Modelling of Solar System with Boost Converter and MPPT

Akash Varshney[1], Ashish Kumar[2], Imran Khan[3]
[1,2,3]Department of Electrical Engineering, Azad Institute of Engineering & Technology, Lucknow, India

***Abstract*- in this paper, another approach is anticipated for examination on tie-line control of grid solar system. Anticipated method depends on the power control of tie-line. This technique offers low stress on utilization of customized control topology. The working principle of described method is that the grid is developed by the solar system for the distribution of energy and tie- line control is developed with the help of two parameters viz. Frequency and power. In this paper usage of a boost converter for control. In this paper use of a boost converter for control of photovoltaic power utilizing Maximum power point following (MPPT) control mechanism is displayed. First the photovoltaic module is analysed utilizing semolina programming for the principle point of the task the boost converter is to be utilized alongside a Maximum power point control mechanism. The MPPT is responsible for extracting the maximum possible power from the photovoltaic and feed it to the load by means of the boost converter which Step Up the voltage to required extent. The primary point will be to track the most Maximum power point of the photovoltaic module with the goal that the greatest conceivable power can be separated from the photovoltaic the calculation written in M file of mat lab and use in simulation. Both the boost converter and the solar cell are modelled using SIM power system block.**
Keywords: Maximum power point tracking (MPPT), photovoltaic (PV) power system, maximum power point (MPP), switching mode DC-DC converter, Perturb & Observe control.

I. INTRODUCTION

Solar energy is one of the most important renewable energy sources. Compared to conventional non renewable resources such as gasoline, coal, etc, solar energy is clean, inexhaustible and free. Photovoltaic System (PV) is getting popular by day as the crude oil price increases and unstable in the global market. Furthermore with green peace movement, and the consciousness of mankind has heightened up regarding green energy, photovoltaic may be one of the solution for better as well cleaner energy as it is naturally harness from the Sun energy.

The photovoltaic provide one of the most efficient way of producing energy with real perspective in the future considering the actual situation of the classical power resources Around The World usually when a PV module is directly connected to the load the operating point is rarely at the maximum power point or mpp the PV array is and regulated DC power source which has to be properly condition in order to Interface it to the state that is of the DC Converter is presented at the PV array output for mppt purpose that is for extracting the maximum available power for a given insulation level.

The mppt is used for extracting the maximum power from the Solar PV module and transferring That Power to the load. Dc-dc converter serve the purpose for transferring that Power to the load dc-dc converter serve the purpose of transferring maximum power from the Solar PV module to the load dc-dc converter act as an interface between the load and the module changing the duty cycle the load impedance as seen by the source is varied and matched at the point of the peace power with the source so as you transfer the maximum power.

Therefore MPPT technique is required to obtain maximum power from a PV system mppt is used in photovoltaic system to maximize the photovoltaic array output power irrespective of the temperature and radiation condition and of the lord electrical characteristics with the use of dc-dc converter like buck converter boost converter and buck boost configurations

II. MATHEMATICAL MODEL

The building block of PV arrays is the solar cell, which is basically a p-n semiconductor junction, shown in Fig.1. The V-I characteristic of a solar array is given by Eq. (1)

$$I = I_{ph} - Io\ [|e^{q(V+I.\frac{Rs}{akT})}\ ] - (\frac{V+I.Rs}{Rp}). (1)$$

Where:

- V and I represent the output voltage and current of the
- Rs and R pare the series and shunt resistance of the cell.
- q Is the electronic charge.
- Ip his light-generated current.
- Io is the reverse saturation current.
- Alpha is a dimensionless factor.
- K is the Boltzmann constant, and Tk is the temperature in

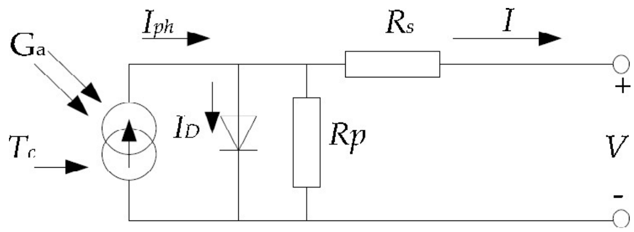

Figure 1: Equivalent circuit of PV array

Equation (1) was used in computer simulations to obtain the output characteristics of a solar cell, as shown in Figure 2. This curve clearly shows that the output characteristics of a solar cell are non-linear and are crucially influenced by solar radiation, temperature and load condition [2,5]. Each curve has a MPP, at which the solar array operates most efficiently

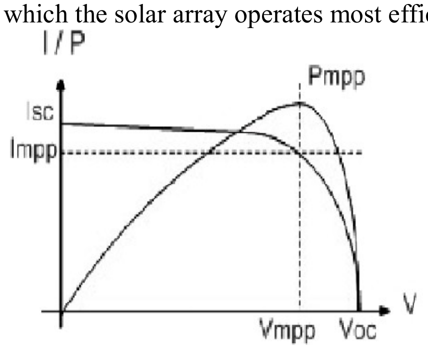

Figure 2: I/P-V characteristic of a solar cell

III. BOOST CONVERTER

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).

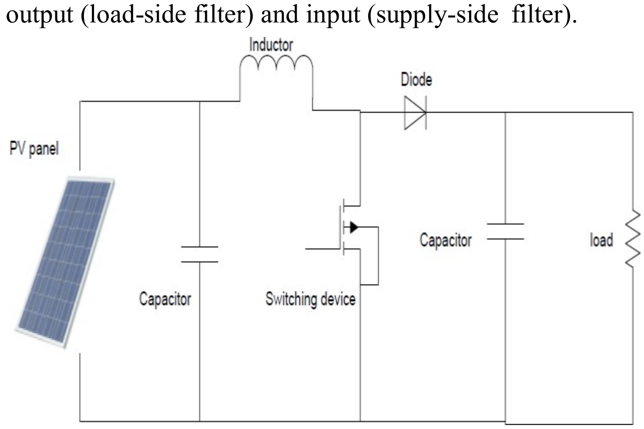

Figure 3: Boost converter

IV. PROPOSED MPPT ALGORITHM

Maximum power point tracking, or MPPT, is the automatic adjustment of the load of a photovoltaic system to achieve the maximum possible power output. PV cells have a complex relationship between current, voltage, and output power, which produces a non-linear output. This output is expressed as the current-voltage characteristic of the PV cell. Constant fluctuations in external variables such as temperature, irradiance, and shading cause constant shifts of the I-V curve upwards and downwards. A change in temperature will have an inversely proportional effect on output voltage, and a change in irradiance will have a proportional affect on output current [1]. The maximum power point tracking (MPPT) can be addressed by different ways, for example: fuzzy logic, neural networks and pilot cells.

Nevertheless, the perturb and observe (P&O) and Incremental Conductance (INC) techniques are widely used, especially for low-cost implementations. The P&O MPPT algorithm is mostly used, due to its ease of implementation. It is based on the following criterion: if the operating voltage of the PV array is perturbed in a given direction and if the power drawn from the PV array increases, this means that the operating point has moved toward the MPP and, therefore, the operating voltage must be further perturbed in the same direction. Otherwise, if the power drawn from the PV array decreases, the operating point has moved away from the MPP and, therefore, the direction of the operating voltage perturbation must be reversed [6].

The MPP tracker operates by periodically incrementing or decrementing the solar array voltage. If a given perturbation leads to an increase (decrease) the output power of the PV, then the subsequent perturbation is generated in the same (opposite) direction. In Fig.6, set Duty out denotes the perturbation of the solar array voltage, and Duty+ and Duty_ represent the subsequent perturbation in the same or opposite direction, respectively[2,5].

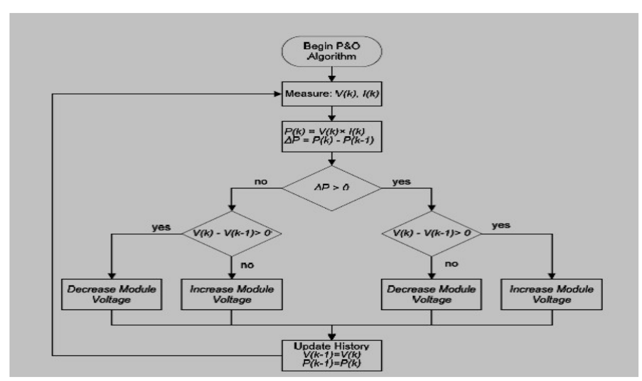

Figure 4: P&O Algorithm

V. SIMULATION

The modelling and simulation of the system (photovoltaic generator, boost converter and MPPT algorithm P&O) is then made with Mat lab/Simulink software to validate the control strategy and evaluate the performance of the system. Fig. 5

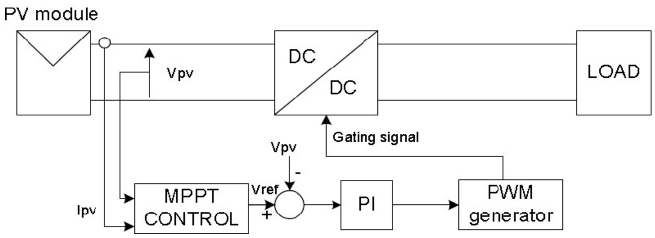

Figure 5: System simulation model

We show that the MPPT control forces the system to work optimally at all times around the maximum power point

Simu link model of the photovoltaic system with MPP

The maximum power point controller block is shown in Fig. 4.8 The voltage and the current of the photovoltaic array are the input, and the duty cycle is the output.

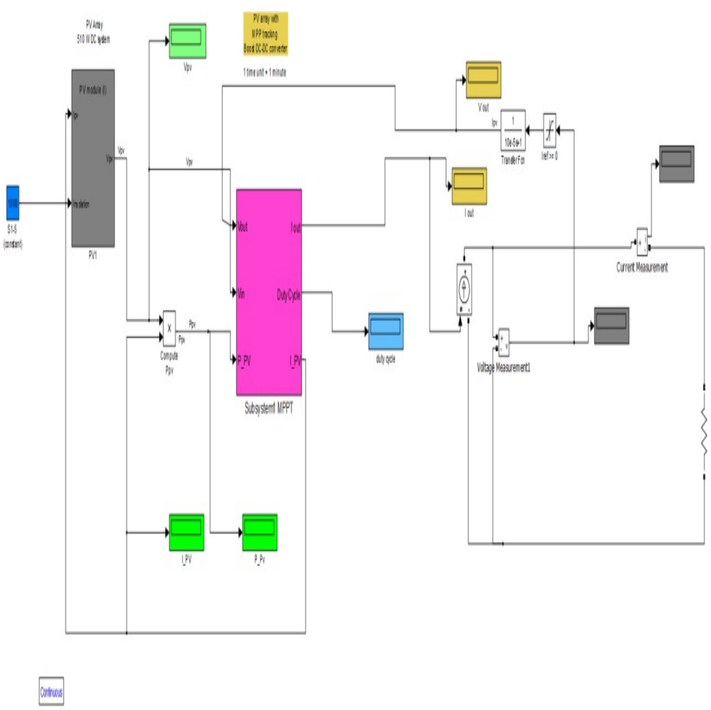

Figure 6: Simulation of the PV system with MPPT

The duty cycle is compared to a triangle wave signal to generate the PWM. The frequency of the triangle wave is the pulsation frequency of the boost converter.

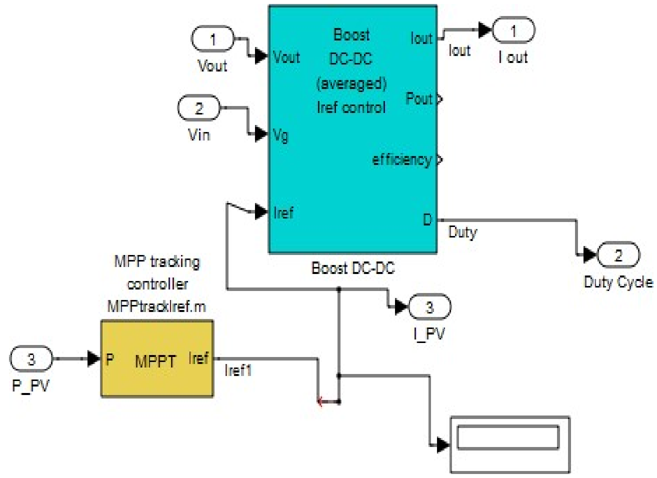

Figure 7: Simulation of the DC to dc converter with MPPT

The perturb and observe algorithm is implemented and shown in Fig. 4.9. The duty cycle is increased or decreased until the maximum power point of the photovoltaic is reached. The step of the duty cycle is constant, and it determines the efficiency and accuracy of the MPPT controller.

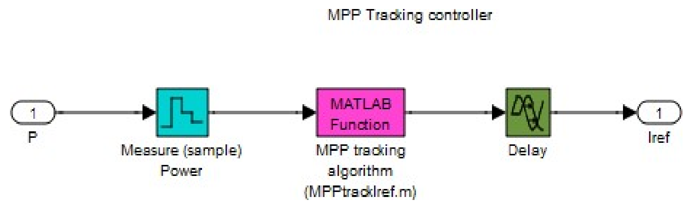

Figure 8: Simulation of the perturb and observe algorithm

This simulation presents an analysis of the photovoltaic array with boost converter and resistive load. The temperature, irradiance and load, are varied to determine the performance of the MPPT and track the maximum power of the PV. The major component of Grid-tied PV system is the GTI which along with regulating the voltage and current received from solar panels ensures that the power supply is in phase with the grid power. On AC side, it keeps the sinusoidal output synchronized to the grid frequency (nominally 50Hz). The voltage of the inverter output needs to be variable and a touch higher than the grid voltage to enable current to supply the loads in the house or even supplies excess power to the utility

Photovoltaic array characteristics

(I) the I-V and P-V characteristics of single cell

Fig shows the I-V and P-V characteristics and table shows the maximum power point of the single cell at the different insulation **1000W/m2**

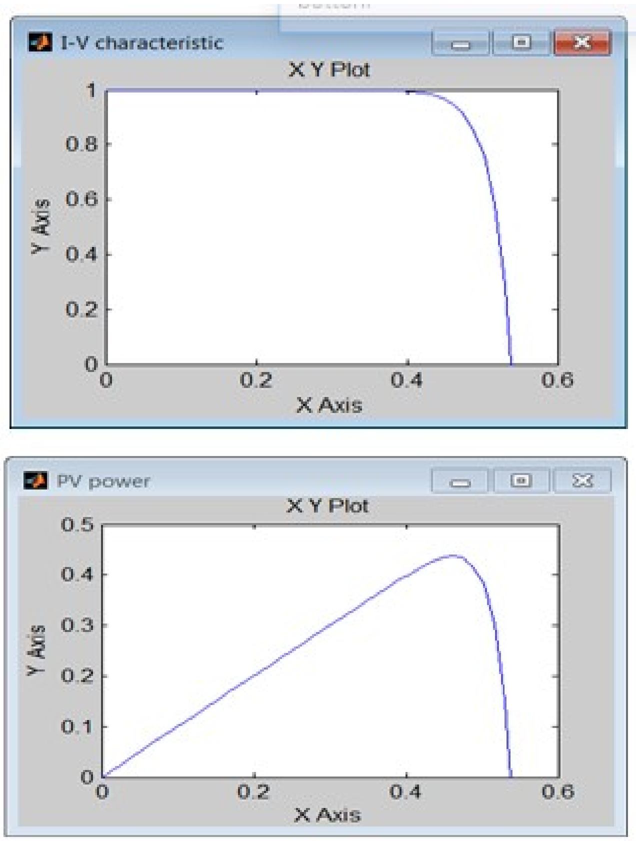

Figure 9: I-V curve and P-V curve of the BP MSX 120 modules 800W/m2

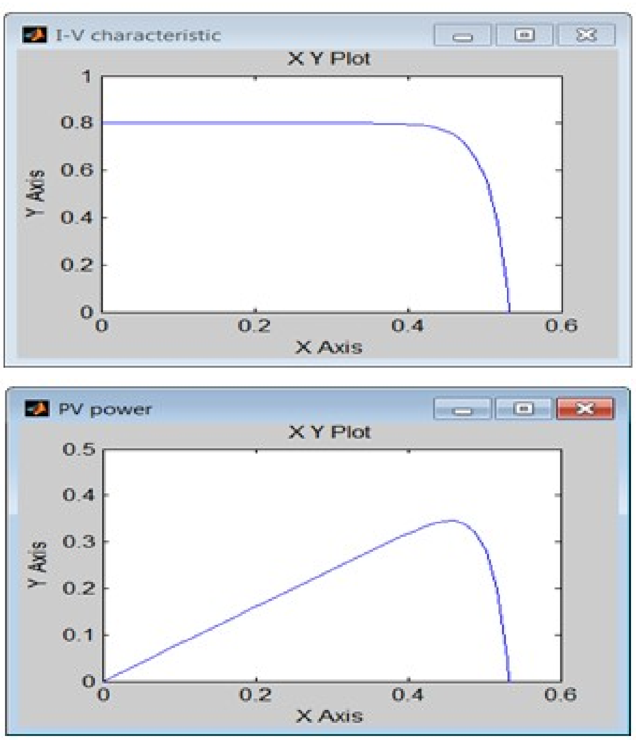

Figure 10: I-V curve and P-V curve of the BP MSX 120 modules 600W/m2

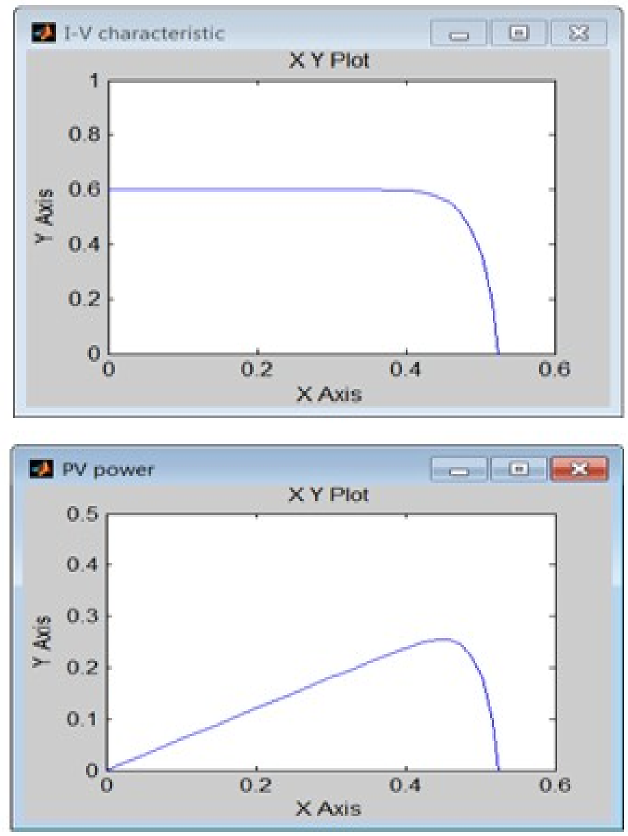

Figure 11: I-V curve and P-V curve of the BP MSX 120 module

Table 1: Photovoltaic Module Maximum Power Point Values at 1000, 800 & 600w/M2

Ratting	MPP power	MPP Voltage	MPP Current
$1000W/m^2$	0.4378	0.46	0.9517
$800W/m^2$	0.3458	#######	0.7517
$600W/m^2$	0.255	#######	0.5718

The photovoltaic model used is the NE-80EJEA. It has a maximum power output 80 W. The table 5.2 gives the characteristic of the module NE-80EJEA at STC 25C.

(I) Photovoltaic system with a Boost converter

The simulation presents an analysis of the photovoltaic array 26000W with the boost converter. The PV system parameters are:

DC bus voltage Vdc: 400 V

The boost parameters are calculated and the inductance and capacitance values are given below. The boost input voltage nominal is 400 V and, the output voltage is 500 V

R-L type load

Table 2:

R= 100*100/6000 = 1.666 Ω,

L= 1 0 0 *100/6000 = 1.666 H

Input	Output
V_{dc} = 400	V_{dc} = 500
I_{dc} = 372.5	I_{dc} = 298

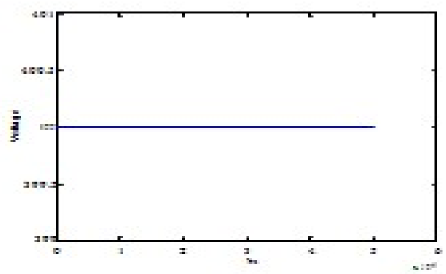

Figure 12: (a) DC I/P Voltage

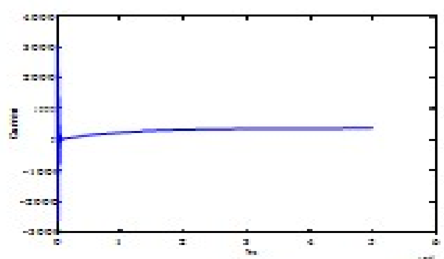

Figure 12 :(b) DC I/P Current

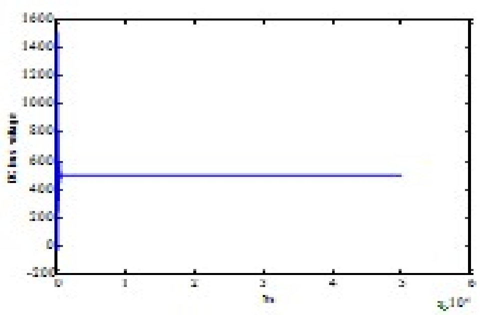

Figure 13: (a) DC Bus Voltage

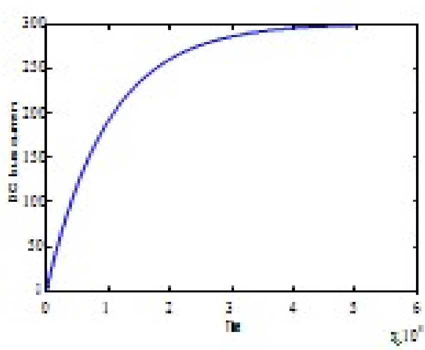

Figure 13 :(b) DC Bus Current

Change input voltage waveform of DC-DC converter with 400 V constant

Table 3: Input /Output

Input	Output
V_{dc} = 450	V_{dc} = 500

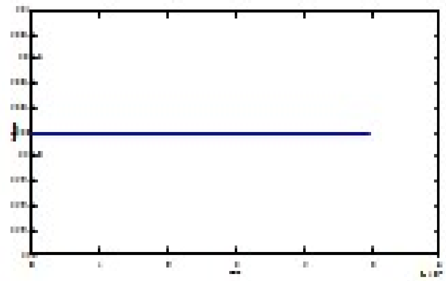

Figure 14: (a) Input Voltage

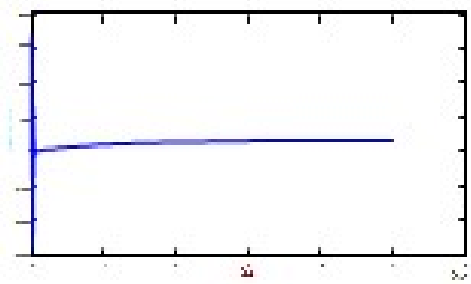

Figure 14: (b) Input Current

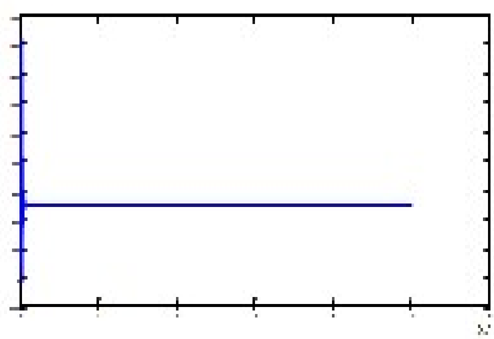

Figure 15: (a) DC Bus Voltage

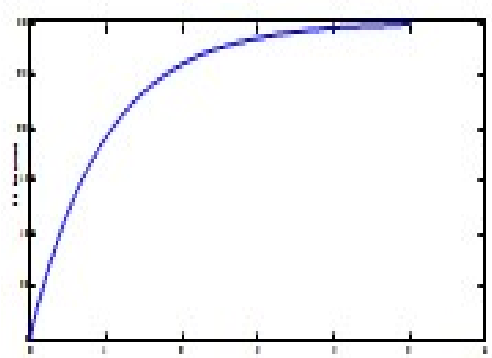

Figure 15: (b) DC Bus Current

(IV) DC-DC converter

Above both the waveform we show that when we change the input voltage there is no effect on output.

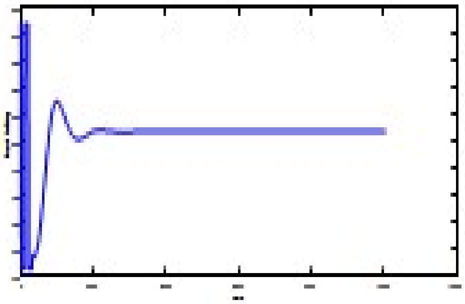

Figure 16 :(a) Input Voltage

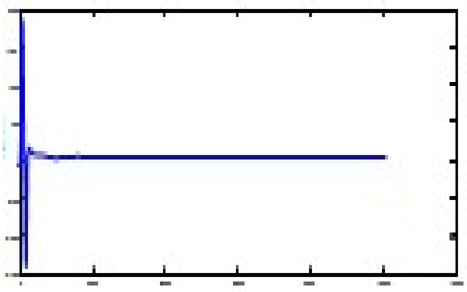

Figure 16 :(b) Input Current

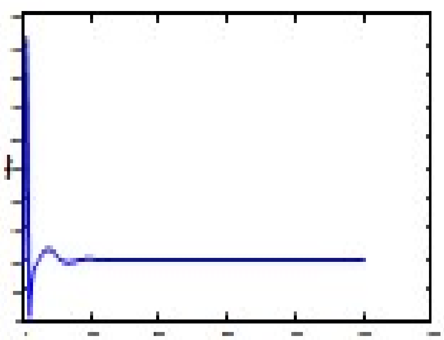

Figure 16 :(a) DC Bus Voltage

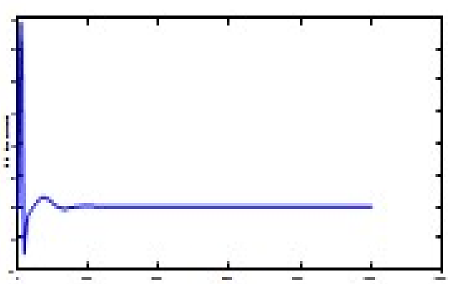

Figure 16: (b) DC Bus Current

Table 4: PV Module Ne-80ejea Data Sheet Values at STC

Short circuit current Isc	5.45 A
Current at maximum power point IMPP	4.95 A
Voltage at maximum power point VMPP	17.6 V
Open circuit voltage Voc	22.2 V
Number cells in series ns	36

The module NE-80EJEA is connected in series and parallel to achieve a maximum power output of 26 kW and output voltage 753 V. Table 5.3.gives the characteristic of the PV for maximum power 26 kW. A PV of 26 KW is made from the NE-80EJEA with 25 modules in series and 10 modules in parallel. The current and voltage at maximum power are respectively 64.49 A and 753 V.

Table 5: Characteristics of 26 KW Photovoltaic

Number of modules in a string series NSS	25
Number of modules in a string parallel NPP	10
Output voltage rating	753 V
Output current rating	64.49 A
Maximum power output	26000W

V. CONCLUSION

In this paper, the study of the photovoltaic system with maximum power point controller has been developed. From the theory of the photovoltaic, a mathematic model of the PV has been presented. Then, the photovoltaic system with DC-DC boost converter; maximum power point controller and resistive load have been designed. Finally, the system has been simulated with Simulink /MATLAB. First, the simulations of the PV panels showed that the simulated models were accurate to determine the characteristics voltage current because the current voltage characteristics are the same as the characteristics given from the data sheet. In addition, when the irradiance or temperature varies, the PV models output voltage current change. Then, the simulation showed that Perturb and observe algorithm can track the maximum power point of the PV, it always runs at maximum power no matter what the operation condition is. The results showed that the Perturb and observe algorithm delivered an efficiency close to 100% in steady state.

The simulations of the PV with maximum power point, boost converter and resistive load were performed by varying the load, the irradiance.

REFERENCES

[1] A Photovoltaic Array Simulation Model for Matlab-Simulink GUI Environment, by Yun Tiam Tan, Student Member, IEEE, Daniel S. Kirschen,Senior Member, IEEE, and Nicholas Jenkins, Senior Member, IEEE.

[2] M.G.Villalva, J.R. Gazoli, E. Ruppert F.Modelling and Circuit Based Simulation of Photovoltaic Arrays University of Campinas-Brazil.

[3] Huan-Liang Tsai "Development of Generalized Photovoltaic Model using Matlab/Simulink, 2008.

[4] I.H. Altas "A Photovoltaic Array Simulation Model for Matlab-Simulink GUI Environment" Dept of Electrical and Electronics Engineering, Karadeniz Technical University, Trabzon, Turkey.

[5] Hasaneen, B.M. and Elbaset Mohammed, A.A., "Design and simulation of DC/DC converter," Power System Conference, 2008. MEPCON 2008. 12th International Middle-East, July 2008, pp. 335 - 340.

[6] Weiping Luo and Gujing Han, "Tracking and controlling of maximum power point application in grid- connected photovoltaic generation system," Second International Symposium on Knowledge Acquisition and Modeling 2009, KAM '09, vol. 3, December 2009, pp. 237 - 240.

[7] Antunes, F.L.M., Santos, J.L., "Maximum Power Point Tracker for PV Systems," World Climate & Energy Event, December 2003.

[8] R.Faranada, S.Leva and V.Maugeri MPPT techniques for PV System; energetic & cost comparison, Member IEEE.

[9] Grid-connected photovoltaic (PV) systems with batteries storage as solution to electrical grid outages in Burkina Faso D Abdoulaye, Z Koalaga, F Zougmore, 1st InternationalSymposiumonElectricalArcandThermalPlasmasinAfrica (ISAPA), IOP Conf. Series: Materials Science and Engineering 29 (2012) 012015.

[10] Zhou Dejia, Zhao Zhengming, Eltawil, M. and Yuan Liqiang; "Design and control of a Three-phase Grid connected Photovoltaic system with developed Maximum power point tracking,"Applied Power Electronics Conference and Exposition, 2008. APEC 2008. Twenty-Third Annual IEEE, May 2008, pp. 973 - 979.

[11] Liang Ma, Wang Ran and Zheng, T.Q., "Modeling and Control of 100 kW Three-phase grid-connected Photovoltaic inverter," Industrial Electronics and Applications (ICIEA), 2010 the 5th IEEE Conference, July 2010, pp. 825 - 830.