



## A Comparative Study Between Perturb and Observe and Cuckoo Search Algorithm for Maximum Power Point Tracking

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**Abstract**—The Photovoltaic system is a sustainable renewable resource that attracts the attention of analysts in current decades. As the ambient conditions change over time as temperature and radiation rise, therefore, the productive power of the system is affected. Since the efficiency of this system is low due to these changes, and to get away from that must use a device called maximum power point tracking. maximum power point tracking is a programmable control technology used to achieve the best power harvest imaginable. This paper clarifies the improvement of one of the techniques of maximum power point tracking in PV systems under varies irradiance and temperature. The new technique consolidates the utilization of traditional perturb and observe method for maximum power point tracking during the underlying phases of tracking and afterward utilizes the cuckoo search algorithm at the final stages in order to detect the best operating duty cycle that controlled the boost converter. The integration between these two methods are appeared to yield quicker convergence to the maximum power point, which will be more efficient than the two techniques are independently utilized and that increased the performance of the system.

**Keywords**—Maximum Power Point Tracking (MPPT), Perturb and Observe (P&O), Cuckoo Search Algorithm (CSA)

## I. INTRODUCTION

Electric power is presently the foundation of modern industry and the main instrument of our modern life. Given the developing demand for power and the expanding utilization of conventional energy assets with an unfortunate effect on the environment, the industry is urging to quicken the quest for various sources of energy. From these new energies available PV energy. The PV is one of the amongst the most sustainable power sources coming. Due to the freely generated electric power which is available anywhere, and it is also environmentally friendly. As the PV equipment generates power with no any gas outflows and its operation is almost silent. In addition, they are easy to design and structure and doesn't need continually maintenance [1]. And it can be the primary wellspring of energy for the far areas from the grid and its implementation is not expensive compared to other standalone systems, while grid associated PV systems are as yet costly. Now Photovoltaic systems are

installed in all the world, and the utilize for this source is increasing each year.

Photovoltaic energy originates from changing part of sun powered radiation into electrical energy. This change relies upon the photoelectric impact. Photovoltaic modules comprise of series and parallel connections of numerous photovoltaic cells. The maximum generated power from PV is changing according to solar radiation and surrounding temperature change. Due to the high cost of PV modules and low efficiency (in the range of 10 and 23% according to its place) [2], so it is essential to have a control framework that aiding in achieve the maximum power point (MPP). This controller is called maximum power point tracking (MPPT). Traditional techniques known in literature are perturb and observe (P&O) [3], incremental conductance (IC) [4], and hill climbing (HC) [5,6]. These procedures are straight forward and simple to execute, however, they are suffered from many fluctuations at MPP, due to that; they have low performance. So, a lot of researches are accomplished to improve the execution of these strategies [7-9]. So the Artificial Intelligence (AI) strategies are utilized to improve the effectiveness of P&O MPPT methodology reviewed in [10]. Fuzzy logic control is one of the strategies that improving the execution of P&O which is presented in [11,12] and incremental conductance in [12,13].

When the solar insolation is uniform, the PV curve have an individual MPP. Besides that, when the PV receives non-uniform insolation on and the partial shading takes place, the curve will be more complicated. As the yield of the PV system suffers from many peaks, which contain only one MPP. Therefore, so far it seems that tracking this point to this case is an improvement problem. So far, much research has been made to identify MPP. In the evolutionary computing family, [14] introduces Genetic algorithms (GA) and [15] presents Differential Evolution (DE). PSO is favored for MPPT as it is

straightforward and portrayed by its quick calculation capacity [16]. The PSO strategy diminishes oscillations state and needs less memory or calculations. What's more, this technique can reach to MPP quickly. but, due to the variation of time, the MPP is changing, so the duty cycle must be in continuity change, so the initialization of it is tedious in MPPT process [17]. The improved PSO (IPSO) strategy has been associated with MPPT in PV arrays that are associated with the grid by using the power electronics. The improved system has high speed rate in achieving the greatest power compared to the conventional PSO; so it decreases the losses in energy during the MPPT procedure, and improves the output proficiency [18]. In [19], the IPSO is presented as the main controller that controls the power of the sources that depending on IC control.

Concerning the rapid technique using cuckoo search algorithm (CSA) for PV MPPT, it is presented in [20]. This procedure has the ability of seeking under the conditions of partial shading. This methodology is characterized by a minimum of temporary fluctuations and fewer errors occurring in a steady state unlike PO and PSO techniques. CSA method is more powerful, as it has better convergence and shows higher proficiency [21]. In [22], the CSA is presented; it is exceptionally effective, as it reaches zero oscillation at the steady state; and therefore, it saves a lot of power. Moreover, this method can follow the MPP effectively when the ecological conditions is rapidly changed.

The remains of this paper is arranged as follows: part 2, speaks about the modelling of PV cell. Part 3, describes in detail the MPPT methodologies used. In last section, a simulation of the MPPT is accomplished by utilizing Matlab/Simulink so as to check the validity of the created MPPT controllers. Thereafter, a comparative study and analytical one is done showing the software/hardware requirements.

## II. MODELING OF SOLAR PV

The equivalent circuitry of a PV cell is appeared in Fig. 1, in which the modest model can be represented by a current source connected parallel with  $SDM$  and the non-idealities are represented by series ( $R_s$ ) and parallel ( $R_p$ ) resistors. The mathematical equation of the yield current of a single PV model can be written as the following: [8]

$$I = I_{ph} - I_r \left[ e^{\frac{q(V+IR_s)}{\eta kT}} - 1 \right] - \frac{V + IR_s}{R_p} \quad (1)$$

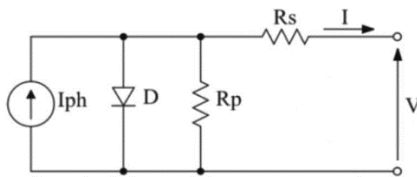


Fig. 1. Equivalent circuit for single diode ( $SDM$ ) model of PV cell

where  $V$  represents the yield voltage of one PV panel,  $I_{ph}$  is the photocurrent,  $I_r$  is the saturation current,  $q$  is the electrical charge ( $1.6 \times 10^{-19} C$ ),  $\eta$  is the  $p - n$  junction quality factor,  $k$  is the Boltzmann constant ( $1.38 \times 10^{-23} J/K$ ), and  $T$  is the temperature (in kelvins  $^{\circ}K$ ).

### A. Requirement for MPPT

So as to feature the significance of the MPPT technique, the  $I - V$  and  $P - V$  attributes of the kotak PV panel are appeared in Fig. 2. It ought to be noted here that there is a singular working point called MPP in both the  $I - V$  and  $P - V$  curves for every radiation and temperature. MPP therefore continues to relocate for any change in weather conditions. Since the cost of each watt of PV and the cost of creating it is higher, the PV system needs to work in MPP. Therefore, MPPT controllers are expected to maintain MPP follow-up and form an essential part of the system. An ideal way to achieve an MPPT controller is to use a Power Electronic (PE) interface between PV and load. The presence of the controller successfully adjusts the obstacle that the system sees, and thus forces the system to work near the MPP [23]. It is suggested that the active MPPT controllers modify the load operating point associated with the duty ratio change DC. To exhibit the limit of MPPT controller both the load line qualities and  $I - V$  curves are plotted in Fig. 3. Assuming that the PV module is connected to a resistive load, the load action point on the  $I - V$  curve is only the intersection of the slope of the load line ( $1 / R$ ) with the  $I - V$  curve.

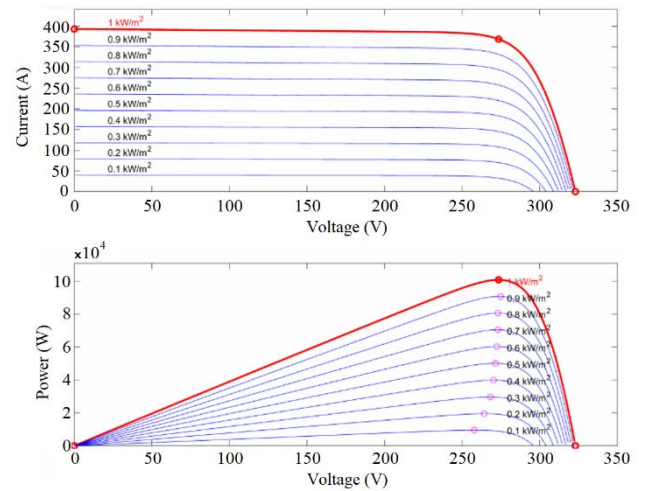


Fig. 2 I-V and P-V characteristic of the PV at varies radiations

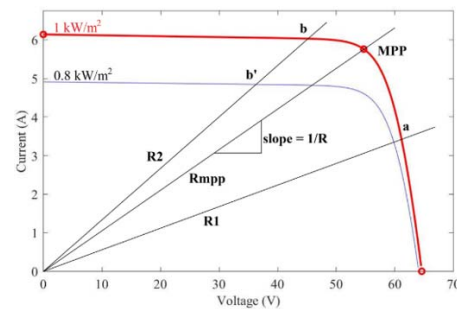


Fig. 3. I-V characteristics of a PV module at different loads  $R_1 > R_{MPP} > R_2$

### III. MPPT ALGORITHMS

#### A. Perturb and Observe method:

P&O strategy is a standout amongst the most regularly utilized techniques practically speaking and scholastically [3]. This strategy relies upon the procedure of experimentation in finding the MPP. At each cycle, the controller estimates the current and the voltage of PV and concludes its actual power; then annoys the operating point by swaying around it. if the power increases, the subsequent stage of the operating voltage shall be in the same direction. And, if the power decays, the operating voltage perturbs in the opposite direction. These steps are repeated until the system achieves the MPP. That MPP is accomplished when  $dP/dV = 0$ . The steps until the system achieves the MPP outlined in Fig. 4.

#### B. Cuckoo Search Algorithm

Cuckoo Search is an optimization technique inspired by the parasite spread of cuckoo birds [21].

The overall flowchart of CSA MPPT is appeared in Fig. 5. By utilizing the present measured values of V and I, the power can be determined. The new values of  $V^{t+1}$  and power are stored in the voltage  $V_{it}$  and fitness  $J_{it}$  arrays, respectively.

samples converge with the MPP, they will merge as a same value, and therefore, will perform the respective power [20].

#### C. Combined system between P&O and CSA

##### P&O method:

1. Set an initial duty cycle to P&O strategy.
2. Disturb the operating voltage by adjusting the duty ratio of the DC converter. If the power is increased, change the duty ratio in the same way; otherwise, continue in the opposite direction.
3. Duplicate the above step until MPP is attained, at this moment, the system is generating the  $d_{optimum}$ .
4. Optimize the PV production power at each time, and if the adjustment in the production power in subsequent samples of PV production power is more than 1% of the estimated PV power re-start the calculation.

##### CSA method:

1. Set the number of particles with fixed positions to be function in  $d_{optimum}$ .
2. Actuate the DC converter utilizing advanced controller relating to the situation of each particle and count its fitness value (power) after the allowable the settling time of the converter.

In each iteration, an examination is required to determine whether the samples have already achieved convergence. If the position with most noteworthy fitness value found by particles ( $i$  and  $j$ ) is known as its own best voltage ( $V_{best}$ )

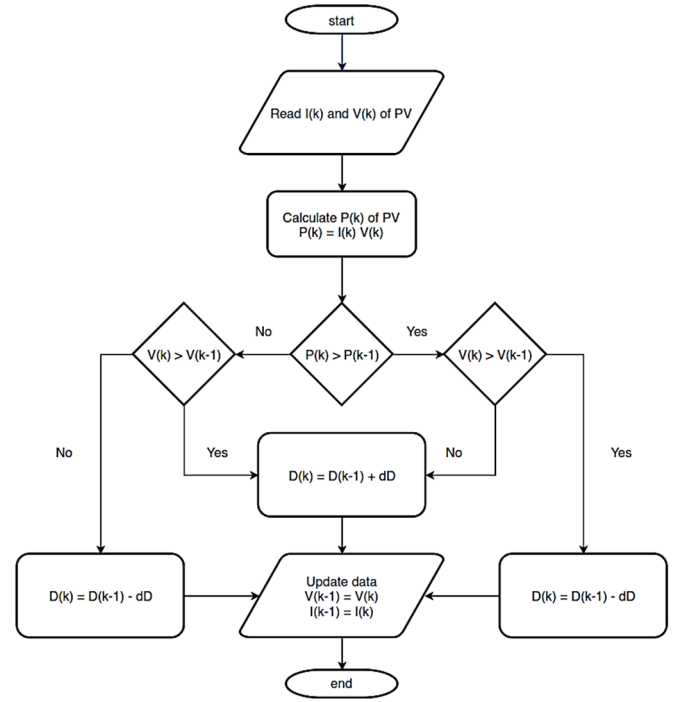


Fig. 4. Flowchart of P&O method

or best power ( $P_{best}$ ). Each time compare the fitness value of particles ( $i$  and  $j$ ) with both ( $V_{best}$ ) and ( $P_{best}$ ). If the present position has higher fitness values, supplant the ( $V_{best}$ ) and ( $P_{best}$ ) with its present position.

3. The position of particles with highest values is occurred at the overall optimal duty cycle ( $d_{overall}$ ).
4. Finally, Fed the ( $d_{overall}$ ) to the DC-DC converter.

The flowchart in Fig. 6, shows the operation of the paper's method.

### IV. SIMULATION RESULTS:

#### A. Results of MPPT based on P&O method:

The output waveforms, shown in Fig. 7 and Fig. 8, indicate the yield power of PV, and output power to the grid via time, due to sudden changes in irradiance at temperature 25 and 50 degrees Celsius respectively.

Fig. 7, shows the output power of the PV due to the change in irradiance at 25 degrees Celsius; as the yield PV power reaches 604.9 kW and the yield power of the grid reaches 592.6 kW for 1000 W/m<sup>2</sup>, and 239.23 kW for the PV output power and 236.25 kW at 400 W/m<sup>2</sup> at the steady state conditions. Meanwhile, it also shows the high overshooting in the output PV power that reaches 0% and for the grid it reaches 0.31792% at standard temperature.

Fig. 8, includes the output power of the PV due to the change in irradiance at 50 degrees Celsius; as the yield PV power reaches 558.83 kW and the yield power of the grid reaches 547.5 kW at 1000 W/m<sup>2</sup> and, 220 kW for the PV output power and 217.18 kW at 400 W/m<sup>2</sup> at the steady state conditions. Also it shows the high overshooting in the output PV power that reaches 7.36717% and for the grid it reaches 0.2009%.

**B. Results of MPPT based on CSA method:**

The output waveforms, that shown in Fig. 9 and Fig. 10, show the yield power of PV, and output power to the grid via time, due to sudden changes in irradiance at temperature 25 and 50 degrees Celsius respectively.

Fig. 9, Indicates the output of PV power due to the change in irradiance at 25 degrees Celsius; as the yield PV power reaches 604.8878 kW and the yield power of the grid reaches 587.5614 kW for 1000 W/m<sup>2</sup>, and 239.0944 kW for the PV output power and 234.4742 kW at 400 W/m<sup>2</sup> at the steady state conditions. Meanwhile, it also shows the high overshooting in the output PV power that reaches 0% and for the grid it reaches 4.50518% at standard temperature.

Fig. 10, includes the output power of the PV due to the change in irradiance at 50 degrees Celsius; as the yield PV power reaches 558.7856 kW and the yield power of the grid reaches 542.3794 kW at 1000 W/m<sup>2</sup> and, 219.7434 kW for the PV output power and 215.2803 kW at 400 W/m<sup>2</sup> at the steady state conditions. Also it shows the high overshooting in the output PV power that reaches 7.375709% and for the grid it reaches 6.2647%.

**C. Results of MPPT based on purpose method:**

The output waveforms, shown in Fig. 11 and Fig. 12, indicate the yield power of PV, and output power to the grid via time, due to sudden changes in irradiance at temperature 25 and 50 degrees Celsius respectively.

Fig. 11, includes the output power of the PV due to the change in irradiance at 25 degrees Celsius; as the yield PV power reaches 604.3476 kW and the yield power of the grid reaches 587.3995 kW for 1000 W/m<sup>2</sup>, and 239.0093 kW for the PV output power and 234.4728 kW at 400 W/m<sup>2</sup> at the steady state conditions. Meanwhile, it also shows the high overshooting in the output PV power that reaches 0% and for the grid it reaches 2.754599% at standard temperature.

Fig. 12, includes the output power of the PV due to the change in irradiance at 50 degrees Celsius; as the yield PV power reaches 552.1898 kW and the yield power of the grid reaches 536.517 kW at 1000 W/m<sup>2</sup> and, 214.3817 kW for the PV output power and 210.137 kW at 400 W/m<sup>2</sup> at the steady state conditions. Also it shows the high overshooting in the output PV power that reaches 8.65829% and for the grid it reaches 6.77984%.

Table I. shows the output power generated from the PV for each case, the grid-fed production power, and exceeding the maximum PV and grid power generation.

**V. CONCLUSION**

The MPPT plan for the PV system under different radiation conditions and temperatures was proposed and discussed. The new methodology includes consecutive integration of existing CSA and P&O techniques. The

global search capability of Cuckoo research is combined with the actual convergence of P&O method, when initiated appropriately, thus developing a more encouraging strategy.

The proposed technique was verified by Matlab / Simulink simulation. Results show great performance with improved MPP convergence and improved temporary response.

It ends up being obvious that the above results exhibit the veracity of the proposed system as it has high efficiency at all abrupt changes of irradiance contrasted and various methods as showed up in table 1, beside its speed in the tracking of the MPP; as it reaches the steady state by a very high speed with no unsettling influence or oscillations.

As observed from the above results, the overshoot because of the sudden irradiance changes has been limited for the above strategies; and for that, it needn't high power electronics components. Besides that, the rising time has been impressively diminished, as the system can accomplish 0.9 from the most extreme estimation of the steady state in under 73.1 msec. compared with other strategies with no oscillations in its yield.

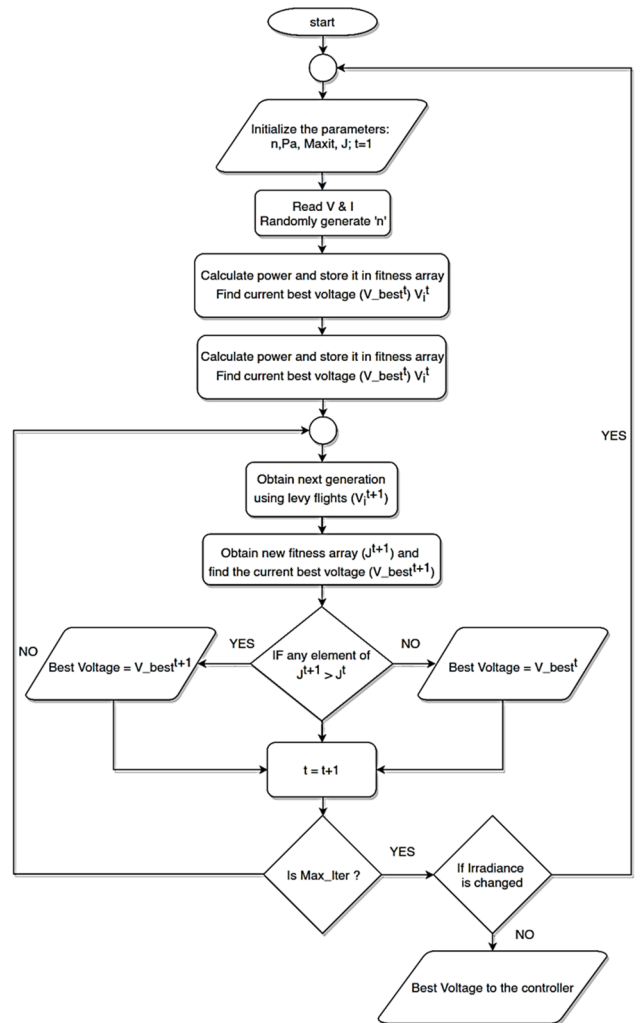


Fig. 5. Flowchart of CSA

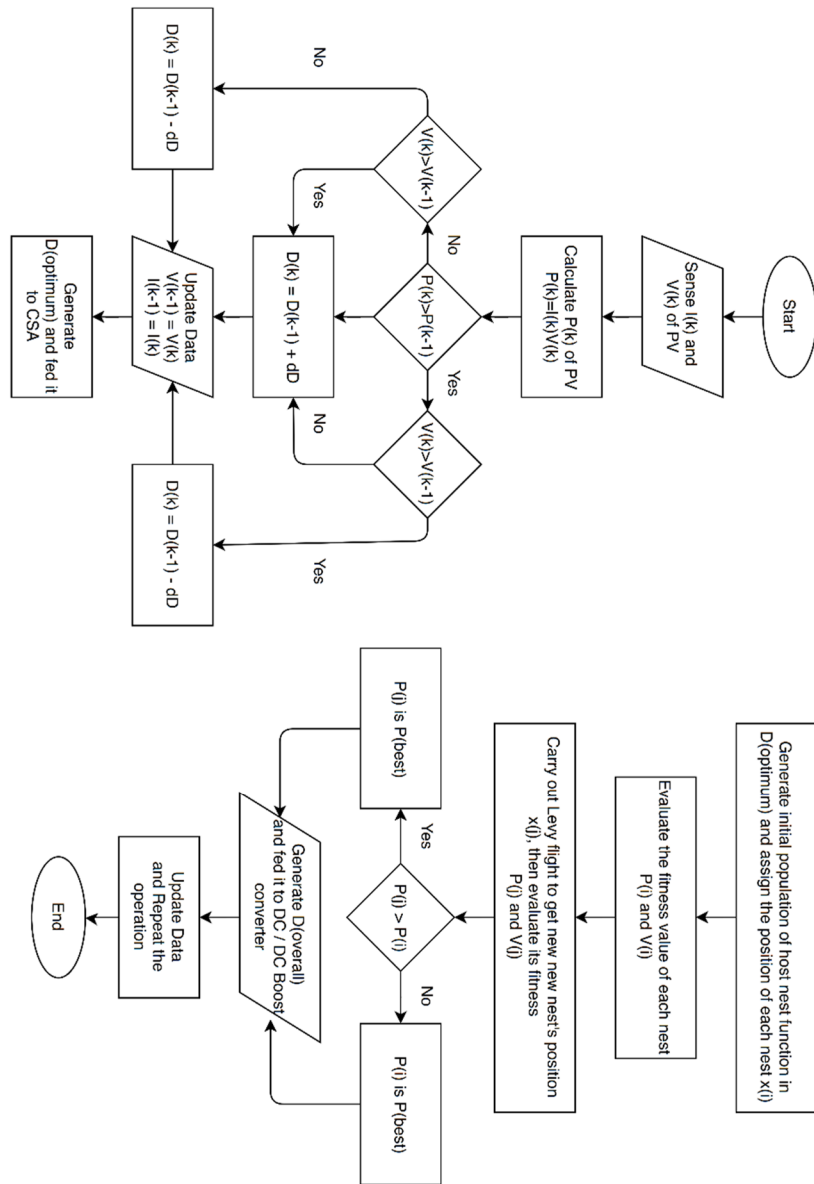


Fig. 6. Flowchart of the purpose method

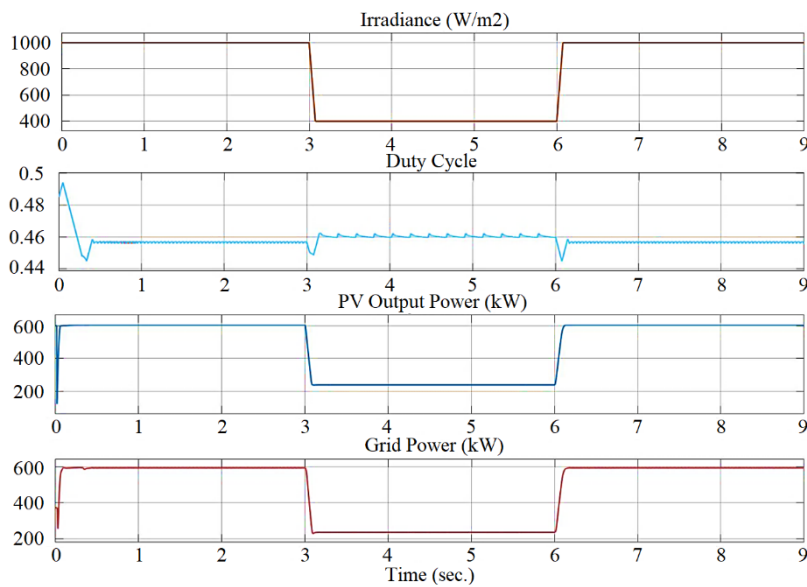


Fig. 7. PV output power and Grid power at varies irradiance and 25 degrees Celsius for P&O MPPT

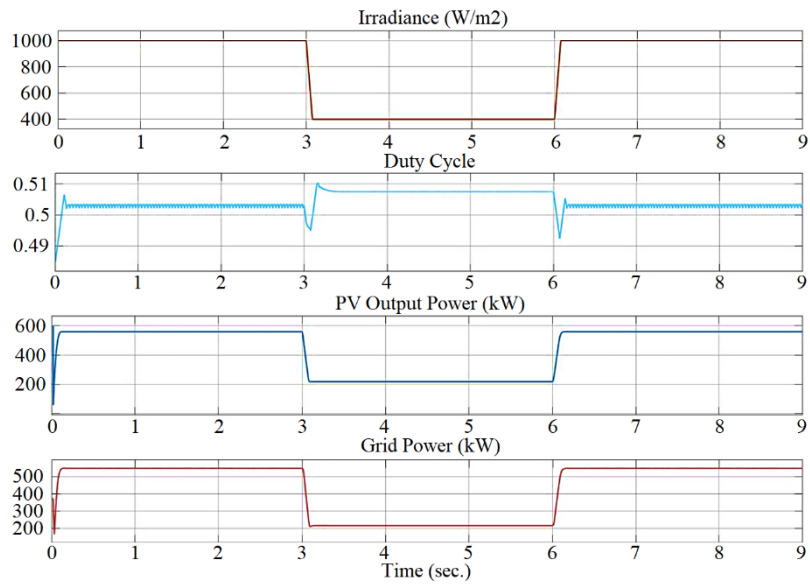


Fig. 8. PV output power and Grid power at varies irradiance and 50 degrees Celsius for P&O MPPT

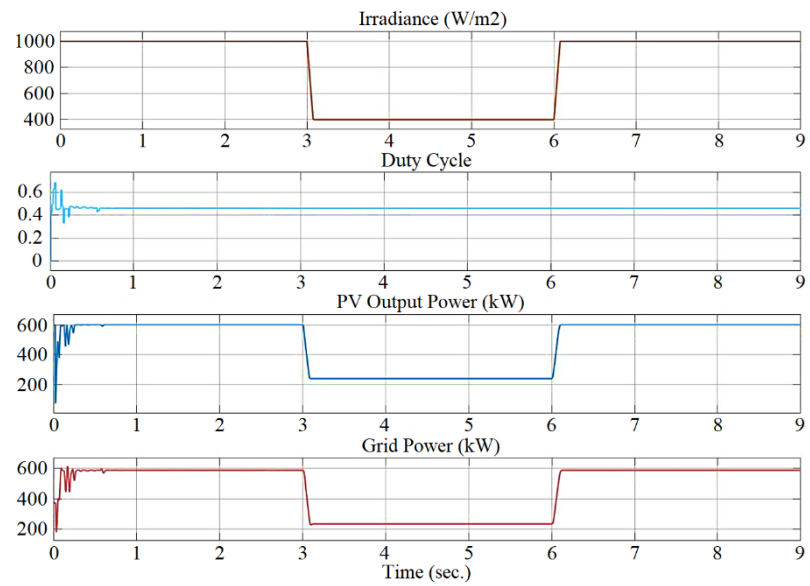


Fig. 9. PV output power and Grid power at varies irradiance and 25 degrees Celsius for CSA MPPT

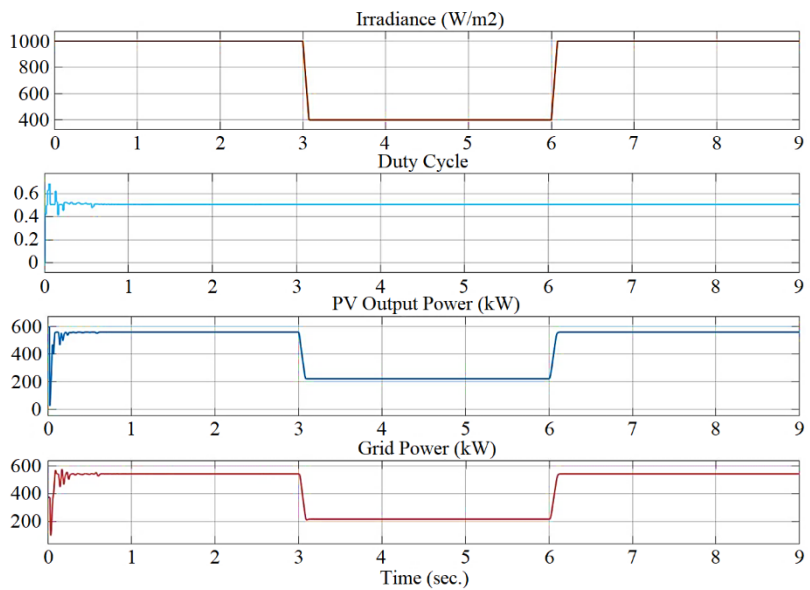


Fig. 10. PV output power and Grid power at varies irradiance and 50 degrees Celsius for CSA MPPT

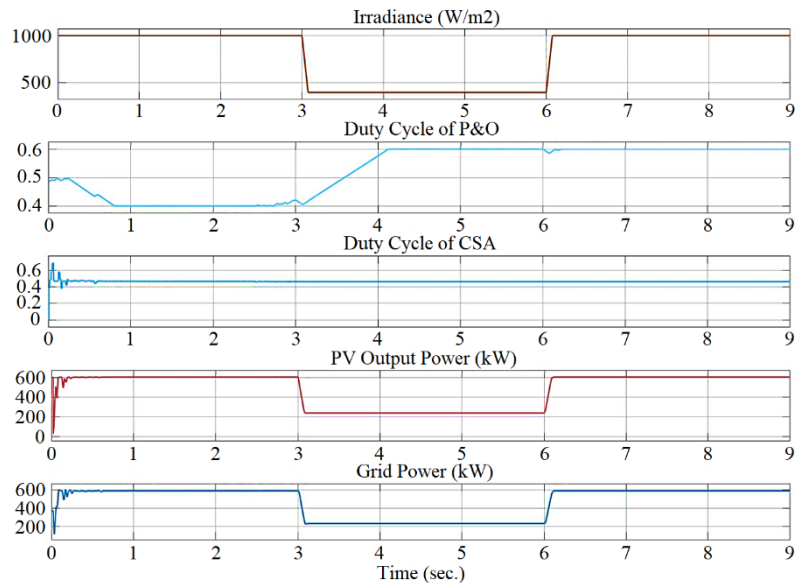


Fig. 11. PV output power and Grid power at varies irradiance and 25 degrees Celsius for purpose MPPT

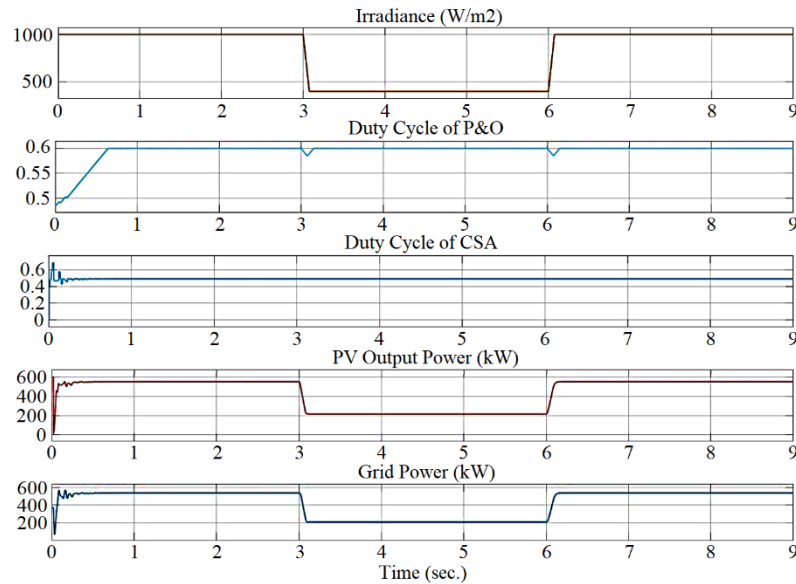


Fig. 12. PV output power and Grid power at varies irradiance and 50 degrees Celsius for purpose MPPT

TABLE I. THE OUTPUT POWER AND THE MAXIMUM OVERSHOOT DUE TO MPPT AT DIFFERENT IRRADIANCE AND TEMPERATURE

MPPT Method	Irradiance (W/m <sup>2</sup> )	Reference Power (kW)	Temp. (°C)	Output Power of PV (kW)	Output Power on Grid (kW)	Maximum overshoot in Power	
						PV (kW)	Grid (kW)
P&O	1000	600	25	604.9	592.6	604.9	594.484
	400	240		239.23	236.25		
	1000	560	50	558.83	547.5	600	548.6
	400	220		220	217.18		
CSA	1000	600	25	604.8878	587.5614	604.8878	614.0321
	400	240		239.0944	234.4742		
	1000	560	50	558.7856	542.3794	600	576.3581
	400	220		219.7434	215.2803		
P&O with CSA	1000	600	25	604.3476	587.3995	604.3476	603.58
	400	240		239.0093	234.4728		
	1000	560	50	552.1898	536.517	600	572.892
	400	220		214.3817	210.137		

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