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Performance Analysis of Converters using Solar Powered Maximum Power Point Tracking (MPPT) Algorithms

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Abstract: ***The need for renewable energy sources is on the rise because of the acute energy crisis in the world today. This paper provides a comprehensive review of the maximum power point tracking (MPPT) techniques applied to photovoltaic (PV) power system. Photovoltaic (PV) offers an environmentally friendly source of electricity. The PV system can supply the maximum power to the load at a particular operating point which is generally called as maximum power point (MPP), at which the entire PV system operates with maximum efficiency and produces its maximum power. These techniques vary in many aspects such as simplicity, digital or analogical implementation, sensors, convergence speed and range of effectiveness, hardware implementation, popularity and cost in other aspects. This paper presents in particulars comparative study between two most fashionable algorithms performance which is Modified incremental conductance algorithm and perturb and observe algorithm. Two dissimilar converters like boost and sepic are used proportional in this study. Few comparisons such as voltage, current and power output and also PV input for each dissimilar combination has been recorded. Since MPPT is an essential part of a PV system, extensive research has been revealed in recent years in this field and many new techniques have been reported. The simulation will consider as Maximum power point tracking (MPPT) is used in photovoltaic array output power, irrespective of the temperature and radiation condition and of the output power in the dc-dc converter (boost and sepic). Thus reducing the complexity of the system, this MPPT algorithmic methods which is based on use of perturb and observe (P & O) and incremental conductance (INC) have been proposed with the PV panel to determine an optimum operating current for the maximum output power.***

Keywords: Photovoltaic array, Maximum power point tracking (MPPT) Algorithms, P & O, INC, boost converter and sepic.

I. INTRODUCTION

Due to the growing demand on electricity, the limited stock and rising prices of conventional sources (such as coal and petroleum, etc.), photovoltaic (PV) energy becomes a promising alternative as it is universal, freely available, environment friendly, and has less operational and maintenance costs [1]. The Solar energy is a renewable, inexhaustible and ultimate source of energy. If it is used in a proper way, it has a capacity to fulfil numerous energy needs of the world. The power from the sun intercepted by earth is approximately 1.8 x 1011MW [2]. PV module represents the fundamental power conversion unit of a PV generator system. The output characteristics of PV module depends on the solar isolation, the cell temperature and output voltage of PV module.

Since PV module has nonlinear characteristics, it is necessary to model it for the design and simulation of maximum power point tracking (MPPT) for PV system applications [4]. Therefore, controlling maximum power point tracking (MPPT) for the solar array is essential in a PV system [6]. A PV's maximum power point (MPP) varies with solar insulation and temperature. Its V-I and V-P characteristic curves specify a unique operating point at which maximum possible power is delivered [3]. At the MPP, the PV operates at its highest efficiency. In general, a

power source is operated in conjunction with a dc-dc power converter (boost and sepic), whose duty cycle is modulated in order to track the instantaneous MPP of the PV source [7]. There are several methods and controllers that have been widely developed and implemented to track the MPP. In the last years researchers and practitioners in PV systems have presented survey or comparative analysis of MPPT techniques. The various MPPT techniques are Perturb and Observe (P&O) method [6], Incremental Conductance(IC) method[10], Artificial Neural Network method , Fuzzy Logic method [9], Constant Voltage , Three Point weight Comparison , short Current Pulse , Open Circuit Voltage , the temperature method. In MPPT, most control schema use the P&O technique because it is easy to implement. But the oscillation problem is unavoidable [6]. An incremental conductance (INC) MPPT method that is implemented by detecting the harmonic comparative analysis of MPPT techniques, the various MPPT techniques are Perturb and Observe (P&O) method [6], Incremental Conductance(IC) method[10], Artificial Neural Network method , Fuzzy Logic method [9], Constant Voltage , Three Point weight Comparison , short Current Pulse , Open Circuit Voltage , the temperature method. In MPPT, most control schema use the P&O technique because it is easy to implement. But the oscillation problem is unavoidable [6]. An incremental conductance (INC) MPPT method that is implemented by detecting the harmonic components of the PV module voltage and current was first proposed to track accurately the peak power of PV systems that are subjected to random variations in isolation.

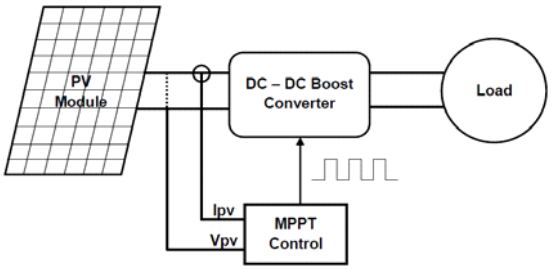

Fig. 1 Typical diagram of MPPT in a PV System

Hence, in this paper a P & O and INC MPPT technique is proposed [7]. These maximum power point techniques are faster and also it can minimize the voltage fluctuation after MPP has been recognized. The circuit diagram of photovoltaic system is shown fig. 1. The PV system is modelled using power system block set under MATLAB / SIMULINK. The MPPT algorithms are modelled using MATLAB function system.

II. PHOTOVOLTAIC MODULE AND ARRAY MODEL

The model of solar cell can be categorized as p-n Semiconductor junction. When exposed to light, the DC current is generated. As known by many researchers, the generated current depends on solar irradiance, temperature, and load current. The typical equivalent circuit of PV cell is shown in Fig. 2. The basic equations describing the I-V characteristic of the PV model are given in the following equations:

$$0 = Isc - Id^{(-Vd/Vt)} - Ipv \quad (1)$$

$$Id = Io\,(e^{Vd/Vt} - 1) \quad (2)$$

$$Vpv = Vd - Rs\,Ipv \quad (3)$$

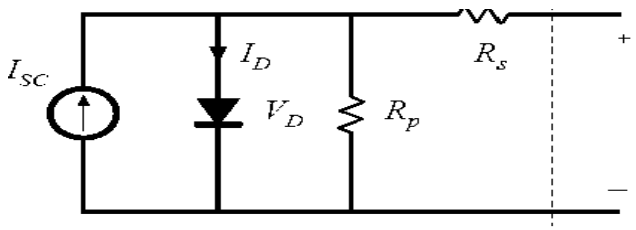

Fig. 2 Typical circuit of PV solar cell

Where:

- I_{PV} is the cell current (A).
- I_{SC} is the light generated current (A).

- I_D is the diode saturation current (A).
- *Rs* is the cell series resistance. (Ω)
- *R p* is the cell shunt resistance (Ω)
- *Vd* is the diode voltage (V).
- *Vt* is the temperature voltage (V).
- *Vp* is the cell voltage (V).

III. MAXIMUM POWER POINT TRACKING TECHNIQUES

The output power of the solar PV module changes when the changes in direction of the sun, change in solar isolation level and change in temperature. Here the modified and also the most common algorithms of P& O and the incremental conductance methods have been described. The modified Incremental Conductance method offers the main advantage of providing high efficiency, voltage under rapidly changing atmospheric conditions, so it has been employed in the proposed model. However in this paper another MPPT algorithm such as modified P&O could be used to formulate the comparative analysis.

a. Modified Perturb and Observation Technique (P&O)

One of the most simple and popular techniques of MPPT is the P&O technique. The main concept of this method is to push the system to operate at the direction in which the output power obtained from the PV system will be increased. Following Fig.3 shows the Flowchart of the P&O which describes the change of output power according to the changes of the PV panel parameters.

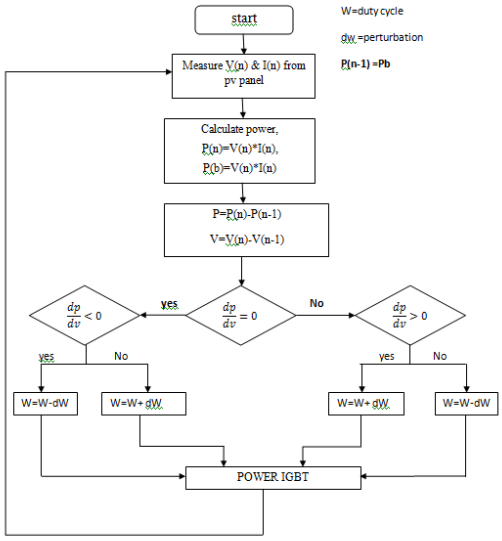

Fig. 3 Flow Chart of the P&O Method.

If the change of power is positive, the system will keep the direction of the incremental current (increase or decrease the PV current) as the same direction, and if the change is negative, the system will change the direction of incremental current command to the opposite direction. This method works well in the steady state condition (i.e the radiation and temperature conditions change slowly). However, the P&O method fails to track MPP when the atmospheric condition is rapidly changed.

b. Modified Incremental Conductance (Inc-Cond) Technique:

This method exploits the assumption of the ratio of change in output conductance is equal to the negative output conductance of instantaneous conductance. Thus, MPP can be tracked by comparing the instantaneous conductance to the incremental conductance. It is the same efficient as P&O, good yield under rapidly changing atmospheric conditions.

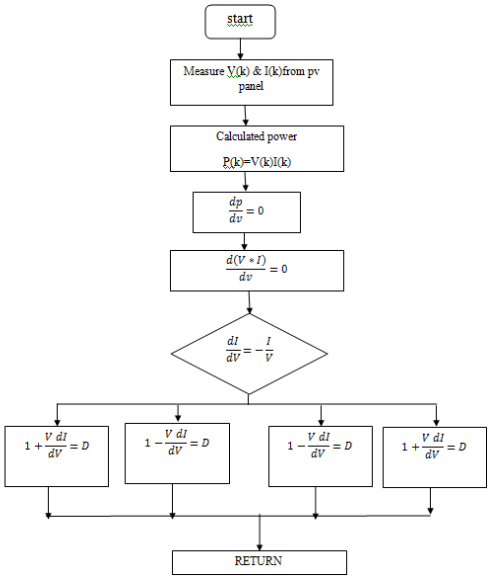

Fig. 4. Flow Chart for INC Method.

Here in this modified INC method, also the same perturbation size problem as the P&O exists but an attempt has been made to solve and increase the output power by taking more numbers of variable step sizes through incrementing and decrementing the conductance by MATLAB function. But, it requires complex and costly control circuits.

IV. Proposed Model of the System

The proposed perturb and observe (P &O), incremental conductance (INC) algorithm based MPPT technique has been modelled and simulated using MATLAB/SIMULINK software. Fig.5 shows our developed MATLAB/SIMULINK model for perturb and observe (p & o) method with boost converter. Fig.7 shows our modified incremental conductance (INC) method based on DC-DC boost converter techniques.

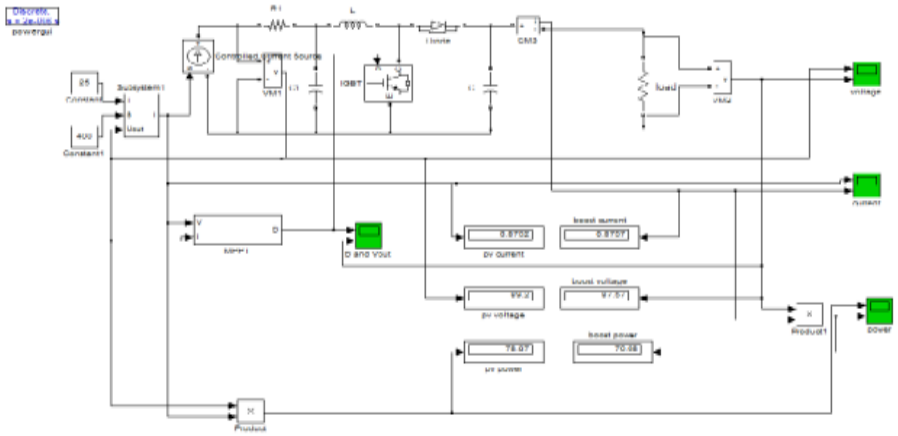

Fig. 5 The simulation diagram for perturbs and observation using boost converter.

The simulation diagram shows that connections of boost converter getting gate signal from MPPT output loops. Here MPPT are using feedback connection and followed p & o algorithms techniques.

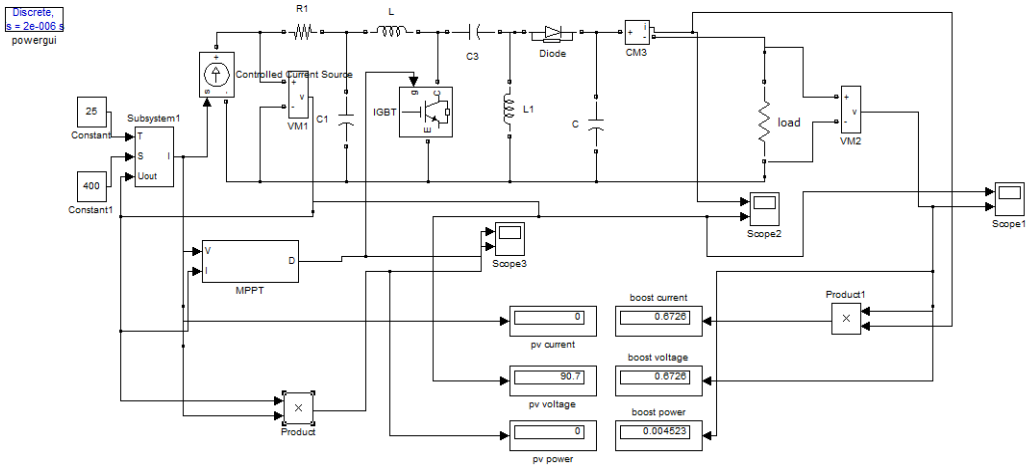

Fig. 6 The simulation diagram for perturb and observation using sepic converter

Here followed new type of converter as sepic converter. Similarly Sepic converter working operation is like as boost converter method. The feedback loop of MPPT algorithms is involved in p & o techniques like as improved power and voltage.

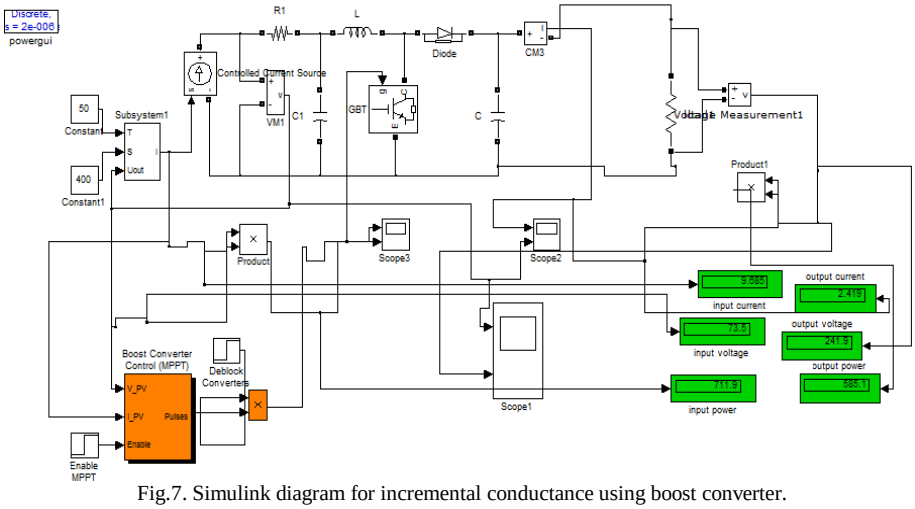

Fig.7. Simulink diagram for incremental conductance using boost converter.

The simulation diagram is shows that the boost converter operation and feedback loop connection of MPPT method are presented in incremental conductance algorithms. When compare with p & o method, the Incremental conductance having output of higher voltage, power and efficiency. But working operation is smaller complex.

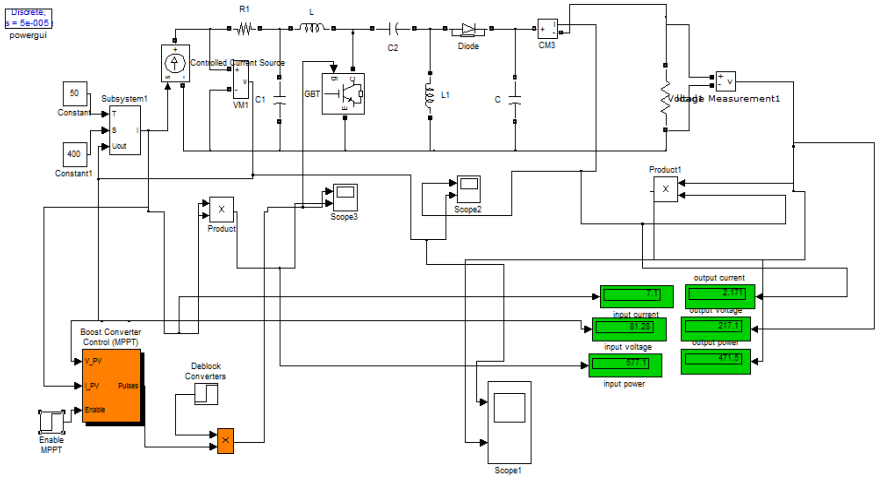

Fig. 8. Simulink diagram for incremental conductance using sepic converter.

The sepic converter is followed in this simulation method. Here MPPT method followed Incremental conductance algorithm. The four simulation methods are involved in Input side measurement of PV panel voltage, current, power. The output

voltage, current, power of PV panel is given to boost and Sepic converters. Here to control the output of the PV panel the current controlled device is connected in boost and sepic converter circuit. The output characteristics of power, current, voltage are separately displayed to make comparison both for boost and sepic converters in the Simulink diagram.

V. SIMULATION RESULTS AND DISCUSSION

All the simulation results for every converter have been recorded to make sure the comparison of the circuit accurately.

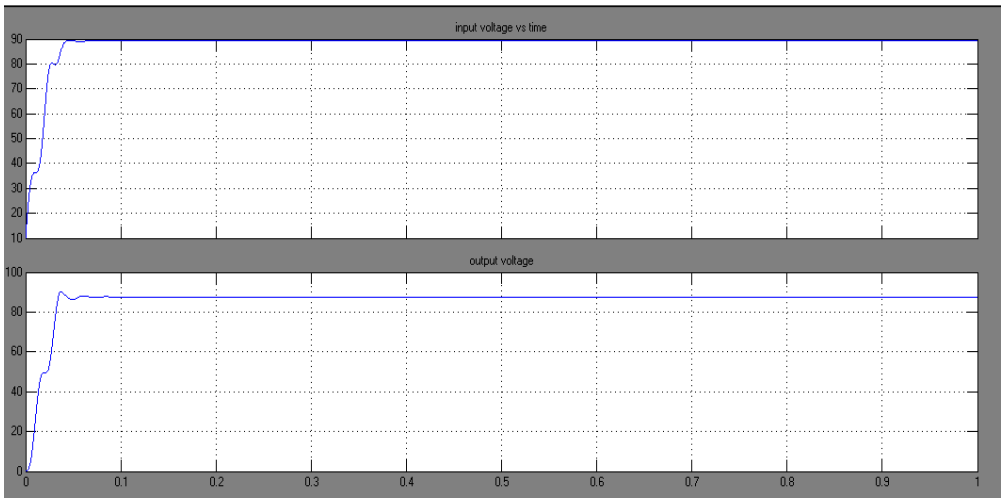

Fig. 9 Input and Output voltage of PV with perturb and observation method using boost converter.

Fig.9 shows that the input and output voltage of PV with perturbs and observation using boost converter. Here the PV panel input voltage is taken as 87V and using MPPT algorithms of perturb &observation the output voltage is raised to 89V.

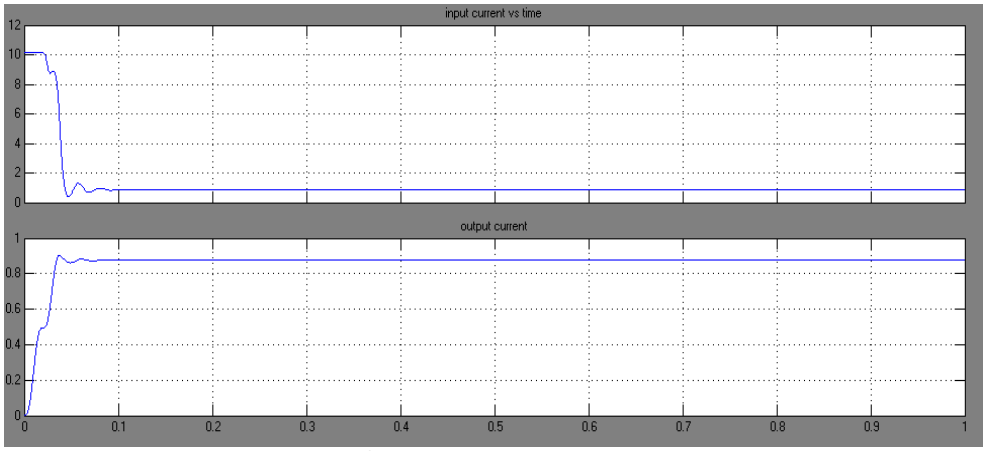

Fig. 10.Input and Output Current of PV with perturb and observation method using boost converter.

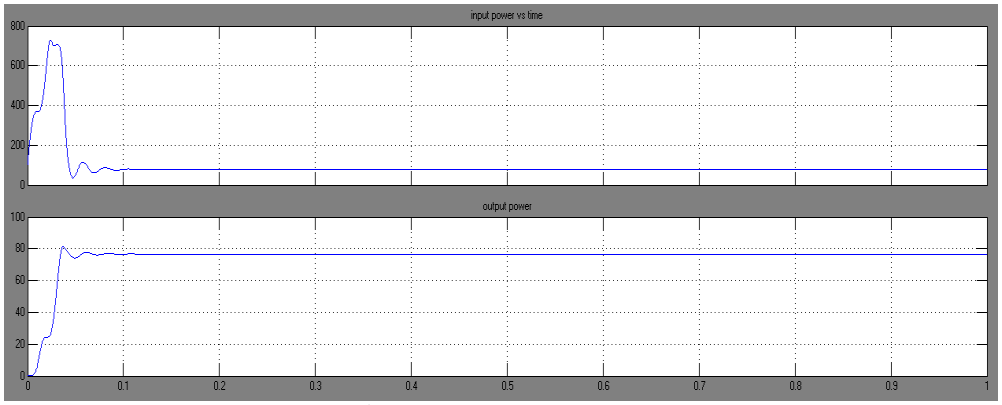

Fig. 11.input and Output power of PV with perturb and observation method using boost converter.

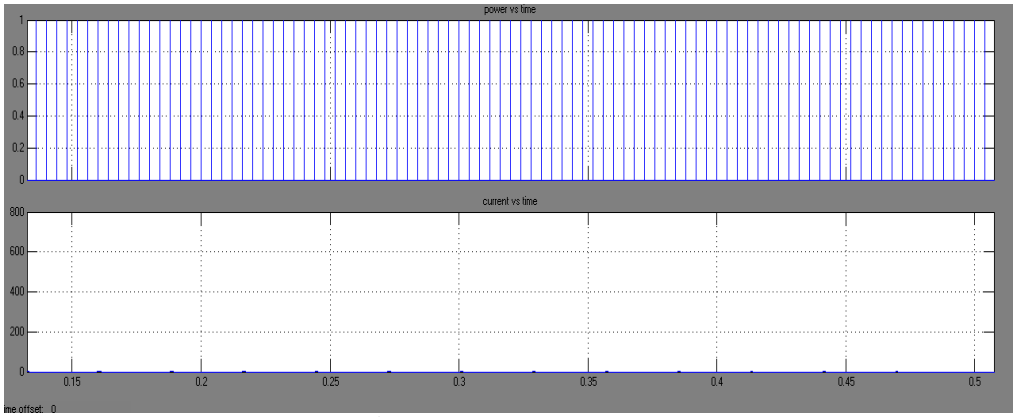

Fig.12.Power and Current for perturb and observation method using sepic converter.

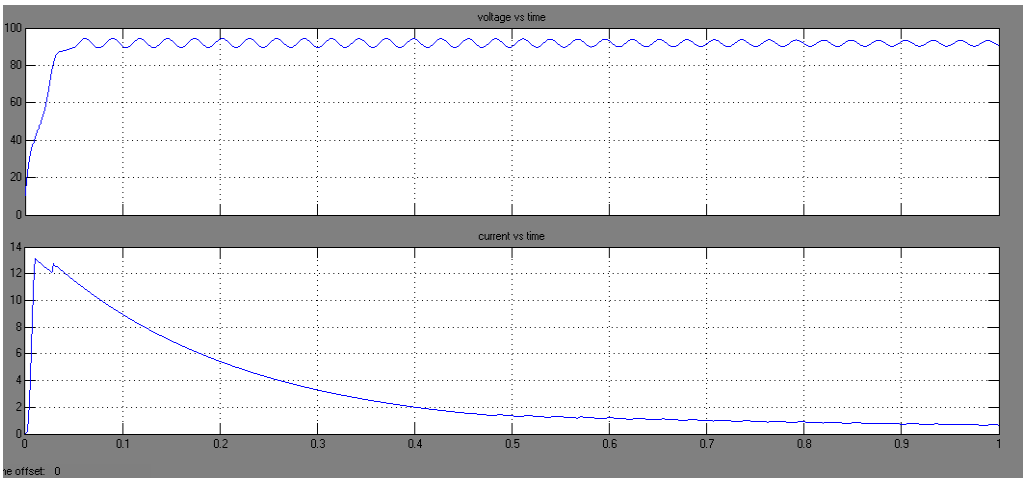

Fig. 13.PV voltage and current with perturb and observation using sepic converter.

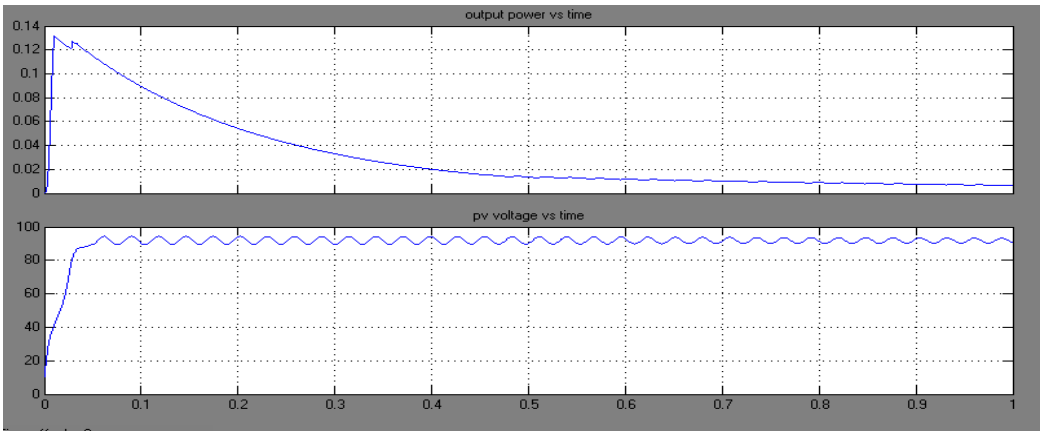

Fig. 14.output power and voltage with perturb and observation using sepic converter.

The PV panel input power is 0.3W and using MPPT algorithms in perturb observation getting output voltage is 67W. Here the current, voltage and power of the pv panel are mainly considered for comparing the MPPT algorithms such as P&O and INC. Also these electrical parameters with these two algorithms have been analyzed using boost and sepic converters.

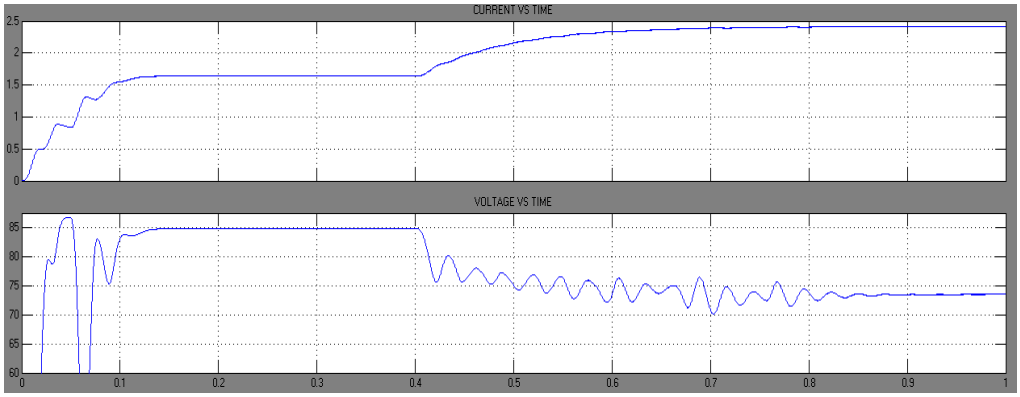

Fig. 15.Output voltage and current with incremental conductance method using boost converter.

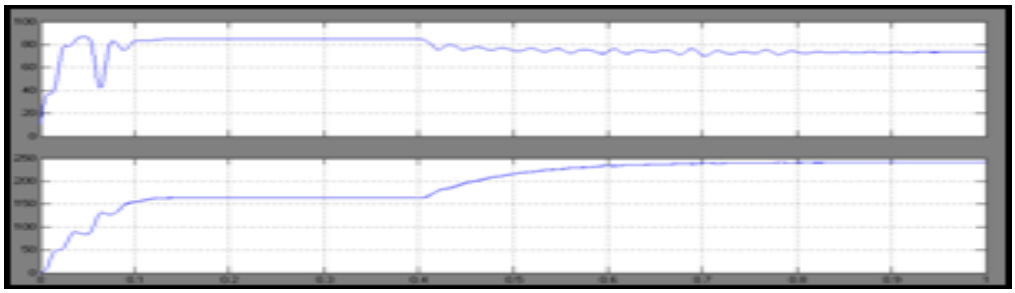
Fig.16. Input and output voltage with incremental conductance method using boost converter.

Fig.16 shows input and output of PV panel with INC method using boost converter. The PV panel input voltage is 80 V but by using MPPT algorithm of incremental conductance method, the output voltage becomes 240 V.

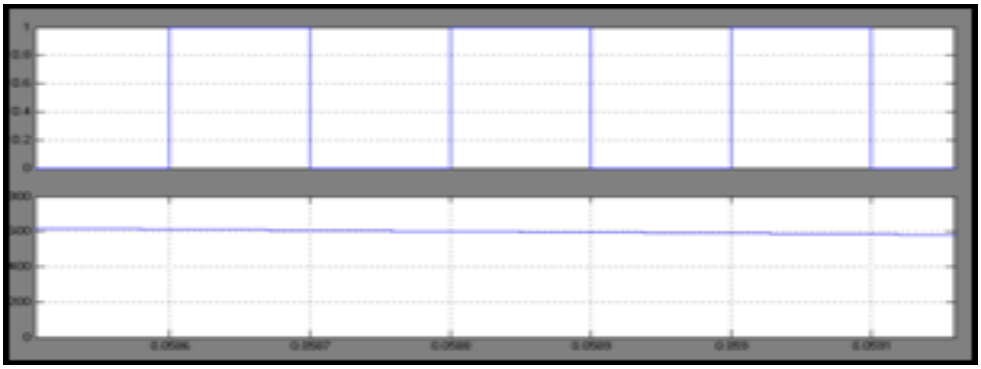
Fig.17. Input and output power with incremental conductance method using boost converter.

From the above result it can be observed that the PV panel input power is 400W and by using MPPT algorithms of incremental conductance method, the output power is increased to 585W.

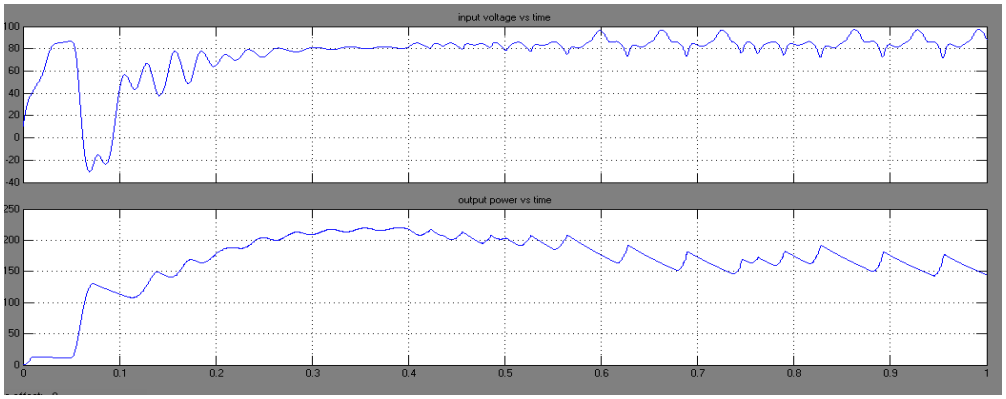

Fig.18 Input voltage and output power of incremental conductance using sepic converter.

Here the PV panel input voltage is 89V and using MPPT algorithms with incremental conductance method of algorithm the output power is reached to 209W.

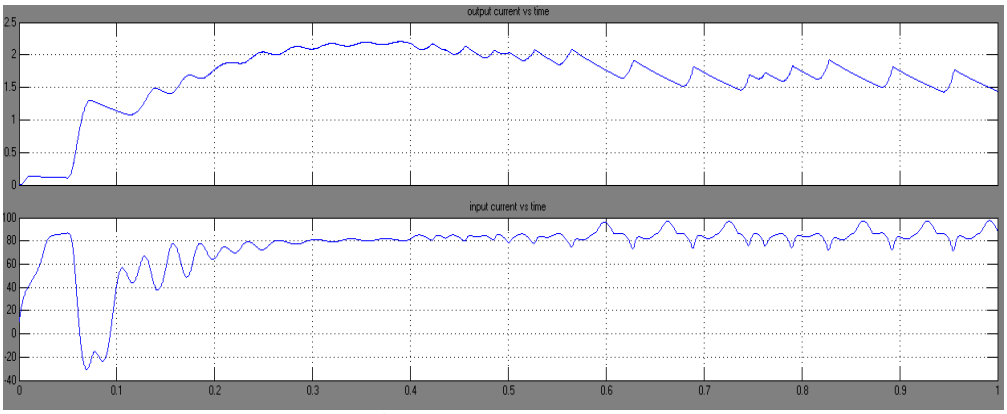

Fig.19. Input and output current of incremental conductance method using sepic converter.

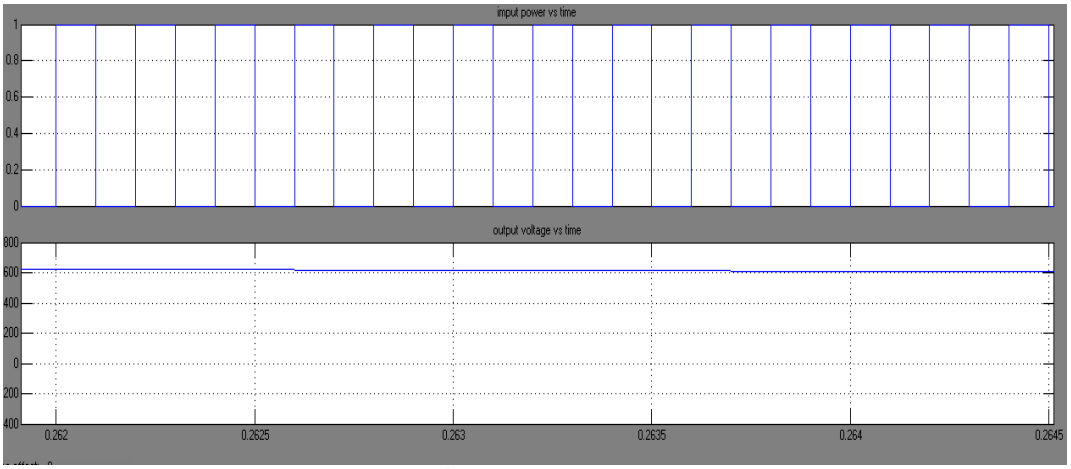

Fig. 20. Output power and voltage of incremental conductance method using sepic converter.

Here the PV panel input power is 0.2W and by using incremental conductance MPPT algorithm output power becomes 145V. From the Simulink diagram and graphical outputs of the above all comparative study has been made and tabulated as shown in table.1.

Tabulation		**Pv input**			**Pv input(ref. mppt)**			**Converter output**		
Algorithms	converter	power	voltage	current	power	voltage	current	Power	voltage	current
P & o	Boost	6	12	0.5	75	89	9	67	87	0.9
	Sepic	6	12	0.5	726	77	9.4	620	249	2.4
Inc	Boost	6	12	0.5	400	80	9	585	240	2.5
	Sepic	6	12	0.5	710	72	9.8	552	234	2.3

Table:1. Comparison of P&O and INC using boost and sepic converters

In this paper it has been analysed and found that the incremental conductance method using boost giving best results when compare with P&O technique with sepic and boost converters.

VI. CONCLUSION

In general, the effectiveness of MPPT is theoretically defined as a ratio of the practical power output to the true maximum power value. In this paper it has been presented a comparison among the different MPPT techniques for the PV system using

(i.e.perturb and observe (p & o), incremental conductance (INC)) using boost and sepic converters. A high voltage gain boost and sepic converters has been presented in this paper for getting improved outputs. Here it has been concluded that the proposed incremental conductance based MPPT technique can track the maximum power in faster rate when compared with the P&O based MPPT technique with boost converter. Also, it has the capability of reducing the voltage fluctuation after MPP has been recognized and the simulation results shown the efficiency of the INC controller in maintaining the stable maximum power point with boost converter.

References

1. Bidyadhar subudhi and raseswari pradhan "A Comparative study on maximum power tracking techniques for photovoltaic power system". In IEEE trans. Sustainable energy, vol. 4, no 1.1, January 2013.
2. Enrico Bianconi and Carlos Andrés Ramos-Paja "A Fast Current-Based MPPT Technique Employing Sliding Mode Control" In IEEE trans. industrial electronics, vol. 60, no. 3, march 2013.
3. Lakhdar Belhadji and Seddik Bacha "Adaptive MPPT Applied to Variable-Speed Micro hydropower Plant" In IEEE trans. energy conversion, vol. 28, no. 1, march 2013.
4. Weidong Xiao and Peng Zhang "Statistic and Parallel Testing Procedure for Evaluating Maximum Power Point Tracking Algorithms of Photovoltaic Power Systems" In IEEE trans. photovoltaic's, vol. 3, no. 3, July 2013.
5. Yuan-Chih Chang and Chia-Ling Kuo "Development and Operational Control of Two-String Maximum Power Point Trackers in DC Distribution Systems" In IEEE trans. power electronics, vol. 28, no. 4, April 2013.
6. Guan-Chyun Hsieh and Hung-I Hsieh "Photovoltaic Power-Increment-Aided Incremental-Conductance MPPT With Two-Phased Tracking" In IEEE trans. power electronics, vol. 28, no. 6, June 2013.
7. Oscar López-Lapeña and Maria Teresa Penella "A New MPPT Method for Low Power Solar Energy Harvesting" In IEEE trans. Industrial electronics, vol. 57, no. 9, September 2010.
8. Shuai Jiang and Yuan Li "Grid-Connected Boost-Half-Bridge Photovoltaic Micro inverter System Using Repetitive Current Control and Maximum Power Point Tracking" In IEEE trans. power electronics, vol. 27, no. 11, November 2012.
9. Trishan Esram and Patrick L. Chapman "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques" In IEEE trans. energy conversion, vol. 22, no. 2, June 2007.
10. Hairul Nissah Zainudin and Saad Mekhilef "Comparison Study of Maximum Power Point Tracker Techniques for PV Systems" In IMEPCON'10. Power systems, vol 19 December 2010.
11. Kinal Kachhiya and Makarand Lokhande "MATLAB/Simulink Model of Solar PV Module and MPPT Algorithm" In NCRTET.volt 13-14 may 2011.
12. Pongsakor Takun and Somyot Kaitwanidvilai "maximum power point tracking using fuzzy logic control for photovoltaic systems" In IMECS, computer science, volt 2, march 2012.
13. S. Karthika and P. Rathika "Fuzzy Logic Based Maximum Power Point Tracking Designed for 10kW Solar Photovoltaic System" In IJCSMR, volt 2, Feb. 2012.
14. Chokri Ben Salah, Mohamed Ouali, "Comparison of fuzzy logic and neural network in maximum power point tracker for PV systems", Science Direct Electric Power Systems Research, July 2010, pp.43–50.
15. C.Thulasiyammal, R.Shylaja, " An effective method of solar tracking system using microcontroller" Journal of The Institution of Engineers, Vol 89,Nov 2008.

