International Journal of Electrical and Electronics Engineers
Vol. No.8 Issue 01, January-June 2016
www.arresearchpublication.com
IJEEE ISSN 2321 - 2055

EFFECTS OF PARTIAL SHADING ON PV ARRAY CHARACTERISTICS USING INCREMENTAL CONDUCTANCE METHOD

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ABSTRACT

Due to shortage of non- renewable sources of energy there is requirement of renewable sources. So there is a huge rise in demand of solar energy. Solar energy is being used nowadays in the form of pv arrays.The output of pv array is a function of various parameters such as solar insolation, temp and percentage of shadow on the array. The reason for shadowing is the nearby tall structures and movingclouds During partial shadowing more than one peak is observed in the output of a pv cell.In this paper we aim at observing the impact of shading on array characteristics using MATLAB model of p v array. The insolations incident on different models are considered to be different. Then we compare the output of the MATLAB model with the theoretical values.Here we aim to design and develop simulation of solar panels connected in series integrated with a boost converter and MPPT algorithm taking into account the effects of partial shading.

Index Terms: Bypass diodes, Incremental Conductance, Insolation , Partial shading, PV Array

I INTRODUCTION

Nowadays due to shortage of fossil fuels and increasing pollution the demand of solar energy has increased considerably. The solar energy is having much more demand as compared to other sources because it is favorable to climate and does not cause pollution.it has no issues of global warming associated with it.in the areas where power supply is not possible such as in hills and valleys solar energy is a good solution. Several other advantages are the ease of allocation, easy to maintain.The economic advantage is the reduction in cost due to absence of fossil fuels. There are many regions around the globe where there is strong sunshine throughout the year. These regions are the tropical and sub-tropical regions.so use of solar technology is enormously advantageous in these areas .A pv array transforms solar energy to electrical and the process is termed as photovoltaic effect. The output of pv array is a function of solar radiation,temp and the connection of solar array that is whether it is connected in series or in parallel. The result follows a nonlinear relationship between the output power and voltage values. There is a continuous variation in output with the variation of incident solar irradiance.In order to extract highest power various MPPT algorithms are in use. some of them are hill climbing method and the bisection method.

Partial shading causes the output to have more than one peaks.Earlier used MPPT techniques were suitable for only one peaks in the output. The reason for more than one peak is the use of bypass diodes.By-pass diodes eliminates the problem of hot spot formation.A hotspot is generated when solar insolation incident on various modules are different. Thus it becomes essential to develop an MPPT algorithm which does not have these demerits of earlier used methods and which would give satisfactory result in the MATLAB SIMULINK environment.

II LITERATURE REVIEW

In past researches were conducted to observe the output of solar array with and without shading effect.in the experiment performed by walker impact of parameters such as load variation and temp was observed . The study performed by walker did not consider partial shading impacts on the output. Then a research conducted by Alonso.et al included the effect of shading on pv modules. The study was not applicable on pv arrays and worked well for a single pv module..Kawamura conducted a research to consider impact of shading. His research was applicable for pv array as a whole but was not applicable for a single pv module and could not find peaks for a single module case.Among all the research conducted it was observed that there is a continuous rise in output power until global maximum power point is reached and after that there is a continuous decrease in the output. In another research a pi curve scanner technique was used to find the peak points.

PV CELLS, MODULES AND ARRAYS

The power generated by pv cell is dependent on the amount of electric current which it produce. The electromagnetic force generated is also a function of the current.

Vc = (A*k*Tc/e)ln ((Iph+I0-Ic)/I0) - Rs*Ic

The symbols used are

Vc: cell output voltage, V.

Tc: reference cell operating temperature (20 °C). Rs: series resistance of cell (0.001 Ω).

Iph: photocurrent, function of irradiation level and junction temperature (5 A). I0: reverse saturation current of the diode (2*10-4 A).

Ic: cell output current, A.

k: Boltzmann constant (1.38 × 10-23 J/K). e: electron charge (1.602 × 10^-19 C).

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www.arresearchpublication.com
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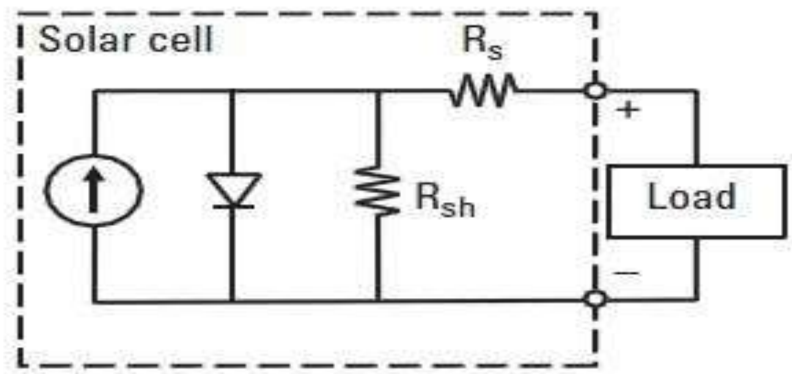
In our modeling of solar cell we have considered one diode circuit. For a greater accuracy and precision the circuit could have been designed using two diodes. But our scope of study is limited to single diode model.



DC equivalent circuit

2.1 Partial Shading Effects

The cause of partial shading is the nearby tall structures and the climatic conditions suchs as stormy weather and the moving clouds .The power generated by unshaded module was found to be greater than a shaded module.In a module current passing through different modules are same due to their cascade connection.This cause shaded cells to carry more power than their short ciruit rating. This results in the formation of a voltage of apposite polarity on the shaded cells.So there is an overall reduction in the system voltage.These cells cause reduction of power loss and acts as if a new load has been added on the system.The current in cascaded connection of cells can't be greater than the current through the cell with greatest shadingThe power loss in shaded cells have a negative impact on neighboring cells. The power loss in shaded cells cause formation of hotspots which results in failing of the entire pv array.

2.2 Incremental Conductance Method

Incremental conductance method uses two voltage and current sensors to sense the output voltage and current of the PV array

At MPP the slope of the PV curve is 0.

(dP/dV)MPP=d(VI)/dV

0=I+VdI/dVMPP

dI/dVMPP = -I/V

The left hand side is the instantaneous conductance of the solar panel. When this instantaneous conductance equals the conductance of the solar then MPP is reached. Here both the voltage and current are sensed simultaneously. Hence the error due to change in irradiance is eliminated. However the complexity and the cost of implementation

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increases.

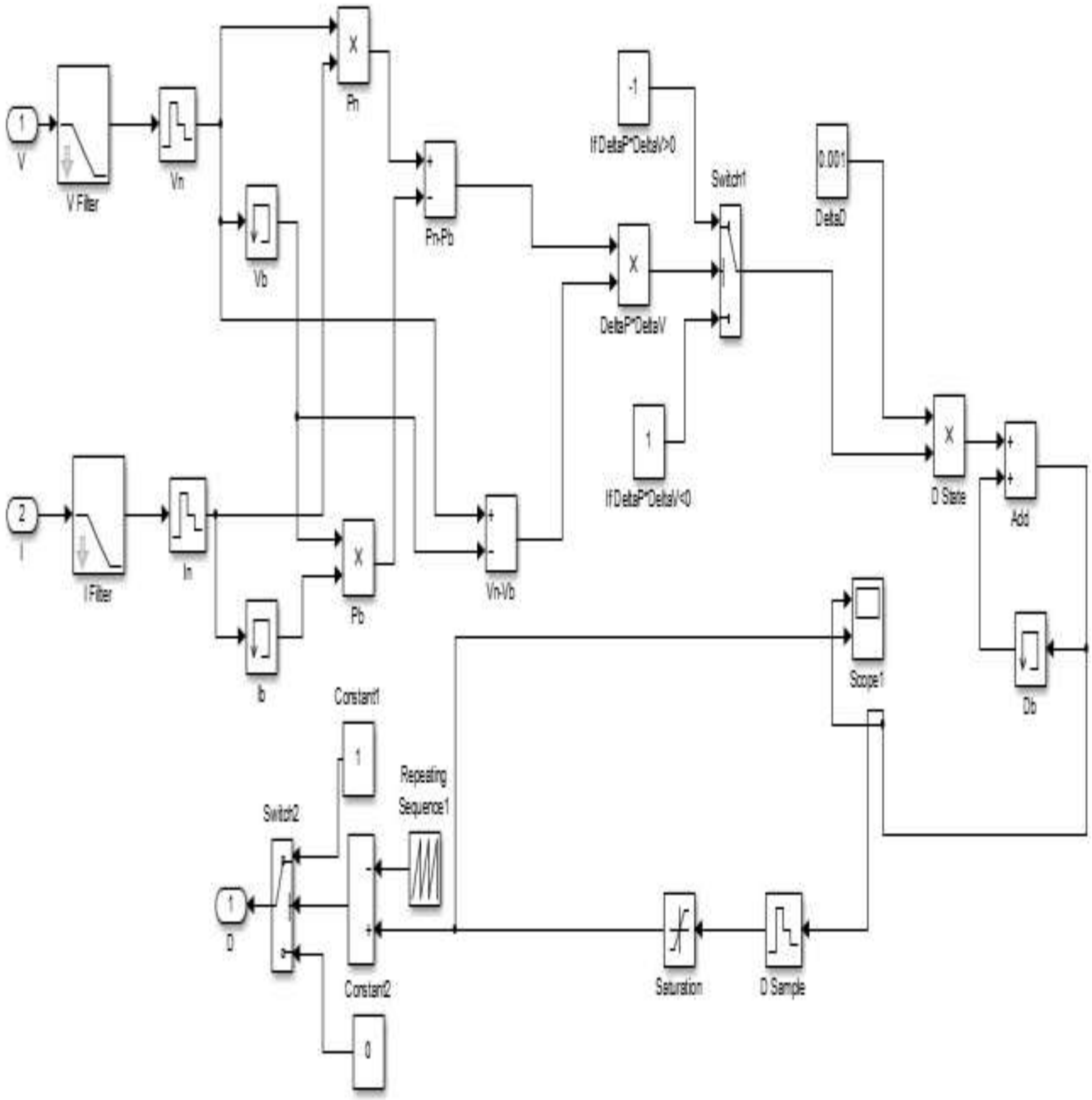

Fig. 1 Simulink Model of PV Array using incremental Conductance method

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Table 1 Specifications of a PV cell

Parameter @STC	Variable	Specs.
Maximum circuit voltage in watts	P_m	235W
Open circuit voltage in Volts	V_{oc}	54.2V
Short Circuit current in Amps	I_{sc}	6.2A
Voltage @max. Power	V_{mp}	45.8V
Current @max. power	I_{mp}	5.1A
Temperature Coefficients	Voltage	-(80±10) mV/° C
	Current	(0.065±0.15) %/°C
Type of cell	Mono Crystalline Silicon	

III RESULTS AND FINDINGS

Simulation of a PV Cell without Shading Effect

The simulation is carried out for a cell surface temperature of 25° C, 60 solar cells in series and 4 rows of solar cells in parallel. The irradiation (shown in Figure 5.3) is taken to be varying to display the effect of shading on the solar panels, to reflect real life conditions and effectively show the use of an MPPT algorithm in field runs. It varies from 60 Watt per sq. cm. to 85 Watt per sq. cm, which is close to the day values of solar radiation received on the earth's surface. The simulation is run for a total of 0.12 seconds, with the irradiation taking up a new value every 0.03 seconds and staying constant for the consequent 0.03 seconds.

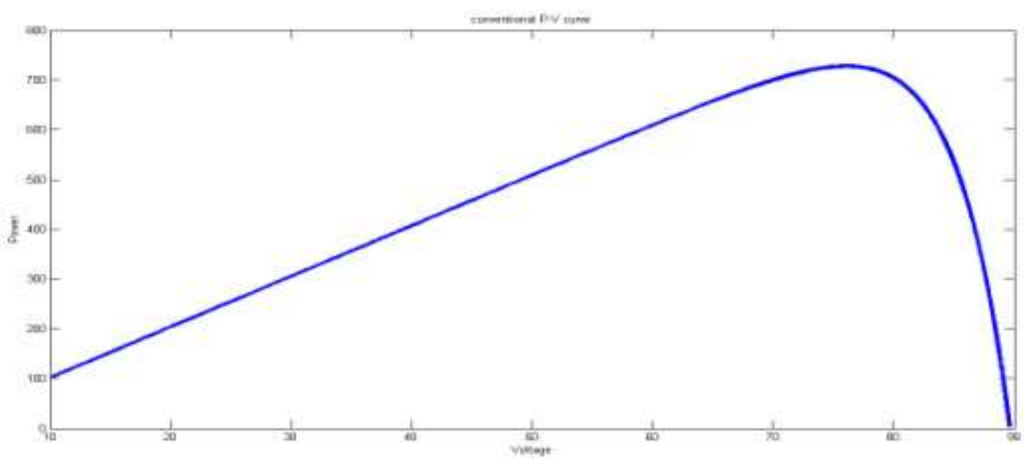

Fig. 2 Conventional PV cells v/s voltage without shading effect

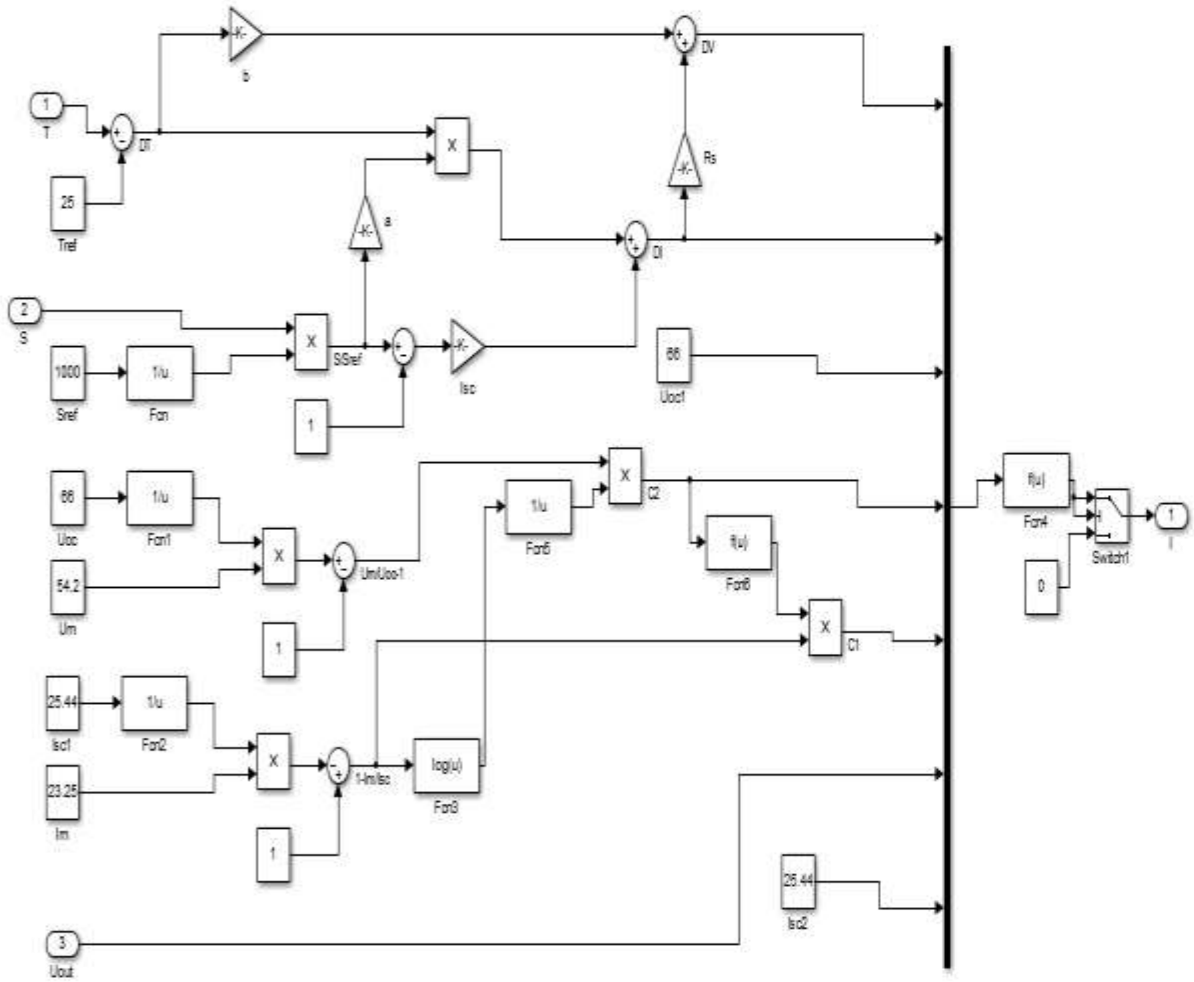

Fig 3 Simulation of a PV cell without considering Shading effect

Simulation of a PV Cell With Shading Effect

In the final model, three solar panels are attached in series with variable solar radiation values to reflect the real world shading effect on the solar panels attached in cascaded form .The current obtained from the solar panels is fed to the boost converter which with the help of MPPT algorithm can tune the DC voltage as per the required level and can be used for various real life applications. A boost converter has been used in our simulation. It finds applications in various real life scenarios like charging of battery bank, running of DC motors, solar water pumping etc. The simulation has been done for a resistive load of 300ohm. For efficient running of a motor, we should undergo load resistance matching techniques. In the boost converter circuit, the inductor has been chosen to be 0.763 mH and the capacitance is taken to be 0.611 µF.

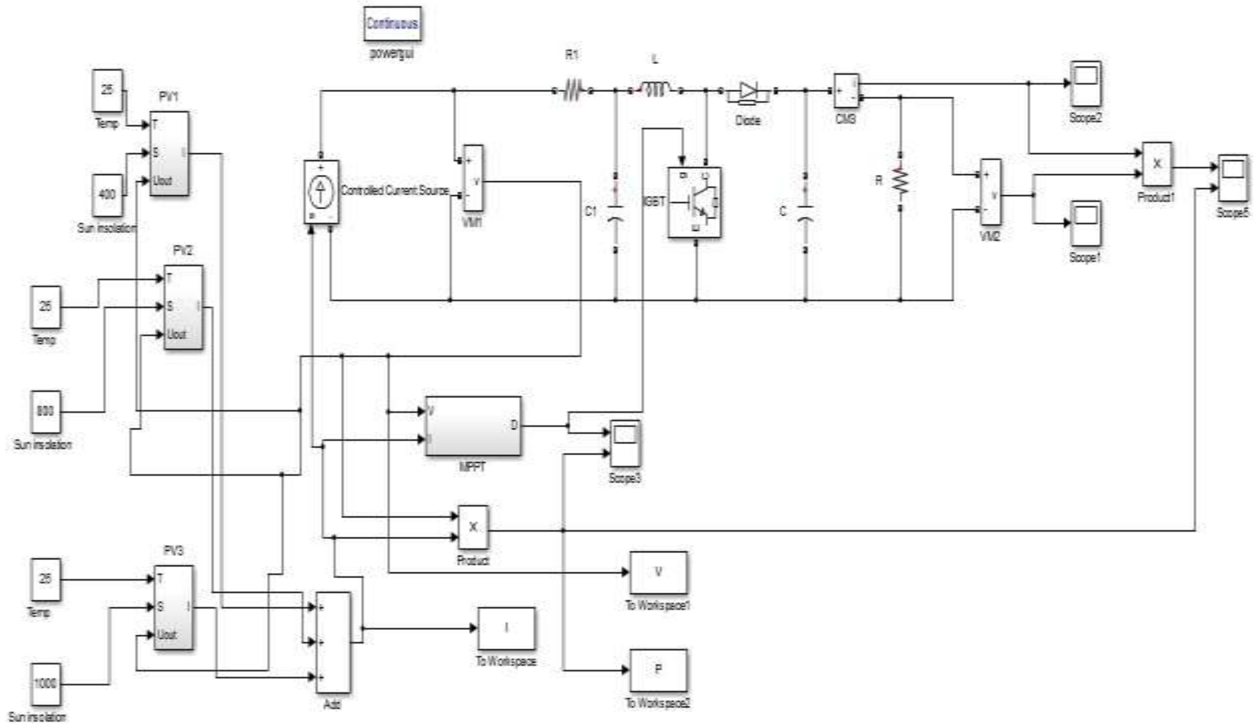

Fig 4 Simulink model of a PV cell with considering Shading effect

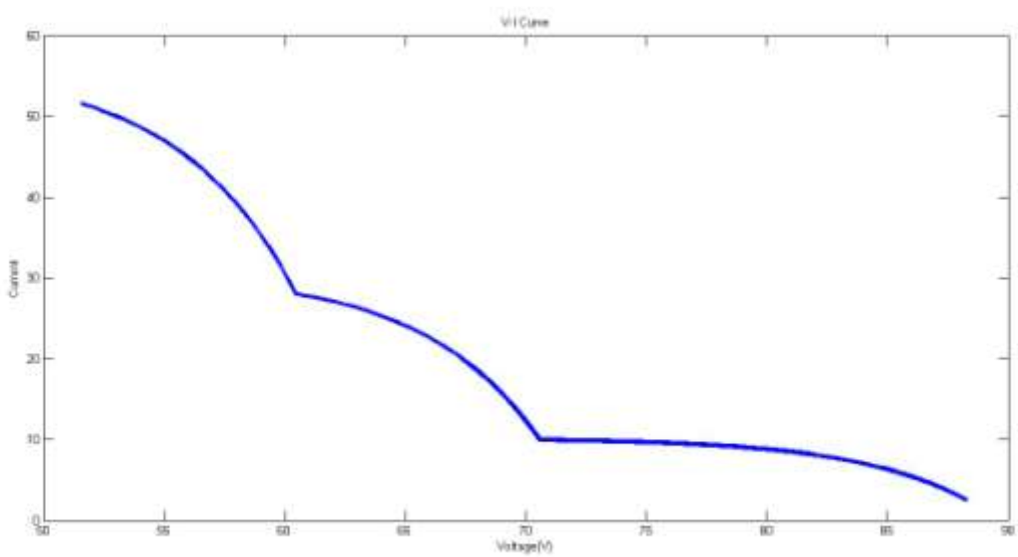

Fig 5: VI Characteristics of a PV cell

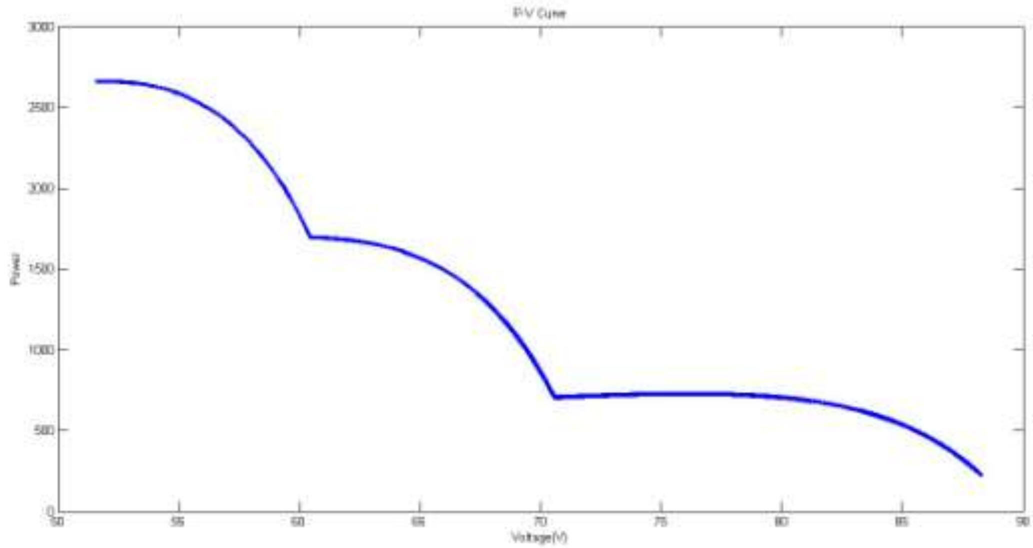

Fig 6: Power-Voltage characteristics of PV Cell

Figure 5 and 6 are showing the PV and VI curve of the cascaded solar panels , the variation of Voltage and power with due effect of shading or variable sun radiation availability is quite visible .

In figure 7 and 8 the output voltage and current after boost convert is displayed. With the help of boost converter tuning using MPPT, the constant voltage at the output side is successfully achieved

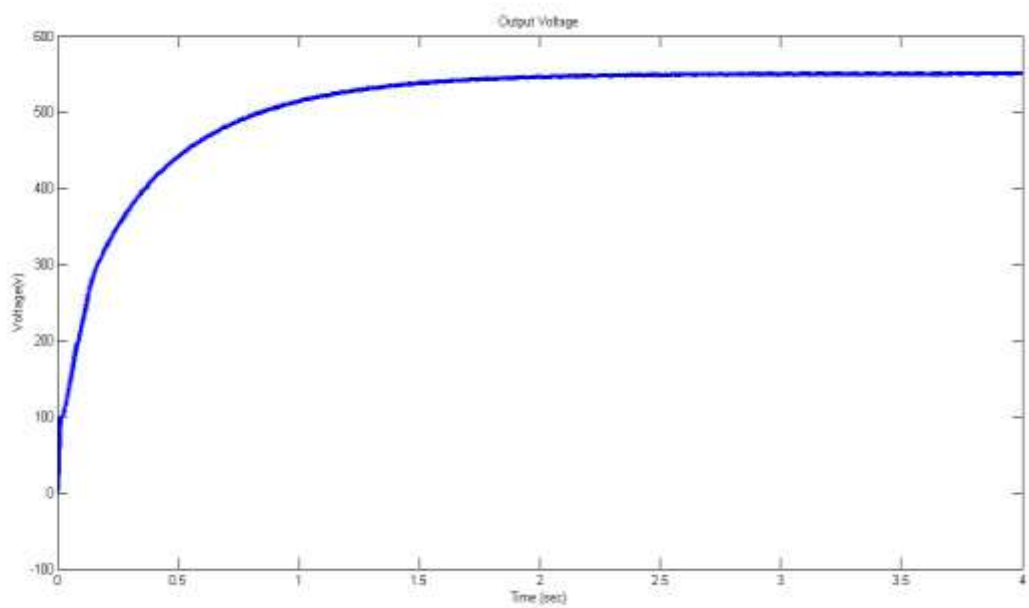

Fig. 7: Output voltage w.r.t time with boost converter

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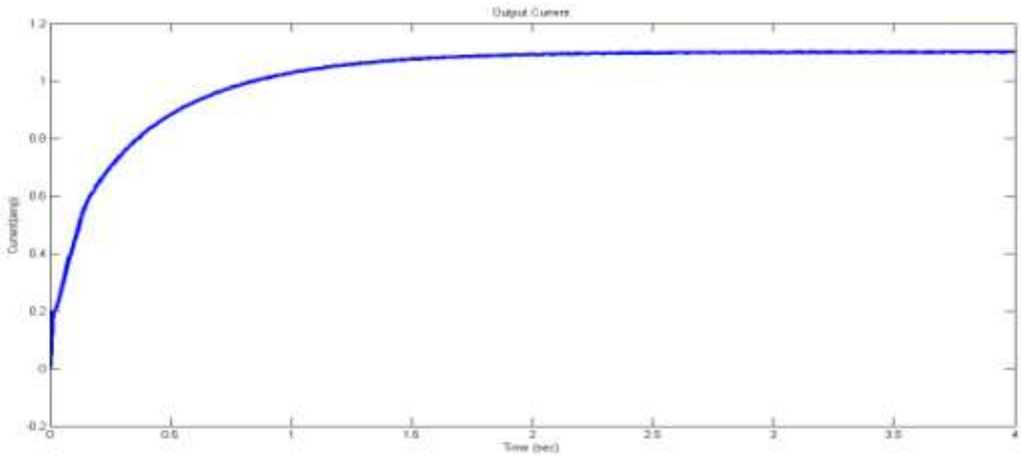

Fig8: Output current w.r.t time with boost converter

IV CONCLUSION

The solar panel mathematical modeling with shading effect is successfully simulated with complete analysis using resistive DC load. Three different solar panels are connected in cascaded form and a constant DC voltage is obtained using boost converter topology with MPPT incremental conductance topology.

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