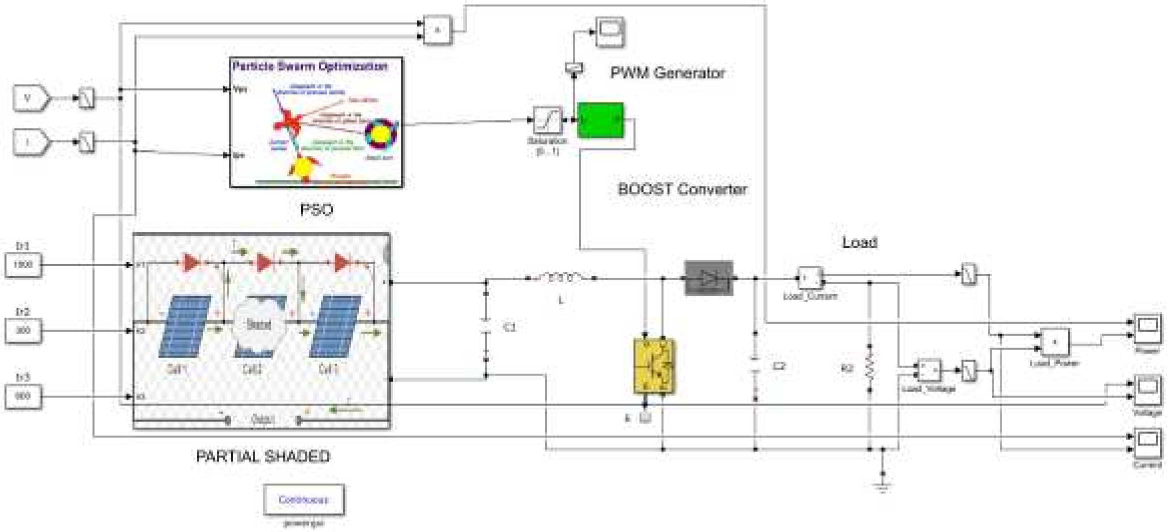


**Figure 5 Simulink Model of the MPPT_PV_SYSTEM Using PSO Algorithm**

To analyse the performance of the output voltages, the output currents and the output power are measured as shown. The PV parameters of the system are shown in Table I.

**TABLE I PV PARAMETERS**

| Parameters | Specifications |
|---|---|
| Maximum power (W) | 83.2824 W |
| Parallel strings | 1 |
| Series-connected modules per string | 1 |
| Cells per module (Ncell) | 60/3 |
| Open circuit voltage Voc (V) | 37.92*20/60 |
| Short-circuit current Isc (A) | 8.62 |
| Voltage at maximum power point Vmp (V) | 30.96*20/60 |
| Current at maximum power point Imp (A) | 8.07 |

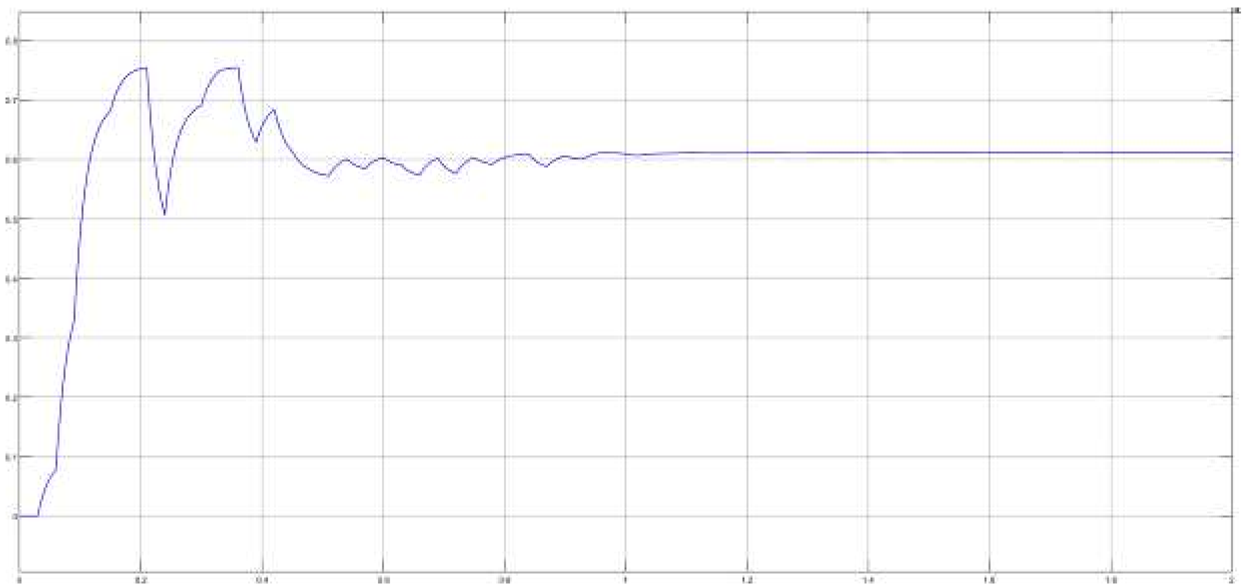

**Figure 6 PWM Pulses Vs Time in (S)**

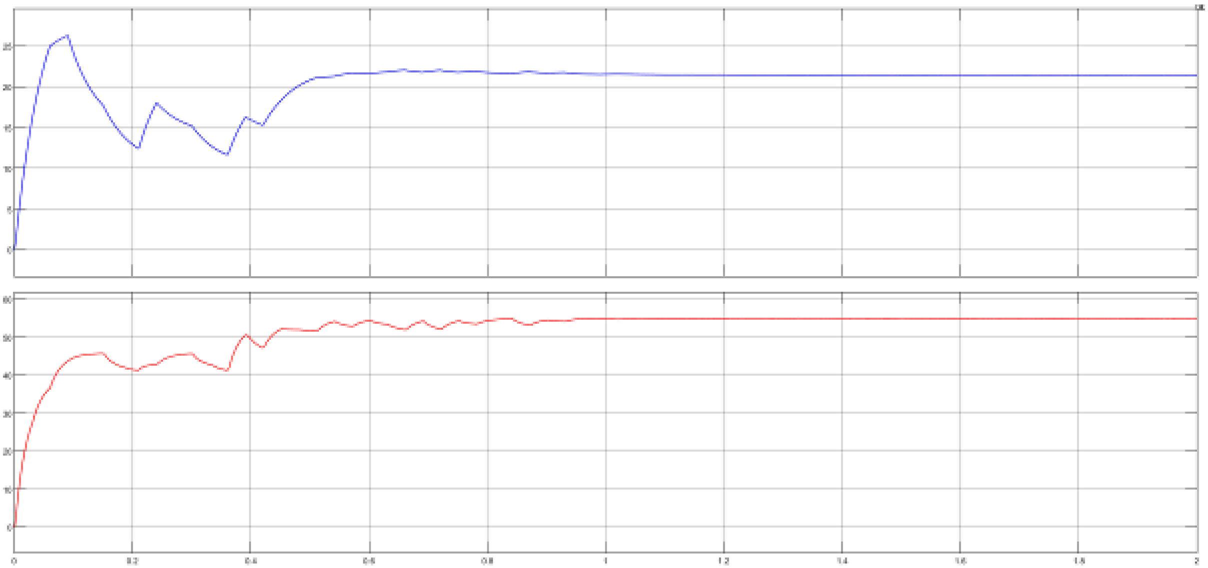

**Figure 7 Output Voltage Vs Time in (S) from Boost Converter**

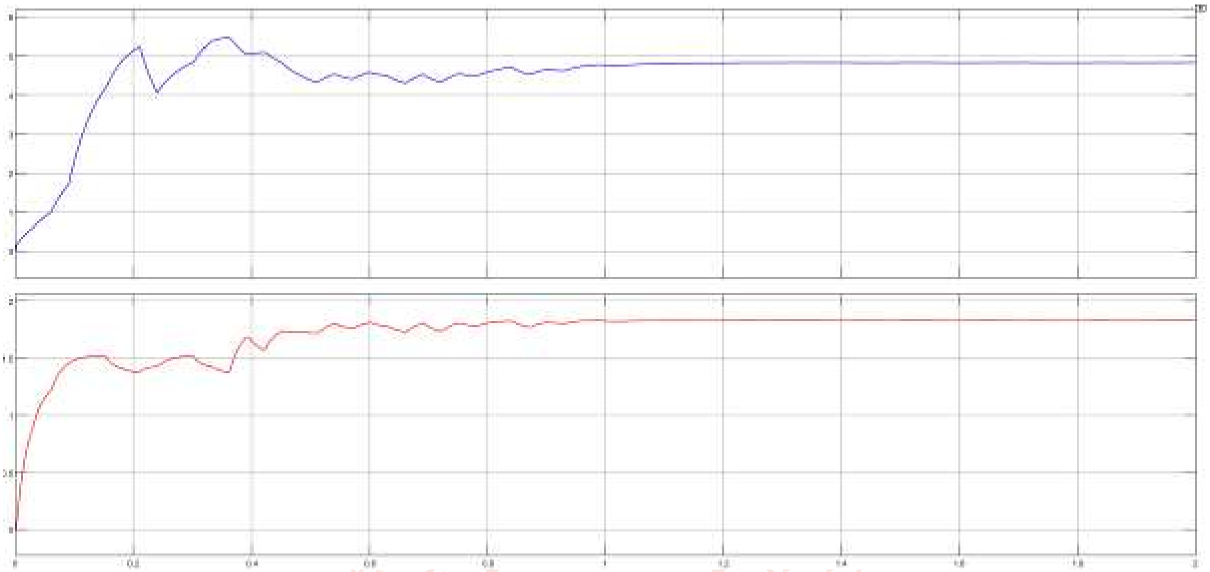

**Figure 8 Output Current Vs Time in (S) from Boost Converter**

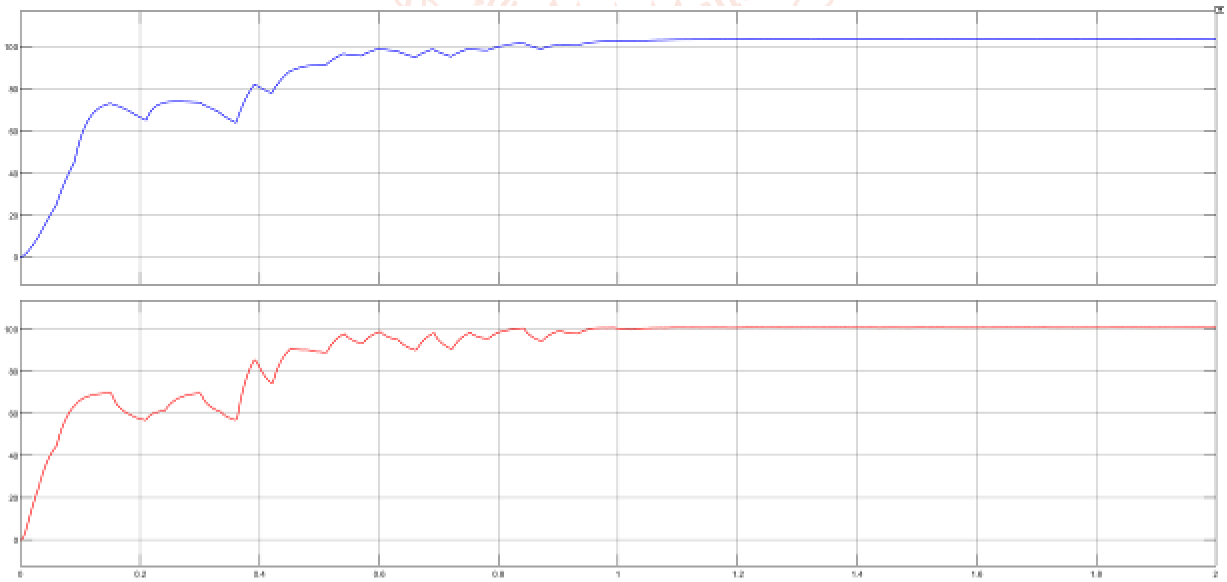

**Figure 9 Output Power Vs Time in (S) from Boost Converter**

## 5. CONCLUSION

In this study, the PV system and boost converter parameters are calculated, and MPPT tracking is achieved using the PSO Algorithm. The primary goal of this work is to offer a maximum power point tracking approach based on the PSO Algorithm for monitoring the PV system's Global Maximum Power Point. Figure.6 depicts the PWM used on the boost DC-DC converter. During the PSC condition, the suggested PSO algorithm may be correctly conducted. All other algorithms failed to create numerous peaks due to the PSC condition. differentiate between GMPP and LMPP are used to provide electricity surrounding LMPP. As a result, the PSO Algorithm is effective; it has a high convergence rate, which distinguishes it from many traditional algorithms.

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