Performance Analysis of Maximum Power Point Tracking Using Hill climbing Search Technique

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Abstract- *The requirement of renewable energy sources is on high demand due to very high energy crisis within the world today. India plans for producing 20 Gigawatts of Solar power by the year 2020,but we have only accomplised less than half a Gigawatt of our capability as of March 2010. Solar energy is a major energy resource in a tropical country like india. The major difficulty for solar PV system is their low efficiency and high capital cost. For maximizing output power of photovoltaic (PV) system, continuous tracking of the maximum power point (MPP) of the system is essential. Maximum power point tracking (MPPT) is a technique that is used for getting the maximum power from one or more solar pv panels. Solar cells have a relationship among solar irradiation, temperature and total resistance that provides a non-linear output known as the I-V curve. It is the aim of the MPPT technique for sampling the output of the cells and use the appropriate resistance load to get maximum power under any environmental conditions. Maximum power point tracking (MPPT) algorithms give the theoretical approach to get the Maximum power point of solar pv panels; these algorithms can be realized in various forms of hardware and software.*

Keywords- Maximum power point tracking, Photovoltaic System.

I. INTRODUCTION

The Requirement for Renewable Energy

Renewable energy is that energy which obtains from natural resources like sunlight radiation, rain, wind, tides and geothermal energy. These energy resources are renewable i.e. it can be replenished. Hence, under all practical conditions, these energy resources are considered to be limitless, unlike conventional fossil fuels [1]. The global energy crisis has given a renewed motivation to the growth and development of Renewable Energy sources. Clean Development Mechanisms (CDMs) are being accepted by organizations across the world. In addition to the speedily decreasing fossil fuels reserves within the world, another vital factor acting against fossil fuels is the pollution after their combustion. Separately, renewable energy sources are found to be much cleaner and generates energy without the harmful effects of pollution over the environment.

A. Different sources of Renewable Energy
B. Wind Energy

Wind turbines are employed to harness the energy present in airflows. Currently turbines range from 600 kW to 5 MW of rated power[2]. Since the output power is a function of the cube of the wind speed, it rises rapidly with an increase in wind velocity. Recent advancements have provided aerofoil wind turbines, which are more efficient and effective because of a good aerodynamic structure.

A. Solar Energy

The tapping of solar energy is given by the British astronomer John Herschel [3] who employed a solar thermal collector box for cooking food during an exploration to Africa. Solar energy can be utilized in two different ways. Firstly the trapped heat is used as solar thermal energy, applied in space heating. Secondly conversion of incident solar radiation into electrical energy, that is the most useful form of energy. This can be obtained with the aid of solar photovoltaic system [3] or with utilizing solar power plants.

Photovoltaic (PV) system converts sunlight energy directly into electrical energy, as shown in figure 1.1

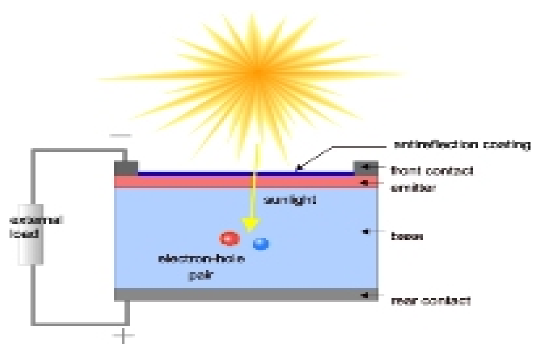

Figure 1. Working of Photovoltaic System

PV cells consists of semi-conductor materials similar to semiconducting materials employed in computer chips. When sunlight falls on these materials, the solar energy extracts electrons from their atoms, permitting the electrons to flow through the material for producing electricity [4].

B. PV CELL

PV cell electrical equivalent circuit shown in figure 1.2

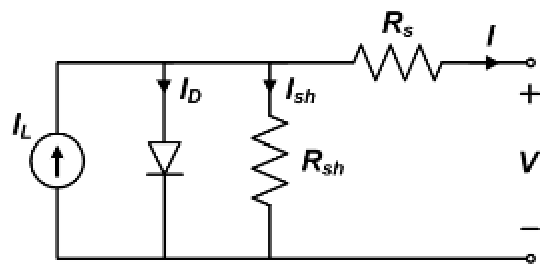

Figure 2. Electrical Equivalent Circuits for PV Cell

I= I_L-I_{sh}-I_D
Where,

I = output current (ampere)

I_L = photo generated current (ampere)

I_D = diode current (ampere)

I_{SH} = shunt current (ampere).

$$I_D = I_0 \left[\exp\left(\frac{V + IR_s}{nV_T}\right) - 1\right]$$

where n is the diode ideality factor (unit less, usually between 1 and 2 for a single junction cell), I_0 is the saturation current, and V_T is the thermal voltage given by:

$$V_T = \frac{kT_c}{q}$$

Where, k is

Boltzmann's constant $(1.381\ \times 10^{-23}\ \mathrm{J/K})$

q is the elementary charge $(1.602\ \times 10^{-19}\ \mathrm{C})$.

$$I_{sh} = (V + IR_S)\,/R_{sh}$$

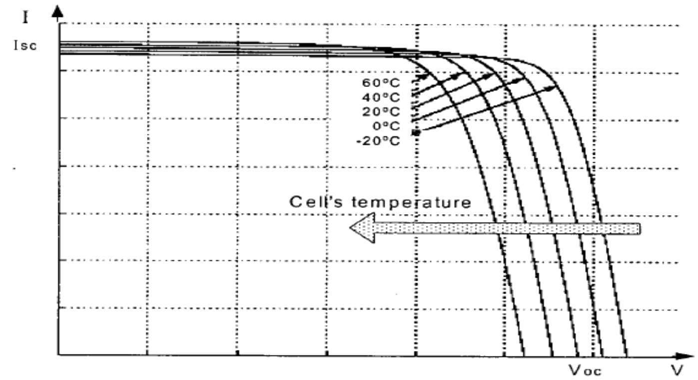

Figure 3. I-V Characteristics Under Various Temperatures

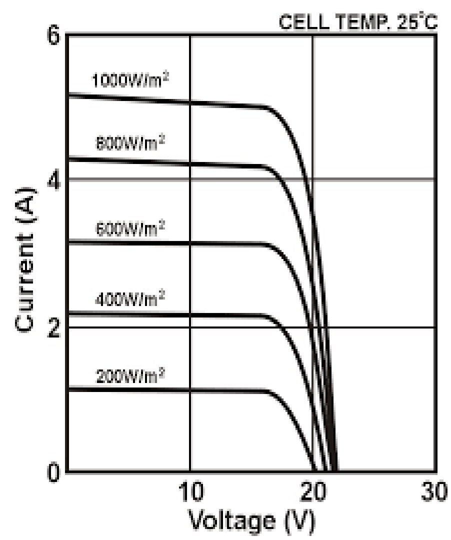

Figure 4. I-V Characteristics Under Different Irradiance

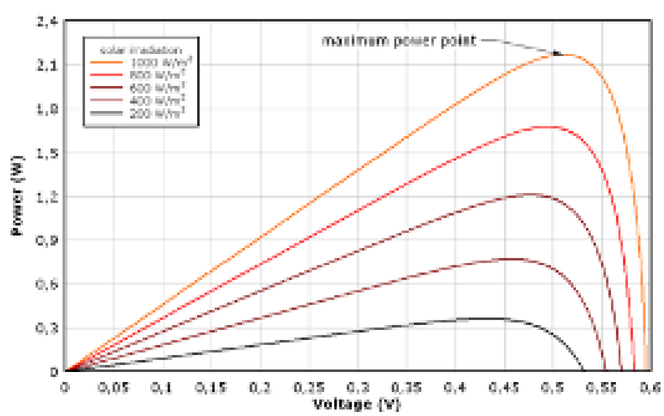

Figure 5. P-V Characteristics Under Different Irradiance

C. HILL CLIMBING SEARCH (P&O TECHNUIQUE) ALGORITHM

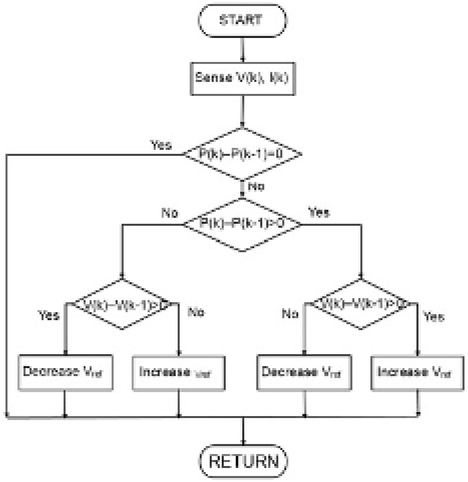

Figure 6. HCS Flowchart

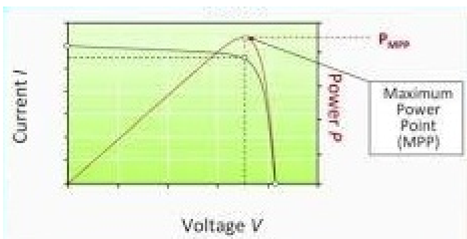

Figure 7. p-v characteristics of a photovoltaic system

Fig 1.7 show the p-v characteristics of a photovoltaic system, we can analyze the p-v characteristics and we can observe that the voltage decreases and the power increases on right side of MPP but increasing voltage will increase power on left side of MPP. This is the basic concept as we have employed in the P&O algorithm for tracking the MPP.

As we can observe in the flow chart, firstly we calculate voltage and current, by utilizing these values, we can calculate power, evaluated power is compared against previous power and consequently we can increase or decrease the voltage for locating the Maximum Power Point by changing the duty cycle of converter.

D. BUCK-BOOST CONVERTER

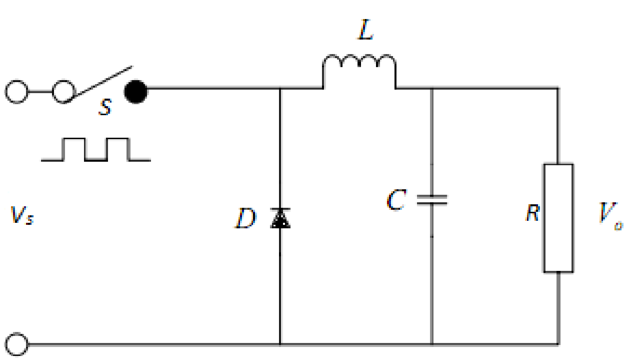

Figure 8. Buck converter

A buck converter is a step down dc-dc converter made of inductor and two switching elements (a transistor switch and diode switch) to control the inductor. It fluctuates between connection of induction to source voltage to boost up energy of inductor and after that discharging the inductor's energy to the load

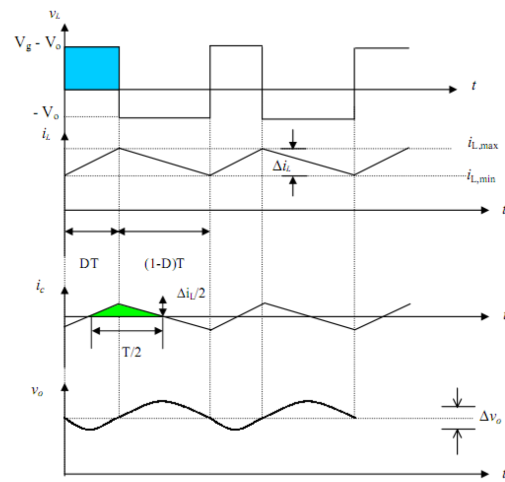

Figure 9. Waveform of Buck converter

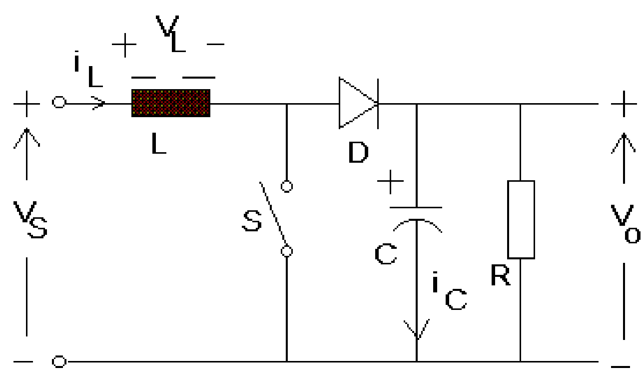

Figure 10. Boost converter

A boost converter step up the DC input voltage and gives at output. The Step converter includes a diode, a transistor as switching devices and at least one energy storing element. Capacitors are usually provided to output in order to perform the action of reducing ripple of output voltage.

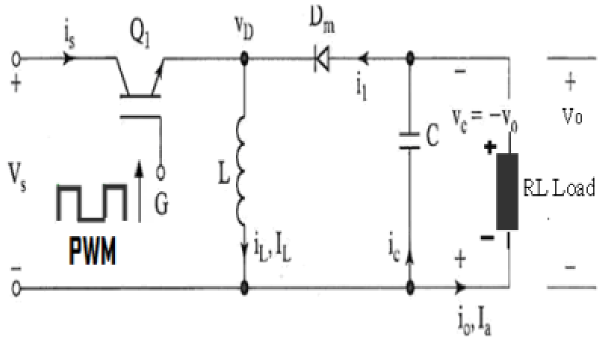

Figure 11. Buck-Boost converter

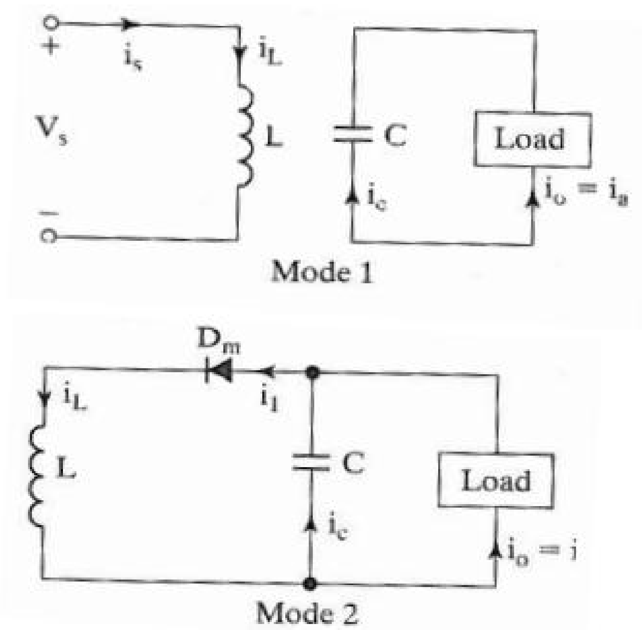

Figure 12. Equivalent circuit of buck-boost converter

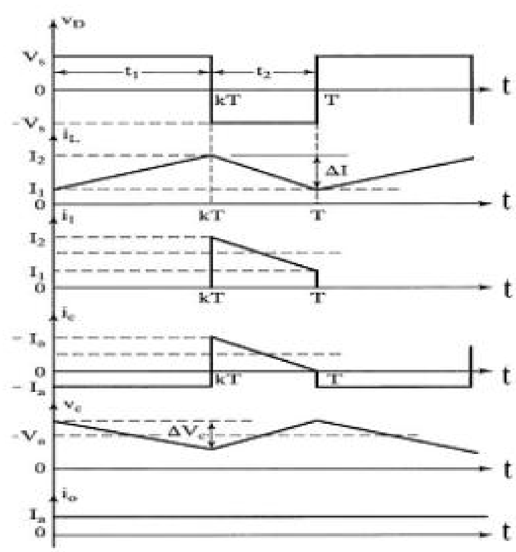

Figure 13. Waveform of buck-boost converter

A buck-boost converter gives an output voltage which may be less than or more than the input voltage therefore the name "buck-boost"; the polarity of output voltage is opposite in comprision to the input voltage. This converter is also called as inverting regulator. The circuit operation is divided into two modes of operation. During mode 1, transistor Q1 turns on and the Dm diode is reversed biased. The input current, which increases and flows through inductor L and transistor Q1. During mode 2, transistor Q1 switches off and the current, that was flowing through inductor L, will also flow through L, C, Dm, and the load. The energy stored in inductor L is transferred to the load and inductor current reduces until transistor Q1 switches on in the next cycle again.

E. SIMULINK MODEL AND RESULTS

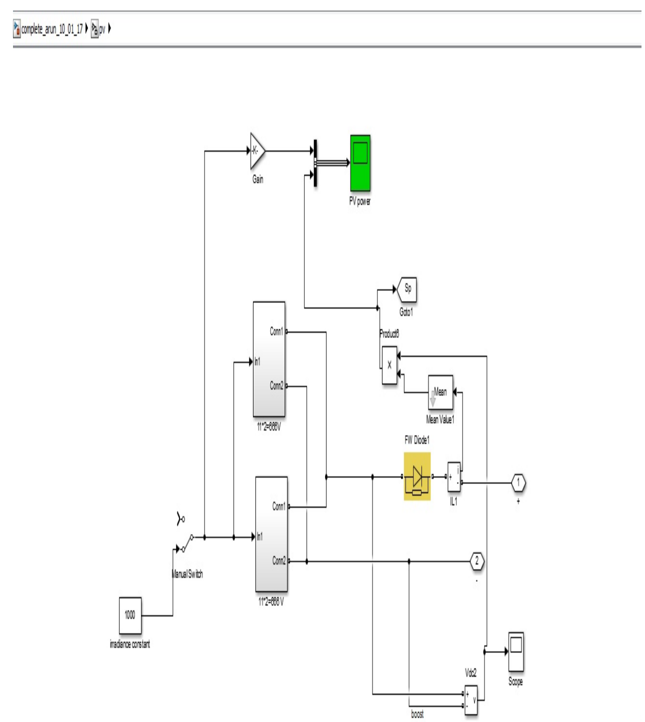

Figure 14. PV Array Model

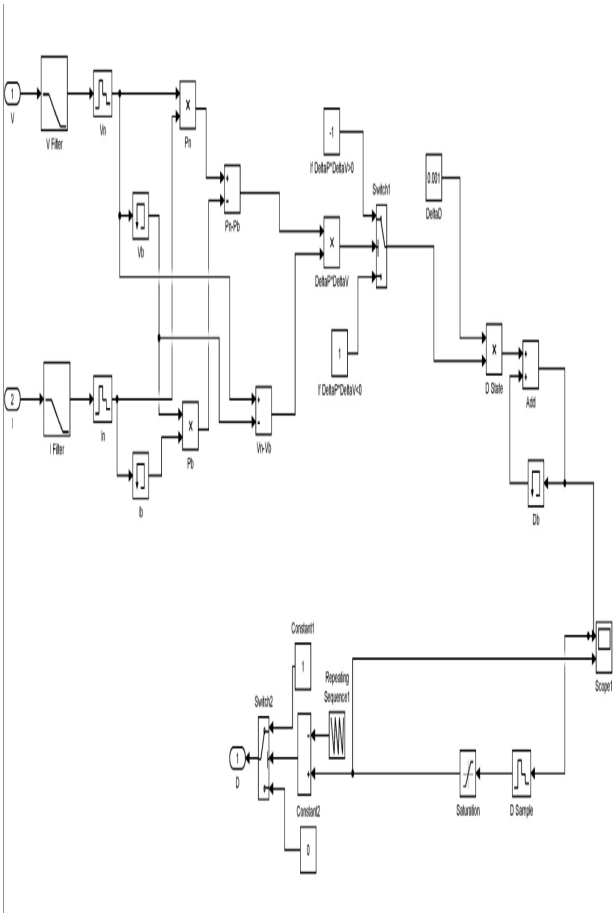

Figure 15. HCS Technique Model

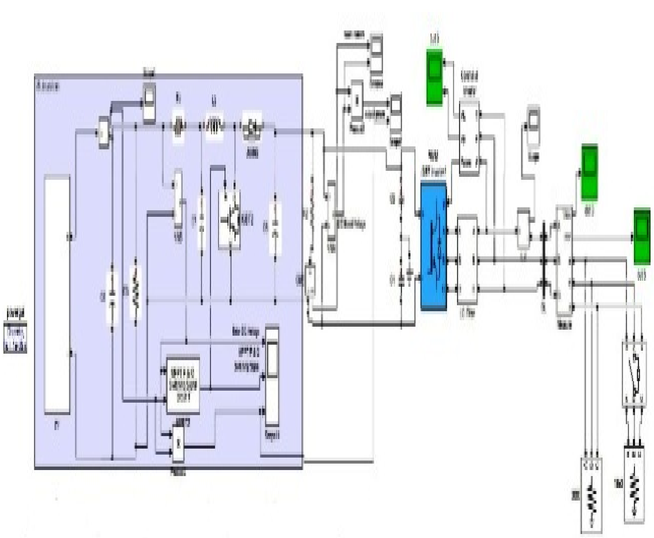

Figure 16. Main Model

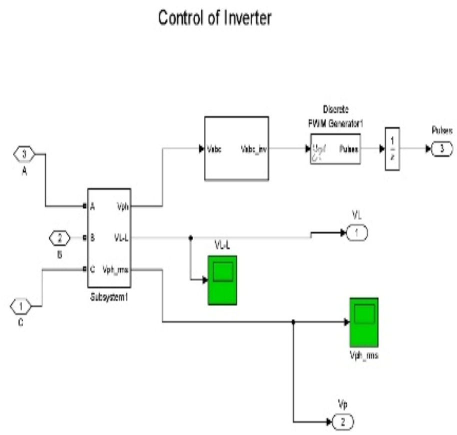

Figure 17. Control of Inverter Model

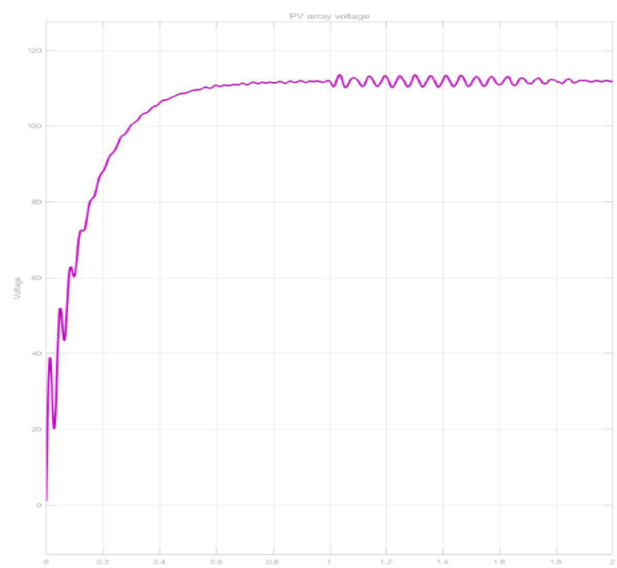

Figure 18. PV Array Voltages

In figure 2.5 shows a PV array Power and PV array output power

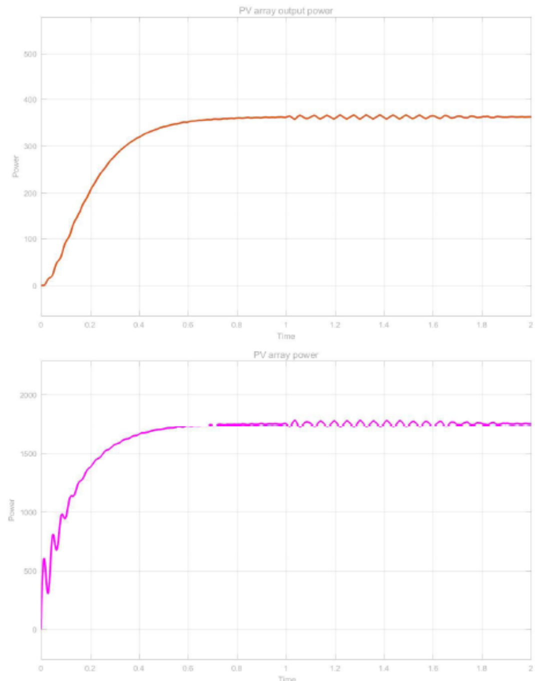

Figure 19. PV Array Power and Output Power

In figure2.6 shows a PV Boost DC Current & PV Boost DC voltage

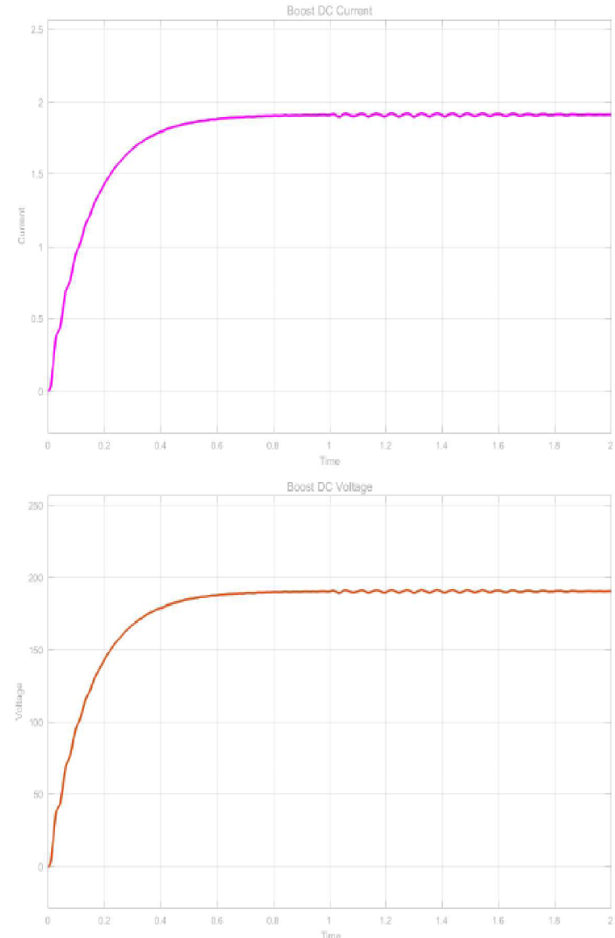

Figure 20. PV Boost DC current & DC voltage

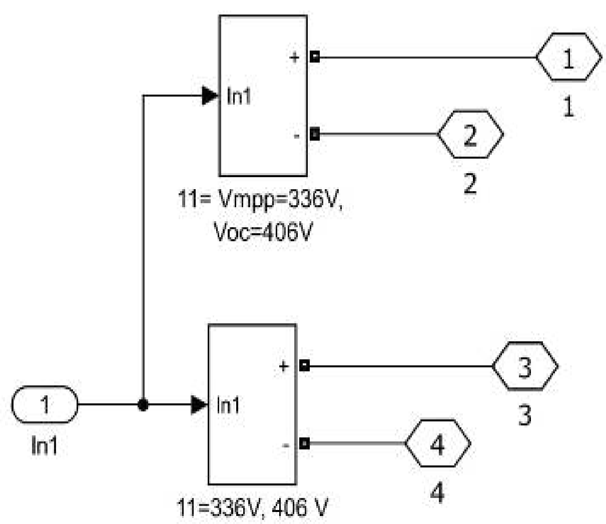

Figure 21. PV module model

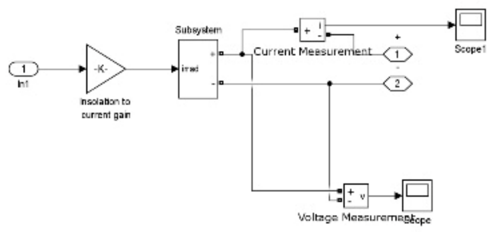

Figure 22. PV Module Subsystem

F. Output Current/Voltage

In figure 2.9 shows Three Phase AC Current and Three Phase AC voltage

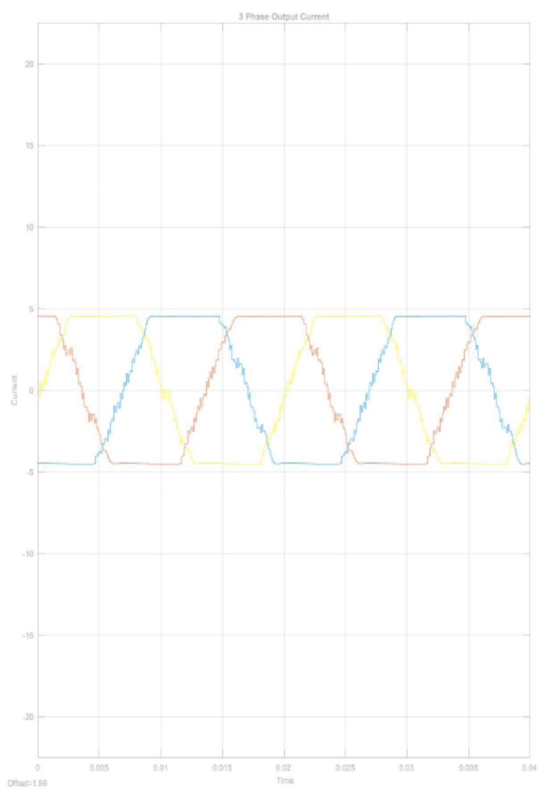

Figure 23. Three Phase AC Current

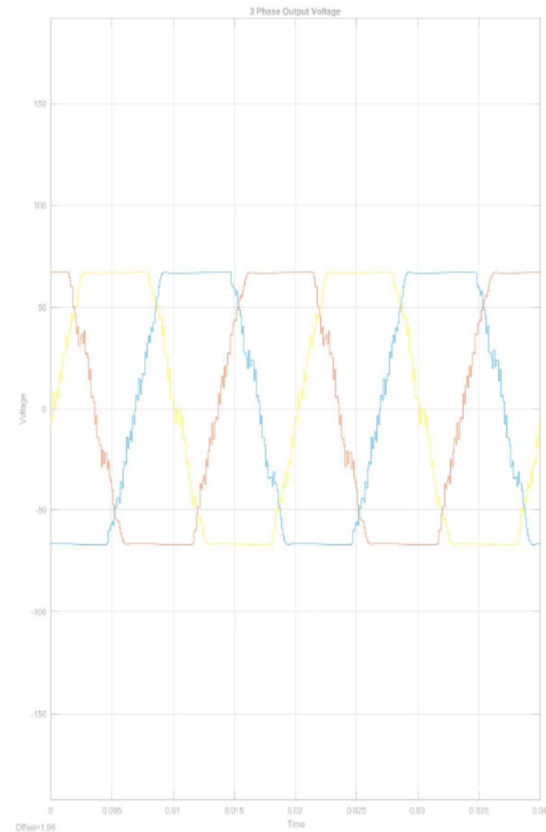

Figure 24. Three Phase AC Voltage

II. CONCLUSION

In this paper, PV cell, module and array are simulated and effect of environmental conditions on their characteristics is studied. Wind energy system has been studied and simulated under different wind velocities. As mentioned above amongst the various methods the study shown here will be extended by opting Perturb and Observe Method (P&O). The main contribution of this thesis is tracking the maximum power point using a closed loop system consisting of some power electronic devices such as boost converter, rectifier and PV module as input device. Instead of using semiconductor devices like diodes, IGBT's will be used.

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