Design and analysis of MPPT for PV system by perturb and observe algorithm

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Abstract. The biggest issue facing the solar system is maximizing the power production of photovoltaic (PV) panels under variable sun radiation and temperature conditions. Maximum power point tracking, or MPPT, is essential to solar systems because it maximizes the power output under particular circumstances, reducing system costs and improving array efficiency. Because the peak power point (MPP) varies with irradiation and cell temperature, suitable techniques must be utilized to track the MPP and sustain system operation in it. The acquired results demonstrate that, in the presence of oscillation, the P & O performance near MPP under constant test circumstances (STC) is superior to that under variable settings. Using MATLAB/Simulink, the way they perform is assessed and compared via digital simulation and theoretical analysis depending on reaction time and effectiveness in diverse temperature and irradiance conditions.

1 Introduction

Finding clean, renewable energy sources such as wind, geothermal, hydro, solar and bioenergy has become more important as concerns about the environment and energy consumption grow, and as global awareness of climate change increases. One such energy resource is photovoltaic energy, which has grown in importance due to its clean, scalable power and low maintenance requirements. Solar radiation is directly converted into electricity using a photovoltaic (PV) system.

Temperature, solar radiation and voltage generated by the PV module affect the amount of energy received. Small loads can be directly powered by the voltage and current that the photovoltaic device has at its terminals.

On the IV curve characteristics, each PV system shows the point of maximum generated power. The maximum power point (MPP) is located at this location. The maximum power point tracking (MPPT) system samples the cell output in order to produce maximum power under any given set of environmental variables, from clear skies to heavy clouds, from rain to fog, and even fog. and applies the proper weight.

Changes in temperature and light in the weather affect the efficiency of the photovoltaic system and change its power output. Monitoring this point is important to get the most out of your PV systems.

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Solar inverters use MPPT algorithms to optimize the power produced by photovoltaic systems. To ensure that the system operates at the maximum power point, or peak of the power voltage curve, algorithms adjust the voltage. There are various methods for monitoring the maximum power point. These include neural networks, voltage during a fractional short circuit, partial current flowing across a circuit, increasing conductance method, and perturbation and observation.

Creating a maximum power point tracker (MPPT) to continuously determine and store the maximum amount of energy from a solar panel is the aim of this effort.. To optimize the power output of a solar PV system, this chapter focuses on maximum power point tracking modeling using a perturb and observe approach.

MATLAB/Simulink software will be employed to model PV systems that have a boost converter coupled to MPPT. as well as PV systems without MPPT. Analytical comparisons will be made in both systems at different solar irradiance levels and temperatures.

2 Modeling of photovoltaic systems

Modeling accuracy is significantly impacted by modeling of PV modules. Photovoltaic modeling involves the evaluation of voltage-power (P-V) and voltage-current (I-V) characteristic curves to simulate a real module under different weather scenarios. The single diode D model's mathematical formulas are displayed in Figure 1. were used to model the photovoltaic module.

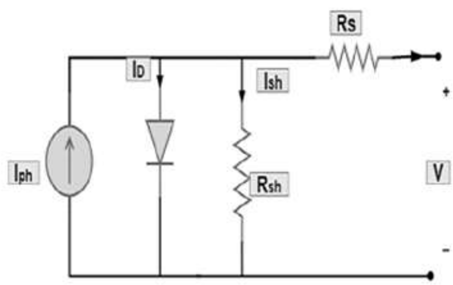

Fig. 1. Simulation of a solar cell with one diode.

3 Mathematical equations for solar batteries

The net output current of the PV module is given by equation (1)

$$I=I_{Ph}-I_D\ [\ \exp(q\times V+I\times R_s/N.K.N_sT)-1\ ]\text{-}V+IR_s/Rsh \quad (1)$$

This illustrates how the module's voltage and current are related. The equations provide the photogenerated current and diode saturation current.. (2), (3) and (4).

$$Iph = [Iscr + Ki(T - Tr)]G / 1000 \quad (2)$$

$$IS = Irs * (T/Tr)3 \exp[qEg/ak(1/Tr - 1/T)] \quad (3)$$

$$I\ rs = Iscr/\exp\ (qVoc\ /nskAT)-1 \quad (4)$$

where T is the actual temperature, n is the diode's ideality constant, k is the Boltzmann constant, q is the electron charge, Iph is the photocurrent, ID is the diode current, and IS is the reverse saturation current. , Rsh - shunt resistance, RS - series resistance, Iph -

photocurrent at rated state, Tn - normal temperature, G - actual irradiation, Gn - rated irradiation, Iscr - rated short circuit current, Vo - rated open circuit voltage, Eg - energy bandgap, Isn - rated saturation current.

Table 2. Sun power spr-415E PV array PV module parameters under standard test conditions (STC).

Sun power spr-415E	PV array
Maximum power (Pmax)	414.8
The voltage at maximum power (Vmp)	72.9
Current at maximum power (Imp)	5.69
Open-circuit voltage (Voc)	35.3
Short-circuit current (Isc)	6.09
Panel efficiency	16.5%
Power tolerance (positive)	+5%

4 Algorithm for perturbation and observation (P&O)

The process known as The Perturb and Observe (P&O) algorithm modifies one variable while keeping track of how that change affects other variables. This technique throws off the solar module or array's voltage. The PV module's voltage is adjusted to ascertain if the power is rising or falling.

The PV module's operational point is located to the left of the MPP., where increasing voltage results in increasing power.

Figure 2 displays the block diagram of the charge controller's chosen P&O algorithm. The MPPT charge controller measures the voltage between the PV module and the load when it is attached. It compares the two voltages after determining the load voltage. After measuring the voltage and current, MATLAB will compute the current output power Pnew and compare it to the power Pold that was previously measured. To extract the most power from the PV panel, the pulse width modulation The duty cycle of PWM is increased if Pnew is greater than Pold. The duty cycle is lowered to enable the system to restore to its prior maximum power if Pnew is smaller than Pold.

The DC/DC converter receives a constant supply of the solar panel's output voltage and current. Vpv may vary around the ideal Vpv value as MPP approaches, and MPP is dependent on the step size. As the disturbance step rises, these oscillations cause the relay's generated power to diminish. It should be mentioned that the MPPT algorithm responds swiftly to abrupt changes in the environment if the step size is large. However, if the step size is tiny, the algorithm becomes comparatively slow and is unable to react fast enough to changes in light or temperature.

MPPT modeling using P&O involves a number of successive processes. The MATLAB software is used to write the code. Figure 2 illustrates the stages involved in implementation. Using current and voltage readings, the system first determines the input parameters of the PV system's P&O algorithm. The photovoltaic system's input parameters, VA and IA, are specified in the code. Simulink, where the whole PV system is designed, initializes VA and IA. The input power is determined by multiplying VA and IA by the algorithm. To capture the prior, the constant variables VAprev, PAprev, and Dprev are constructed. voltage, previous duty cycle, and previous power as specified in the code.

Figure 3 shows a photovoltaic system operating at 1000 W/m2 at 25°C with a maximum power point tracker on STC.

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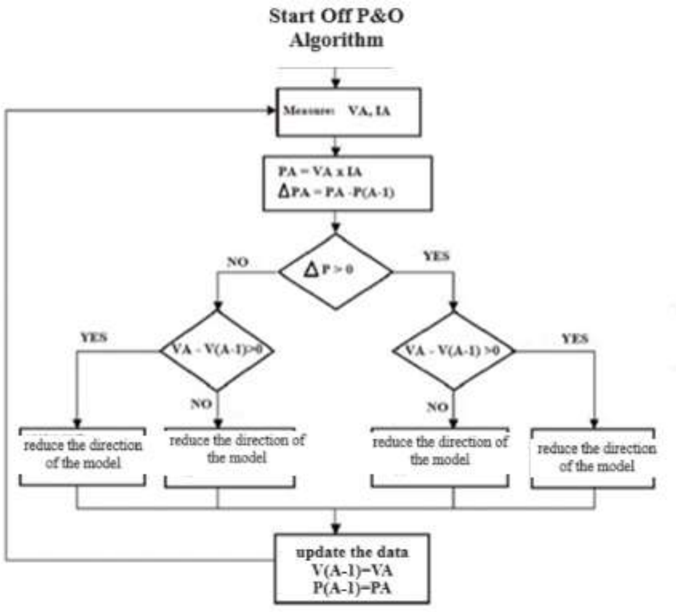

Fig. 2. P&O algorithm flowchart.

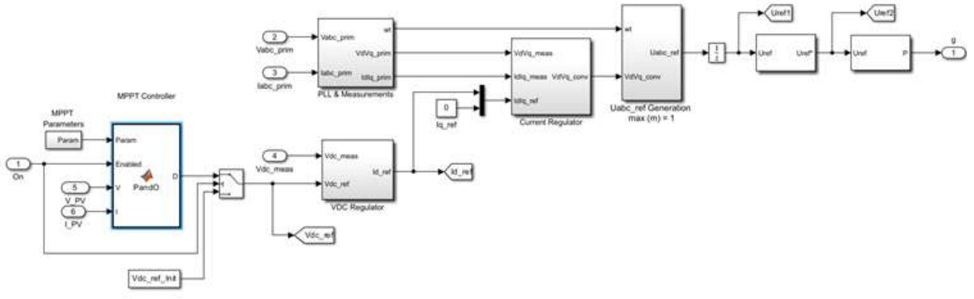

Fig. 3. Photovoltaic system with maximum power sensor at STC, 1000 W/m2 at 25°C.

MPPT modeling using P&O involves a number of successive processes. MATLAB software is used in the writing of the code. Below is the P&O controller code

5 Results obtained

Using MATLAB/Simulink, two scenarios of numerical simulation and theoretical analysis are used to compare and assess the P&O method's performance.

A DC-DC boost converter connects the solar module to the load. Standard test circumstances are used to simulate a PV system with a maximum power point tracker using the perturbation and observation algorithm, as well as a PV system without one.

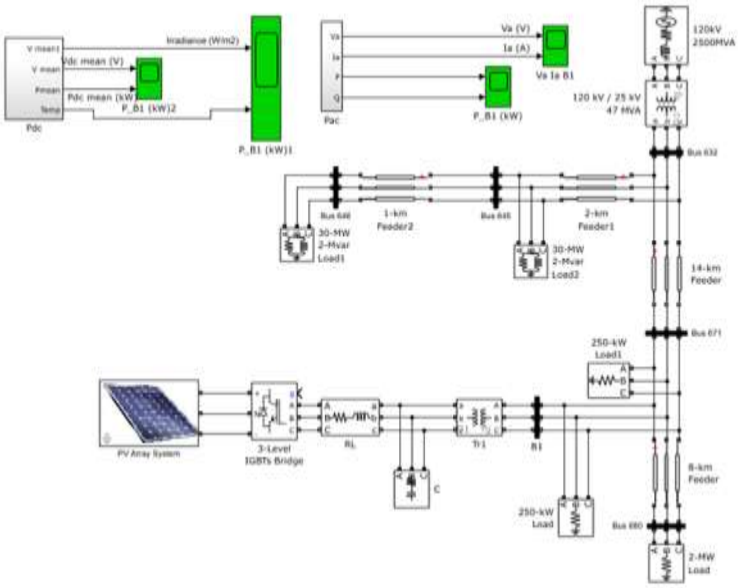

Fig. 4. Complete system designed in Simulink before configuring the p&o controller.

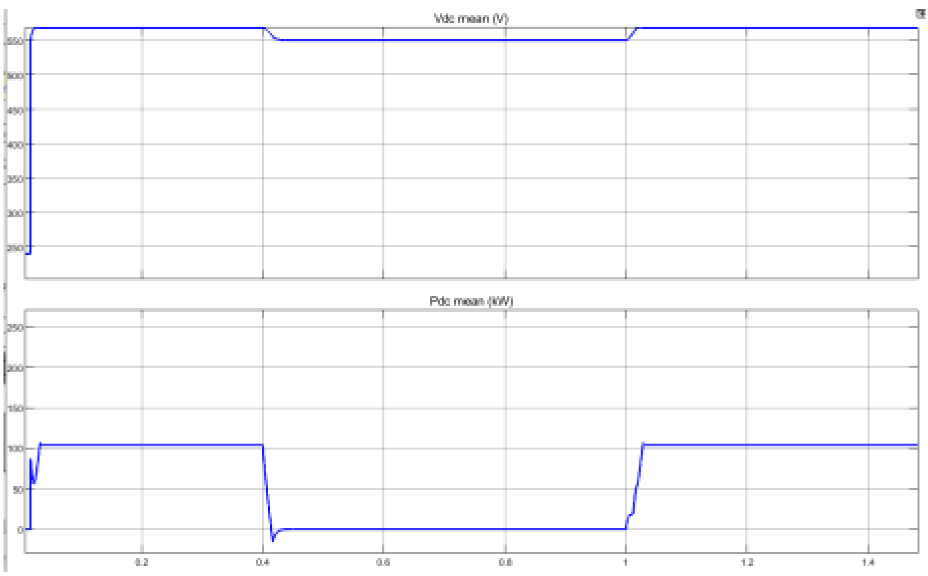

Fig. 5. Voltage and power before setting up the p&o controller.

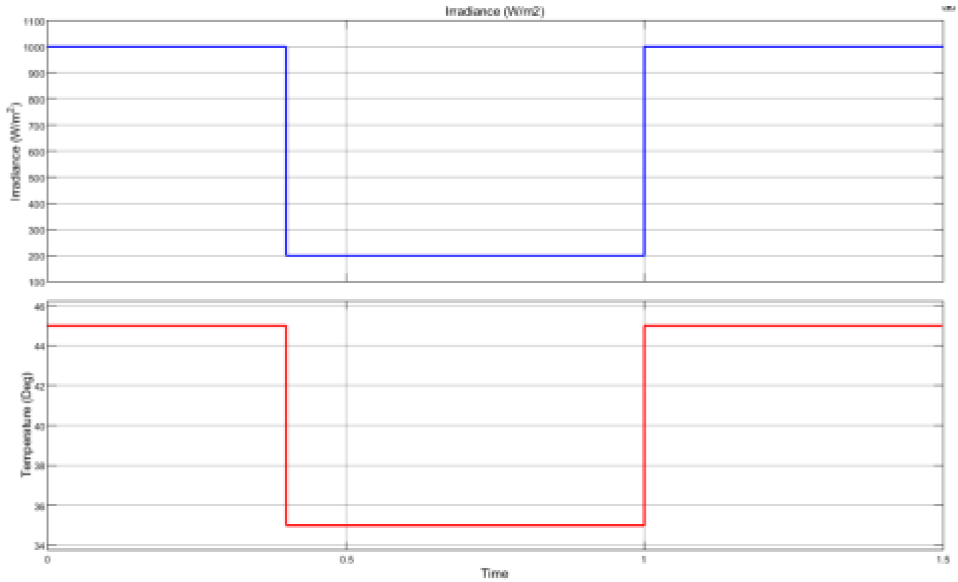

Fig. 6. Radiation and temperature changes before setting up the p&o controller.

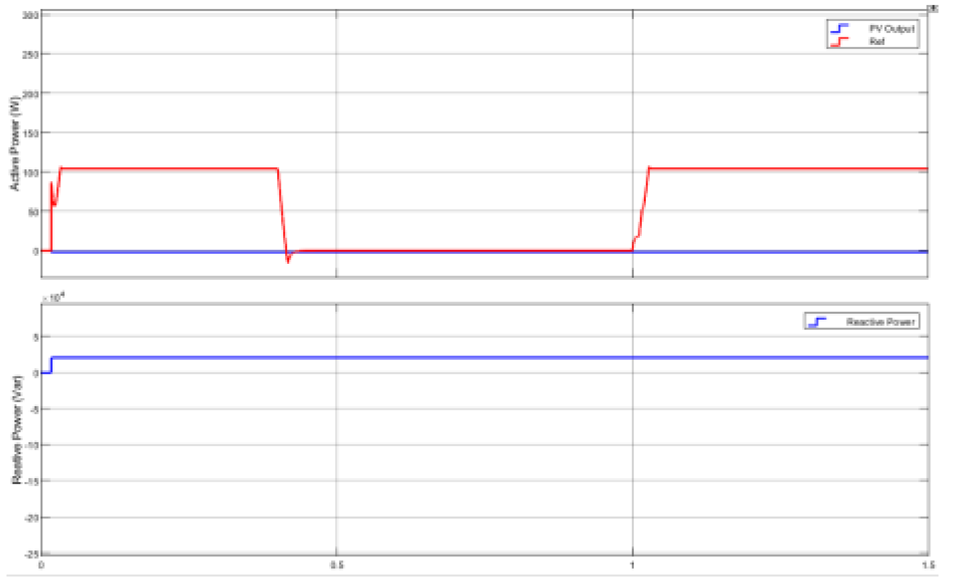

Fig. 7. Active power and reactive power before setting up the p&o controller.

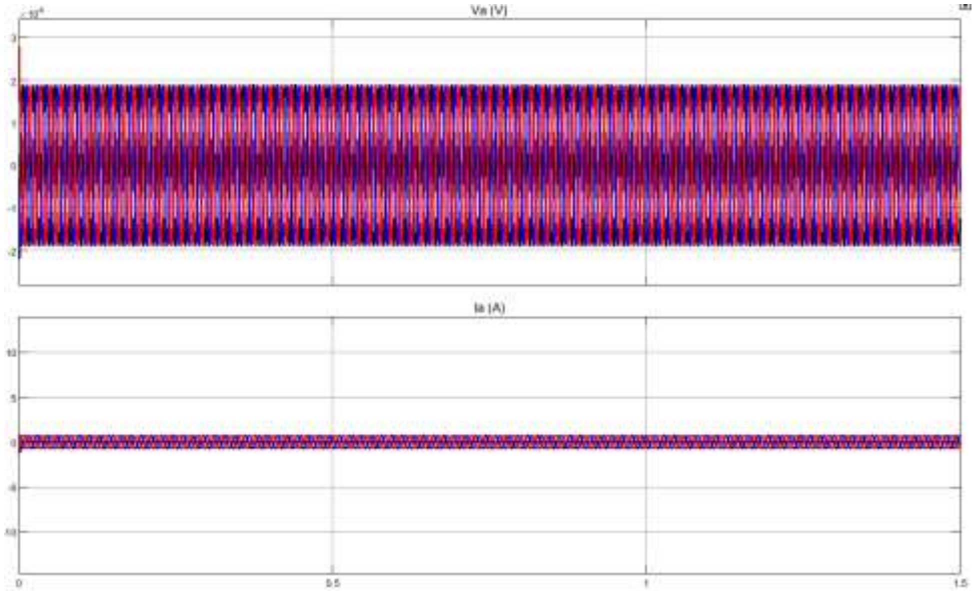

Fig. 8. Output voltage, current and power before setting up the p&o controller.

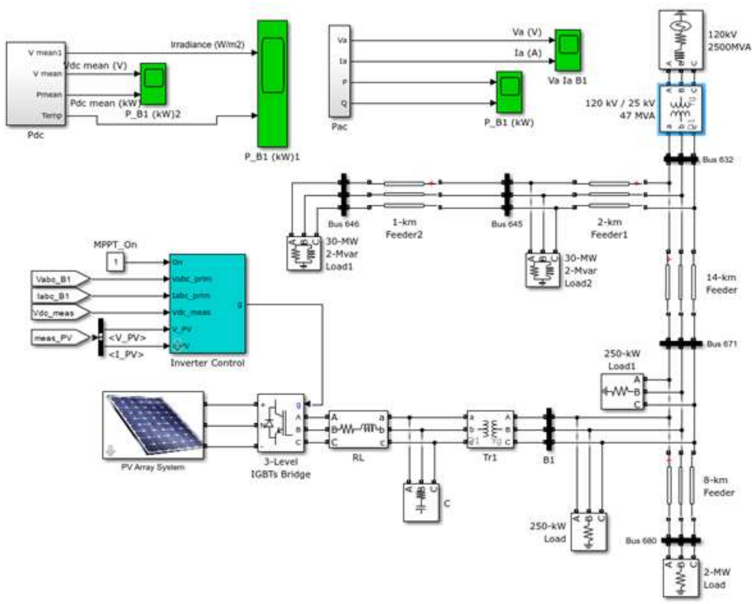

Fig. 9. Complete system developed in Simulink after setting up the p&o controller.

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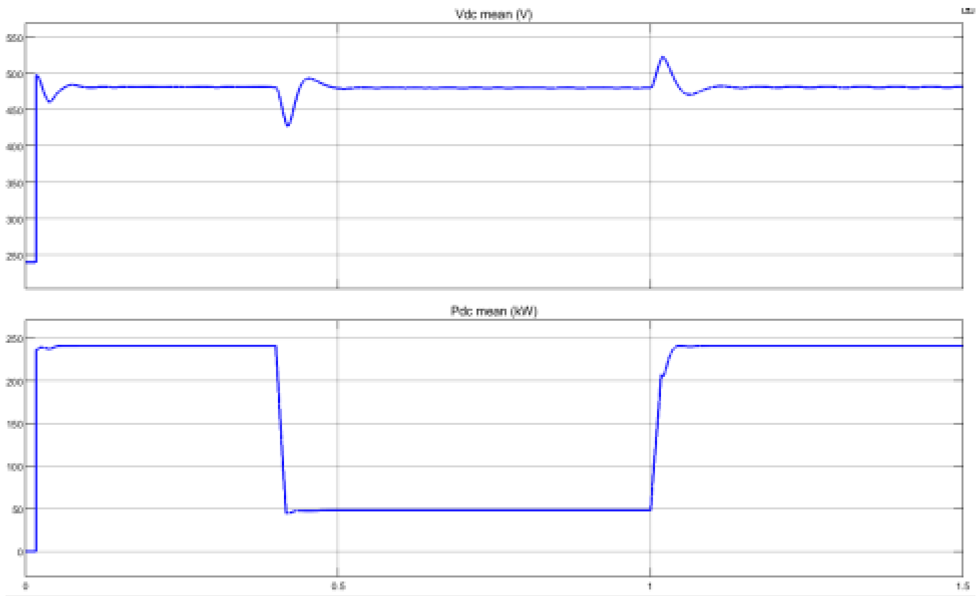

Fig. 10. Voltage and power after setting up the p&o controller.

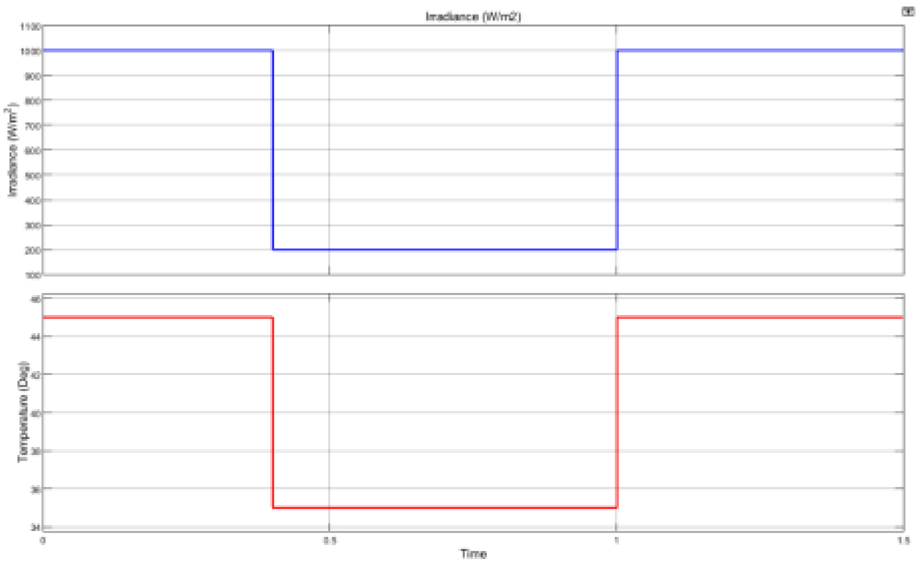

Fig. 11. Radiation and temperature changes after setting up the p&o controller.

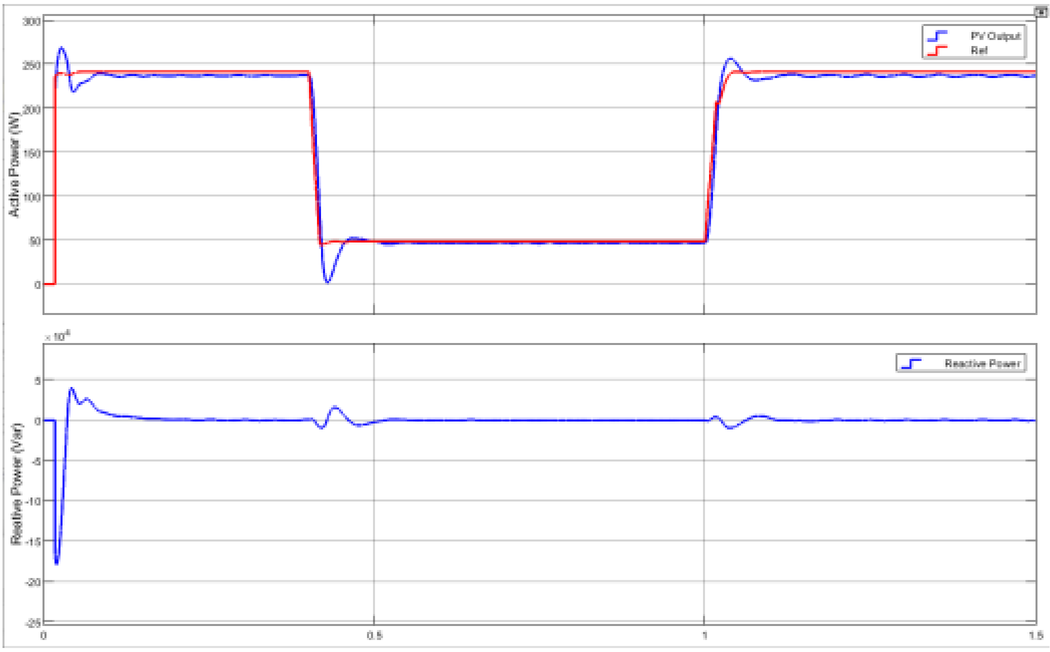

Fig. 12. Active power and reactive power after setting up the p&o controller.

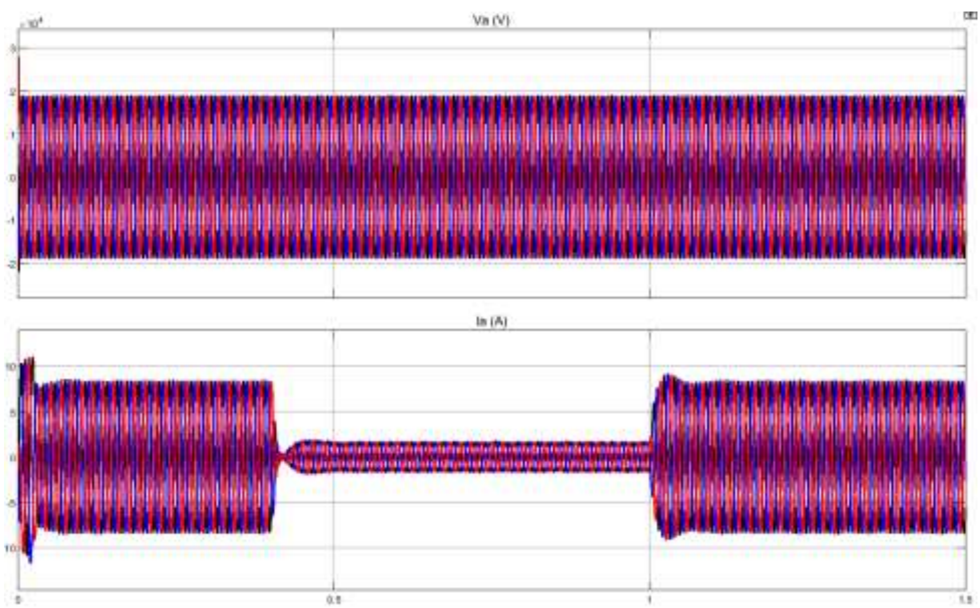

Fig. 13. Output voltage, current and power after setting up the p&o controller.

6 Conclusions

A PV system can identify and stay operating at the maximum power point by using the Perturb and Observe (PO) algorithm as a maximum power point tracker (MPPT).. Increased irradiation results in increased photovoltaic energy output. But an increase in temperature will lead to a slight decrease in the generated photovoltaic power.

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