ANALYSIS OF MPPT BASED ON P&O AND INCREMENTAL CONDUCTANCE TECHNIQUES FOR SOLAR PV ARRAY

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ABSTRACT

Maximum Power Point Tracking (MPPT) algorithms are significant in PV systems because they reduce the number of PV panels necessary to reach the target output power, which lowers the PV array cost. This paper presents a simulation comparison of two popular MPPT algorithms: perturb and observe and incremental conductance. Because of their low cost and ease of implementation, these algorithms are widely utilised. Both algorithms have traced some critical factors such as voltage, current, and power output for each different combination. A 1000 W photovoltaic (PV) array's performance was evaluated using the Matlab simulink tool box.

Keywords: Photovoltaic (PV), Maximum Power Point Tracking (MPPT), Perturb and Observe (P&O), Incremental Conductance (InC).

1. INTRODUCTION

PV generating is one of the most promising renewable green energy sources currently available. PV generating is favoured above other renewable energy sources because to its environmental and economic benefits, as it is clean, limitless, and requires no maintenance. PV cells generate electricity by converting solar energy directly into electricity. PV panels and arrays create DC power, which must be converted to AC power at a regular frequency to feed the loads. As a result, PV systems require power converters to connect the PV arrays to the grid. Grid-connected inverters can transfer photovoltaic-generated energy to power system networks. The likely mismatch between the operational parameters of the load and the PV array is a significant issue in PV systems.

When a PV array is directly linked to a load, the system's operating point lies at the intersection of the PV array and load's I-V curves. Most of the time, the PV array's Maximum Power Point (MPP) is not reached. This issue is solved by employing an MPPT that keeps the PV array's operational point at the MPP. Because the presence of MPP in the I-V plane is unknown, it is computed using a PV array model and measurements of irradiance and array temperature. Calculating these measurements is frequently prohibitively expensive, and the essential parameters for the PV array model are poorly understood. As a result, the MPPT is constantly looking for MPP. Several MPPT continuous search methods have been presented, each based on distinct solar panel properties and the MPP's location [1,4].

A MPPT is used to extract the maximum amount of electricity from a solar PV module and send it to the load. A step up/step down dc/dc converter delivers maximum power from the solar PV module to the load and serves as an interface between the load and the module. When the duty cycle is adjusted, the maximum power is conveyed by changing the load impedance as seen by the source and matching it at peak power. Different MPPT strategies are necessary to keep PV arrays working at their MPP. Many MPPT strategies have been proposed in the literature, including the Perturb and Observe (P&O) method, Incremental Conductance (IC) method, Fuzzy Logic Method, and others [3]. The two most often used MPPT strategies (Perturb and Observe (P&O) and Incremental Conductance Techniques) are investigated [4]. The following is a breakdown of the paper's structure. Section 2 discusses the basic principles of PV cells and the features of

PV arrays. The P&O and InC MPPT algorithms are detailed in Section 3. Section 4 discusses the PV array simulation results, MPPT techniques, and their comparison. The scope for further development is presented in the final section.

2.PV Array Charecteristics

2.1 PV Cell Basic Principle

PV cells are essentially a p-n junction diode with a large area that is made by constructing a junction between the n-type and p-type regions. The incident energy of sunlight strikes a PV cell and is transformed directly into electrical energy. The energy from the transmitted light is used to stimulate free electrons from a low energy state to an unoccupied higher material, shortening the p-n junction and allowing current to pass [2].

2.2 Characteristics of a PV array

The features of a PV cell can be modelled using a single diode equivalent electric circuit. The MATLAB simullink package can be used to create a mathematical model of a solar cell. The I-V characteristic of the ideal solar cell is mathematically described by the following basic equation from semiconductor theory.

$$I=I_{PV,Cell} - I_d \quad (1)$$

Where

$$I_d=I_{0,cell}[exp(qv/akt)-1] \quad (2)$$

Therefore

$$I=I_{pv\ cell}-I_{0,cell}[exp(qv/akt)-1] \quad (3)$$

Where, ‘I PV, Cell’ is the current generated by the incident light (it is directly proportional to the Sun irradiation), Id is the diode equation, Io, cell’ is the reverse saturation or leakage current of the diode, ‘q’ is the electron charge [1.60217646* 10−19C], k is the Boltzmann constant [1.3806503 *10−23J/K], ‘T’ is the temperature of the p-n junction, and ‘a’ is the diode ideality constant. Figure 1 shows the equivalent circuit of ideal PV cell.

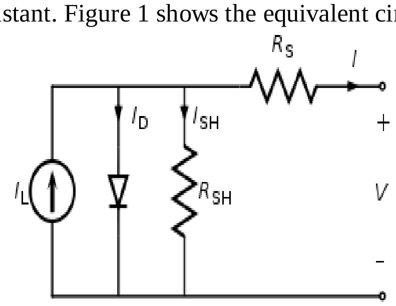

Fig.1:Equivalent circuit of Ideal PV cell

2.3 MPPT

MPPT (Maximum Power Point Tracking) is an electronic system that allows photovoltaic (PV) modules to produce all of the power they are capable of. MPPT isn't a mechanical tracking method in which the modules are "physically moved" to aim more directly at the sun. MPPT is a totally electronic system that changes the electrical operating point of modules so that they can give the greatest amount of power available. Increased battery charge current is available as a result of the extra power gathered from the modules. A mechanical tracking system can be used in conjunction with MPPT, but the two systems are fundamentally distinct.

3. SYSTEM CONFIGURATION

Solar cells directly convert sunlight to dc power. Solar power is generated via photovoltaic cells. The photoelectric effect is what makes solar panels work. Solar cells convert solar energy into electrical energy when they are exposed to sunlight.

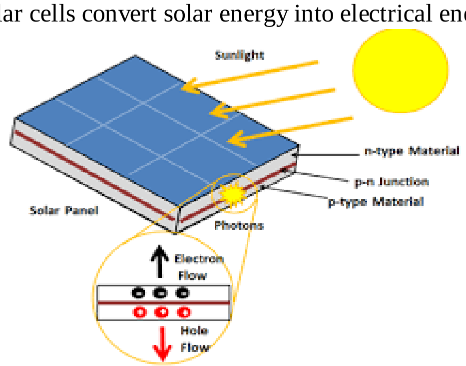

Fig.2:Solar cell

The PV array consists of solar cells that are connected in series and parallel. This array generates electricity directly from solar energy, and its output varies according to temperature and sun irradiance.

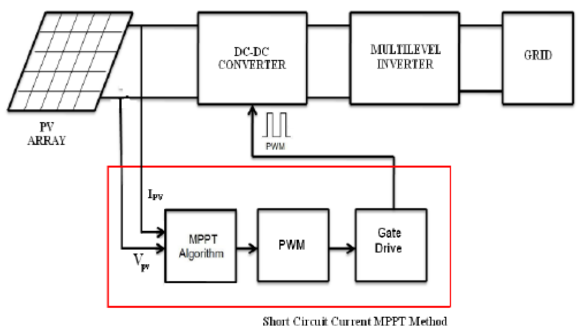

Fig.3: System configuration of PV System

So we are controlling this to maintain maximum power at output side we are boosting the voltage by controlling the current of array with the use of PI controller. By depending upon the boost converter output voltage this AC voltage may be changes and finally it connects to the utility grid that is nothing but of a load for various applications.

4. ROLE OF MPPT IN SPV SYSTEM

When variations in isolation and temperature occur, photovoltaic systems typically use a maximum power point tracking (MPPT) technique to continuously deliver the highest possible power to the load. Photovoltaic (PV) generation is becoming increasingly important as a renewable source because it offers many advantages such as incurring no fuel costs. among others, low costs, no pollution, little maintenance, and no noise .Because of the PV system's low conversion efficiency, controlling maximum power point tracking (MPPT) for the solar array is critical. Maximum Power Point Tracking (MPPT) is a power electronic circuit technique for extracting maximum energy from photovoltaic (PV) systems. PV electricity generation has increased recently.It has grown in popularity as a result of its multiple benefits, including the fact that it is fuel-free and requires very little maintenance.environmental advantages It is critical to operate the PV system at its greatest efficiency to improve energy efficiency.Many maximum power point tracking (MPPT) techniques exist, and various ways have been proposed.for reaching the highest possible powerpoint. However, sufficient comparative analysis is particularly important among the available approaches.It is not done with variable environmental circumstances.

5. MPPT ALGORITHMS

5.1 Perturb and Observe Algorithm(P&O)

In this algorithm, a minor disturbance is introduced. The disturbance causes the solar module's power to fluctuate continually. If the perturbation increases the power, the perturbation continues in the same direction. After the peak power is attained, the power at the following instant falls, and the perturbation reverses. When the steady state is reached, the algorithm oscillates about the peak point. To keep the power variation minimal, the perturbation size is kept small [4]. The method may be simply understood by looking at the flow chart in figure 4.

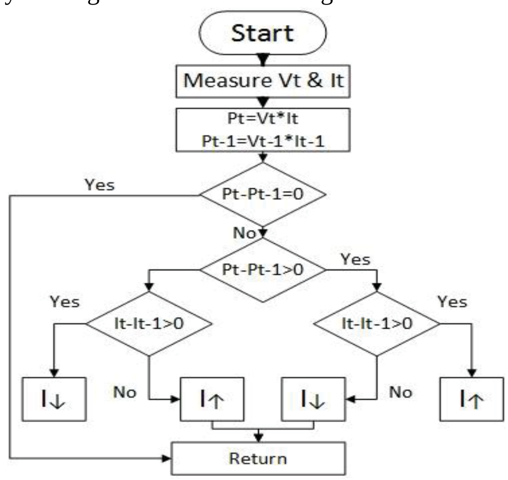

Fig.4: Flowchart of P&O Algorithm

The approach is designed to set a reference voltage for the module that corresponds to the peak voltage of the module. The operational point of the module is moved to that voltage level using a PI controller. This disruption results in some power loss, and it also fails to track the power under rapidly changing atmospheric conditions. However, because of its simplicity, this method is still quite popular.

5.2 Incremental Conductance (IC) Algorithm

The incremental conductance (IC) method overcomes the perturb and observe method's shortcoming in tracking peak power under rapidly changing atmospheric conditions. This approach can tell if the MPPT has reached the MPP and if the operational point has been perturbed. If this criterion is not met, the relationship between dl/dV and –I/V can be used to compute the direction in which the MPPT operating point must be perturbed.

The fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP leads to this relationship. When the MPPT reaches the MPP, this algorithm determines when P&O oscillates around the MPP. This is a clear benefit over P&O. In addition, incremental conductance can follow quickly changing and decreasing irradiance conditions more accurately than the perturb and observe method [4]. This algorithm has the disadvantage of being more sophisticated than P&O. The algorithm is depicted in figure 5 as a flow chart.

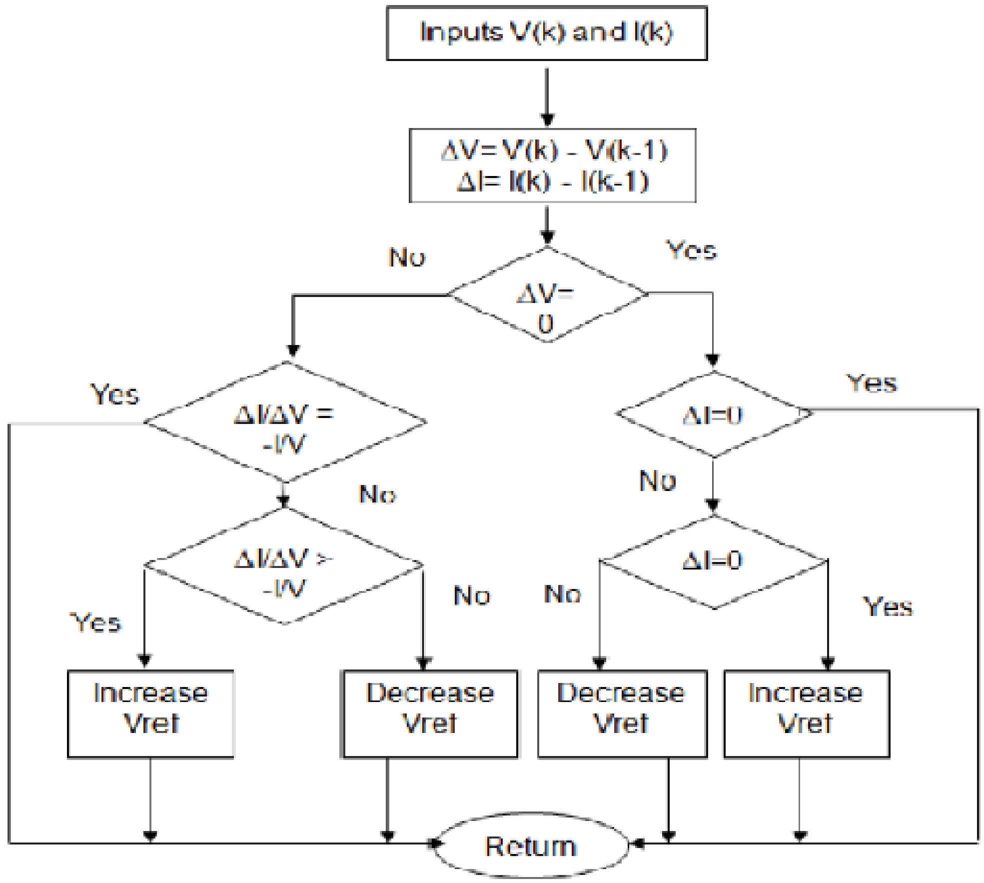

Fig.5: Flowchart of Incremental conductance method

6. SIMULINK MODELS

The mathematical model of PV array is developed using MATLAB Simulink tool box.

6.1 Simulink Model of P&O Algorithm

The 1000W PV array is included in the MATLAB subsystem, as are the equations needed to simulate it. The MATLAB subsystem integrated with PV array replaces the DC voltage source of the dc-dc boost converter. The duty ratio of a dc-dc boost converter is changed, which changes the PV array current and, as a result, the PV array voltage. The MPPT subsystem is used to compute power at various duty cycles and compare it to the power at the current operating point. The duty cycle either rises, falls, or remains constant. Figure 10 depicts a PV array simulink model with dc-dc boost converter and P&O MPPT.

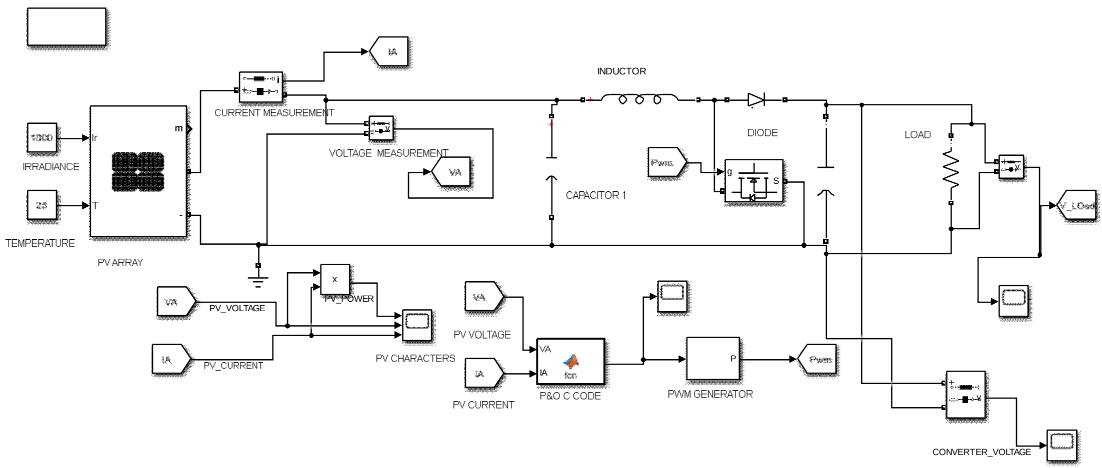

Figure.6: Simulink Model of P&O MPPT with dc-dc converter

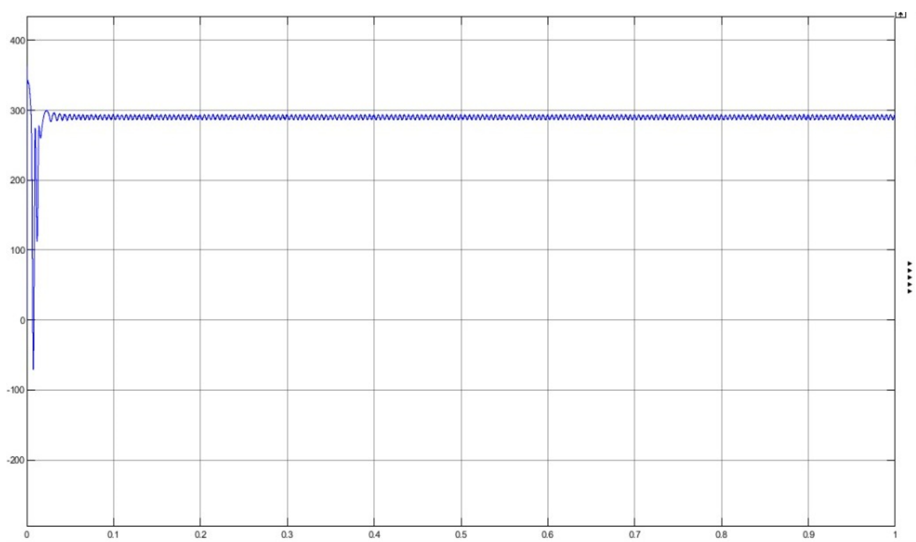

Figure.7: Simulation results of P&O MPPT algorithm

6.2 Simulink Model of Incremental Conductance Algorithm

The simulink model of PV array with dc-dc boost converter and InC MPPT algorithm is shown in figure 8, under the same conditions as the P & O algorithm is simulated.

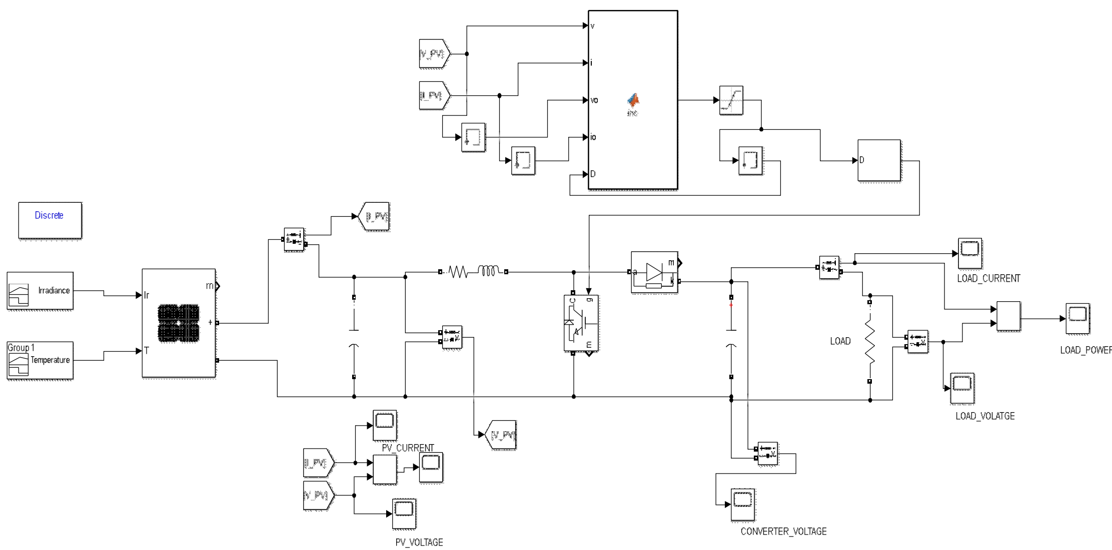

Figure.8: Simulink Model of InC MPPT with dc-dc Converter

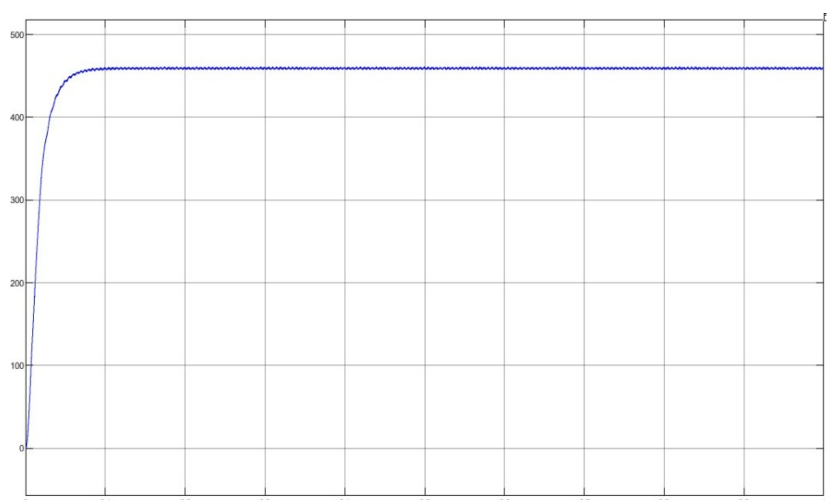

Figure.7: Simulation results of InC MPPT algorithm

6.3 Comparison between P&O and InC MPPT Algorithms

The P & O and InC MPPT algorithms are simulated and compared using the same conditions. When atmospheric conditions are constant or change slowly, the P&O MPPT oscillates close to MPP but InC finds the MPP accurately at changing atmospheric conditions also. Comparisons between the two algorithms for various parameters are shown in the figure

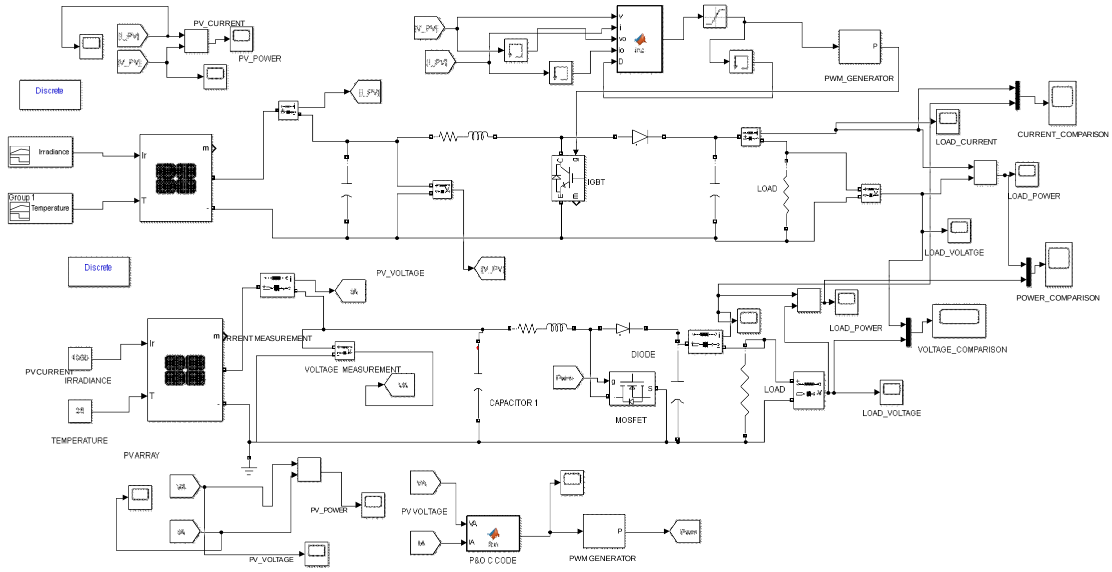

Figure.8:Whole Simulink model for Comparison

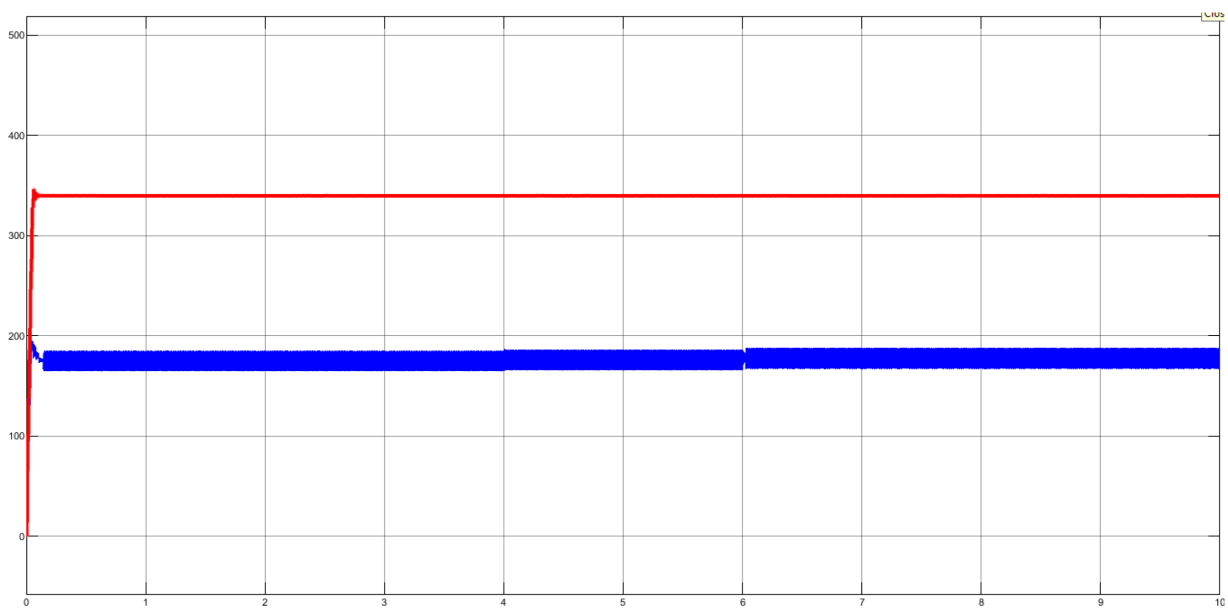

Figure.9:Output Voltages from two techniques

7. CONCLUSIONS

This study uses MATLAB Simulink to create a mathematical model of a 1000W photovoltaic panel. Maximum power point tracking methods are based on this idea. The P&O and incremental conductance MPPT algorithms are explained, as well as their simulation results. The incremental conductance technique outperforms the P&O algorithm, according to research. These methods improve the photovoltaic system's dynamics and steady-state performance, as well as the dc-dc converter system's efficiency.

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