ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.5

# Comparison of P&O and IC controller for Maximum Power Point Tracking of Photovoltaic Array with Grid Connected System

Sandeep kumar singh[1], Dr. Jyoti shrivastava[2]
M.Tech Scholar[1], Assistant Professor[2]
Department of Electrical Engineering
SSET, SHUATS Allahabad, UP, India

**Abstract:**
Now days the tracking of maximum power point techniques are mostly used for photovoltaic (PV) array systems, to track the peak power output which is greatly depends on environmental condition (mainly irradiance & temperature) and load variation. This paper presents in comparative study of Tracking Power between two most popular algorithms technique which is incremental conductance algorithm and perturb and observe algorithm at variable temperature and variable irradiation using the SEPIC converter with Grid connected. And Simulation results compared with the perturbation and observation (P&O) technique and proposed Increment Conduction technique and show the effectiveness of the Increment conduction controller during steady-state and varying environmental conditions.

**Keywords:** Photo-Voltaic Array, SEPIC converter, Maximum Power Point Tracking, Grid-Connected Inverter, Grid System.

## I. INTRODUCTION

Energy plays an important Role in our daily Life activities. There is large increase in Population, urbanization and industrialization. There is increase in demand too that is increase day by day. More over it is assumed that this Fossil Fuel will be depleted in few hundred years. The phenomenon of increasing the rate of energy consumption and supply is decreasing that result into energy shortage. Solar energy is viewed as clean and renewable source of energy for the future. Photovoltaic source are widely used today in many applications such as battery charging, water heating system, satellite power system, and others applications. A MPPT is used for extracting the maximum power from the solar PV module and transferring that power to the load [1, 2]. A SEPIC converter [10] (step up/ step down) serves the purpose of transferring maximum power from the solar PV module to the load. A dc/dc converter acts as an interface between the load and the module. By changing the duty cycle the load impedance as seen by the source is varied and matched at the point of the peak power with the source so as to transfer the maximum power. Figure 1 shows the block diagram of the proposed model.

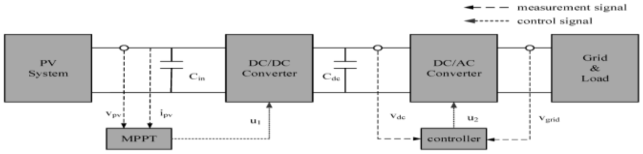


**Figure.1. Block diagram of proposed model**

The MPPT techniques are needed to maintain the PV arrays operating at its MPP [3]. Many MPPT techniques have been proposed in the literature; example are the Perturb and Observe (P&O) methods [1, 3-6], Incremental Conductance (IC) methods [4, 7-9], Fuzzy Logic Method [1, 3, 8], etc. In this paper two most popular of MPPT technique (Perturb and Observe (P&O) methods and Incremental Conductance methods) and SEPIC converter will involve in comparative study with Grid connected system and compare the tracking capability of these two controllers.

### PV Module:

Solar PV is a semiconductor device consisting of an array of cells which directly converts solar radiation into electricity without any intermediate steps. Higher the intensity of the sunlight, the more the amount of electricity generated from PV cell. The photovoltaic (PV) generator consists of solar cells normally connected in series and parallel fashion to provide voltage and current required by the load. This PV generator exhibits a nonlinear voltage versus current characteristic that depends on the enviourmental condition as show in figure (2). A 100-kW PV 330 Sun Power modules (SPR-305) is chosen for a MATLAB simulation.. The array consists of 66 strings of 5 series-connected modules connected in parallel (66*5*305.2 W= 100.7 kW).

### Manufacturer specifications for one module are:

Number of series-connected cells: 96
Open-circuit voltage: $V_{oc}$= 64.2 V
Short-circuit current: $I_{sc}$ = 5.96 A
Voltage and current at maximum power: $V_{mp}$ =54.7 V, $I_{mp}$= 5.58 A

The PV array block menu allows you to plot the I-V and P-V characteristics for one module and for the whole array. The characteristics of the SunPower-SPR305 array are reproduced below

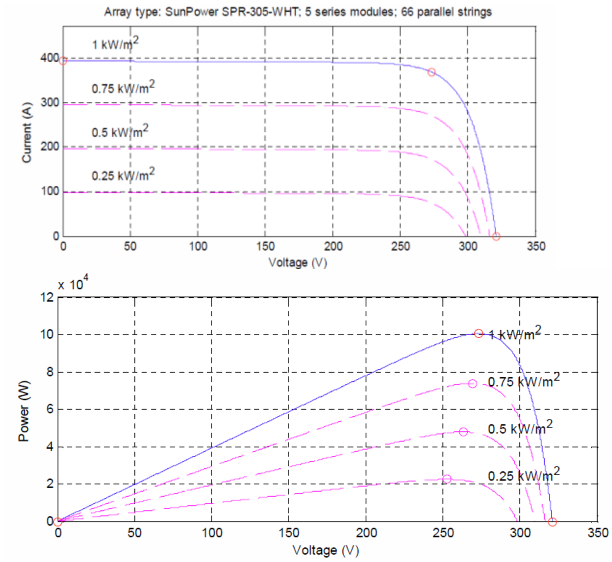


**Figure.2. the characteristics of PV array at variable temperature and irradiation**

I–V and P–V characteristics of a PV module show a unique point on the P–V curve, known as the maximum power point (MPP), in which at this point the solar module is said to operate at maximum efficiency and produces its maximum output power (Pmax) correspondent to a specific current (Impp) and voltage (Vmpp). This point also changes with environmental conditions of temperature and insulation as shown in fig.2.

**Equivalent circuit of photovoltaic cell**

Fig.3 displays equivalent circuit of one-diode model of a PV solar cell. Therefore, the I-V characteristic equation of a PV array (arranged in NP parallel and NS series solar cell) can be described as.

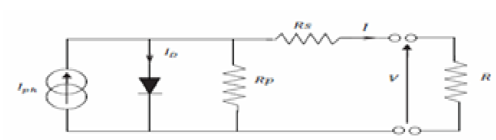


Fig.3 equvalent model of PV

$$I = Np.Iph - Np.Io\left[\frac{\exp\left(v+I\left(\frac{Ns}{Np}\right).Rs\right)-1}{Ns.a.Vt}\right] - \frac{V+I\left(\frac{Ns}{Np}\right).Rs}{\left(\frac{Ns}{Np}\right).R}$$

Where: I and V are the output current and output voltage of the PV array, Io is the diode's reverse saturation current, a: is the diode ideality factor, Rs and Rp is the series and parallel resistance respectively. Other variables are defined as follows: VT (=k T/q) is the thermal voltage of the PV cell, q is the electron charge (1,602·10-19 C), k is the Boltzmann constant (1,380·10-23 J/K), and T is the temperature of the p–n junction in Kelvin (K). Iph is the generated photo-current, mainly depends on the insulations G and cell's temperature T, which is described as [5,14],

$$Iph = (Iph, stc + ki.\Delta T)\ G/Gstc$$

Where Iph, stc (in Ampere, A) is the generated photo-current at Standard Test Conditions (STC), TSTC (25°C) and GSTC (1000 W/m2) are the temperature and the irradiance at STC. The constant Ki is the short circuit current coefficient, normally provided by the manufacturer. On the other hand, the cell's saturation current Io varies with the cell temperature, which is described as [5],

$$Io = \frac{Iph, stc + Ki(T - Tsic)}{\exp((Vo, stc + Kv(T - Tstc)/a.Vt) - 1}$$

**II. SEPIC CONVERTER:**

Fig.4 show the Single-ended primary inductor converter (SEPIC) is a type of DC-DC converter [10], that allows the voltage at its output to be more than, less than, or equal to that at its input. The output voltage of the SEPIC is controlled by the duty cycle of the MOSFET. A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output, by means of coupling energy from the input to the output is via a series capacitor. When the switch is turned off output voltage drops to 0 V. SEPIC is useful in applications like battery charging where voltage can be above and below that of the regulator output.

**Design of SEPIC Converter:-**

Duty Cycle Calculation: The amount that the SEPIC converters step up or down the voltage depends primarily on the Duty Cycle and the parasitic elements in circuit. The output of an ideal SEPIC converter is given by.

$$Vo = \frac{D * Vi}{1 - D}$$

However, this does not account for losses due to parasitic elements such as the diode drop VD. These make

$$Vo + Vd = \frac{D * Vi}{1 - D}$$

This equation becomes

$$D = \frac{Vo + Vd}{Vo + Vi + Vd}$$

The maximum Duty Cycle will occur when the input voltage is at the minimum. The maximum Duty cycle is

$$Dmax = \frac{Vo+vd}{Vo+vimin+Dd}$$

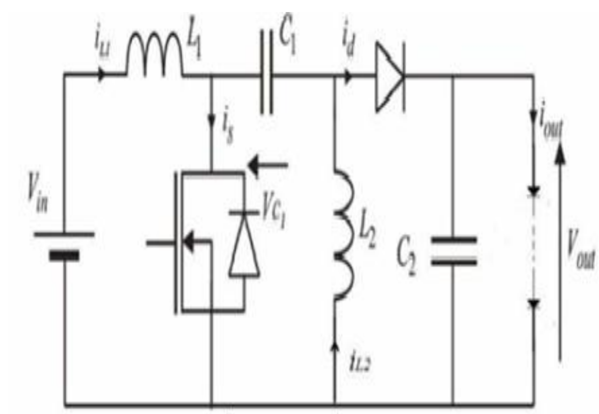


Fig.4 equivalent circuit of SEPIC converter

**MPPT CONTROL ALGHORITHM**

In order to improve the efficiency of the PV generation system, PV array should be controlled to generate the maximum power at the particular environment conditions. Maximum power point tracking (MPPT) is an essential process of self-optimization and aims at using some control algorithms to ensure the PV array to operate at the maximum power point [14]. A maximum power point tracker (MPPT) is a power electronic DC-DC converter inserted between the PV array and its load to achieve optimum matching power point.

### A. Perturb and Observe (P&O):-

P&O is an iterative method it senses the panel operating voltage periodically and compares the PV output power with that of the previous power; the resulting change in power (ΔPPV) is measured. If ΔPPV is positive, the perturbation of the operating voltage should be in the same direction of the increment. However, if it is negative, the system operating point obtained moves away from the MPPT and the operating voltage should be in the opposite direction of the increment perturbation should be reversed to move back towards the MPP. This process continues till dPPV/dVPV=0.

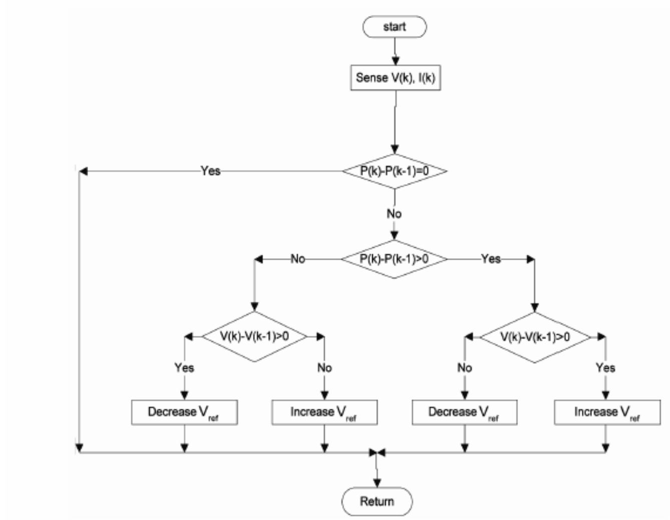


**Figure.5. Flow chart of P&O controller**

The Figure (5) shows the Flow chart of P&O MPPT algorithm. In This method when the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. The algorithm is developed in such a manner that it sets a reference voltage of the module Corresponding to the peak voltage of the module.. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions. But still this algorithm is very popular and simple [4].

### B. PROPOSED INCREMENTAL CONDUCTANCE METHOD:-

Incremental conductance method [11] generally uses voltage and current sensors to detect the output voltage and current of the PV array hence the complexity of the algorithm increases. The slope of the PV curve is zero at Maximum Power Point. The incremental conductance (IncCond) method is based on the fact that the slope of the PV array power curve is zero at the MPP, positive on the left of the MPP, and negative on the right, as given by

$dP/dV = 0$, at MPP
$dP/dV > 0$, left of MPP
$dP/dV < 0$, right of MPP
Since,
$dP/dV= d(IV)/dV= I + VdI/dV =I+V\Delta I/\Delta V$ (4)
Can be rewritten as

$\Delta I/\Delta V = -I/V$, at MPP
$\Delta I/\Delta V > -I/V$, left of MPP
$\Delta I/\Delta V < -I/V$, right of MPP

The MPP can thus be tracked by comparing the instantaneous conductance (I/V) to the incremental conductance (ΔI/ΔV). Vref is the reference voltage at which the PV array is forced to operate. At the MPP, Vref equals to VMPP. Once the MPP is reached, the operation of the PV array is maintained at this point unless a change in ΔI is noted, indicating a change in atmospheric conditions and the MPP. The algorithm decrements or increments Vref to track the new MPP. The Flow chart show in Fig. 6 and MATLAB / SIMULINK model of the Incremental Conductance Algorithm (ICT) is shown in Fig. 6(a)

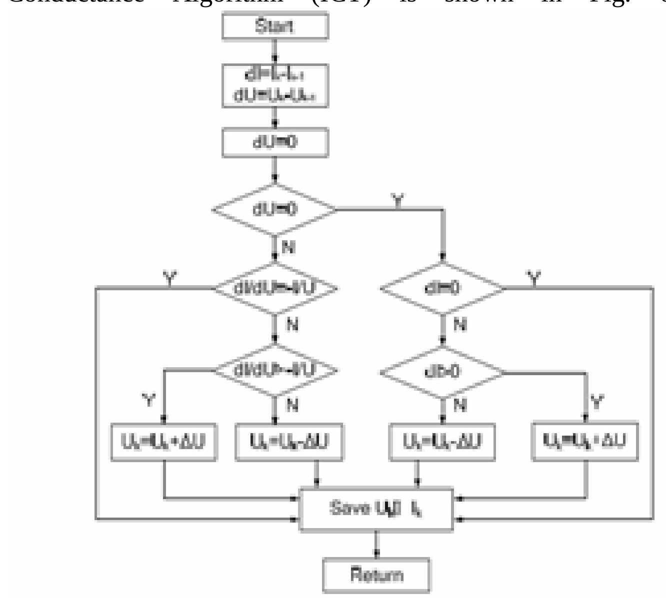


**Figure.6. Flowchart of Proposed IC algoritham**

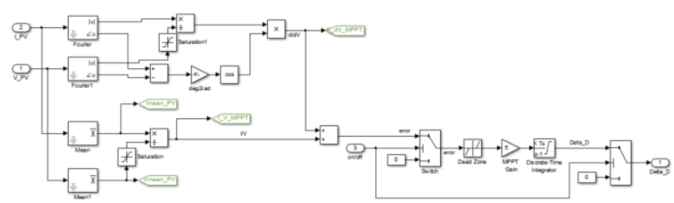

**Figure.6.(a) MATLAB/SIMULINK model of the IC controller**

### Voltage source converter (VSC):-

The voltage source converter (VSC) is controlled utilizing vector control in order to provide a controllable three phase AC current to the grid. To attain unity power factor operation, current is injected in phase with the grid voltage. A phase locked loop (PLL) is utilized in order to lock on the grid frequency and provide a reference synchronization signal for the inverter control system. The MATLAB/SIMULINK model of the VSC is shown in Fig (7). The voltage source converter (VSC) is controlled utilizing vector control in order to provide a controllable three phase AC current to the grid. To attain unity power factor operation, current is injected in phase with the grid voltage. A phase locked loop (PLL) is utilized in order to lock on the grid frequency and provide a reference synchronization signal for the inverter control system [1, 12,16].

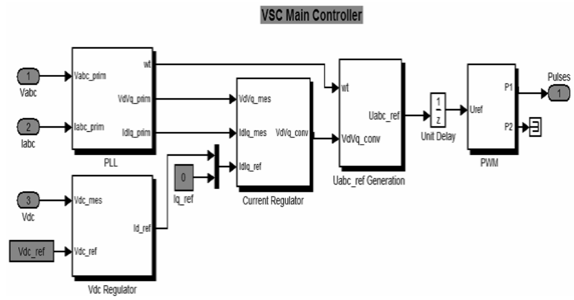


**Figure.7. MATLAB/SIMULINK model of the VSC Grid System**

We connect the 100 kv PV Array to grid model (25-kV distribution feeder + 120 kV equivalent transmission system.

## III. SIMULATION RESULTS AND DISCUSSION:-

In order to find which MPPT technique is better when connected to grid for all PV module , The proposed Increment conduction MPPT Logic Control and P&O based MPPT has been modeled and simulated using MATLAB/Simulink. Fig.8 shows our developed Simulink model. In the simulation study, the Increment conduction MPPT logic based MPPT control is simulated and compared with the and P&O is simulated and under the operating condition assuming the variable temperature and variable isolation.

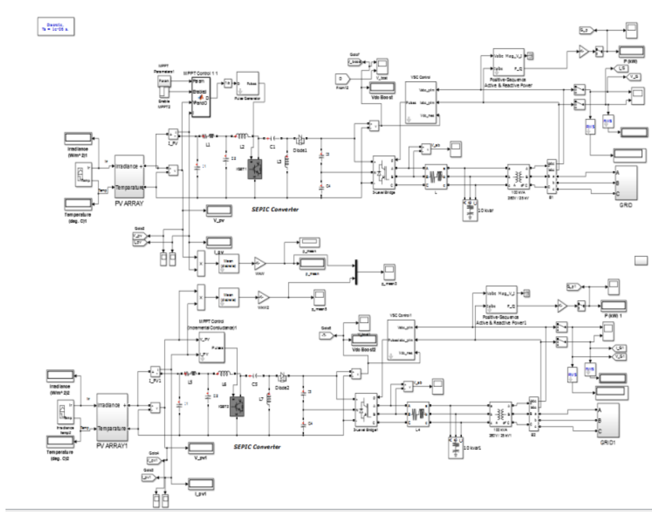

**Figure.8.Comprision study of P&O method and Proposed Increment Conduction method**

**Case1:-**

**When the atmomospheric condition Temparature (250c) and Irradiation (1000 w/m2)is cosnstant at time T=0.0 to 0.6**

| | V_PV | I_PV | P_PV(kw) | Bost_PV voltage | Grid Power(KW) | Grid voltage | Grid current |
|---|---|---|---|---|---|---|---|
| **P&O METHOD** | 271.58 | 370.05 | 100.69 | 500.44 | 89.80 | 14062 | 1.70 |
| **IC METHOD** | 274.37 | 367.05 | 100.72 | 501.62 | 90.01 | 14080 | 1.90 |

Fig 8 Matlab/simulink model of PV system connected to Grid system

**Case 2:-When the atmomospheric condition Temparature is 25$^{0}$c at time T=1.1 to 1.2 and Irradiation is 250 w/m$^{2}$ at time T=1.1 to 1.2**

| | V_PV | I_PV | P_PV(kw) | Bost_PV voltage | Grid Power(KW) | Grid voltage (kv) | Grid current |
|---|---|---|---|---|---|---|---|
| P& O METHOD | 94.85 | 96.81 | 9.18 | 499.67 | 7.92 | 14061.26 | 0.21 |
| IC METHOD | 254.56 | 88.84 | 22.62 | 499.33 | 20.24 | 146062.09 | 0.53 |

**Case 3:-When the atmomospheric Temparature is 750c at time T=2.1 to 2.5 and Irradiation is 1000 w/m2 at time T=2.1 to 2.5**

| | V_PV | I_PV | P_PV(kw) | Bost_PV voltage | Grid Power(KW) | Grid voltage(kv) | Grid current |
|---|---|---|---|---|---|---|---|
| P& O METHOD | 299.97 | 356.17 | 81.91 | 501.53 | 72.97 | 14065.87 | 1.90 |
| IC METHOD | 228.43 | 358.91 | 82.00 | 502.18 | 73.10 | 14065.90 | 1.91 |

**Graph analysis of P&O and IC controller connected to PV system with grid system**

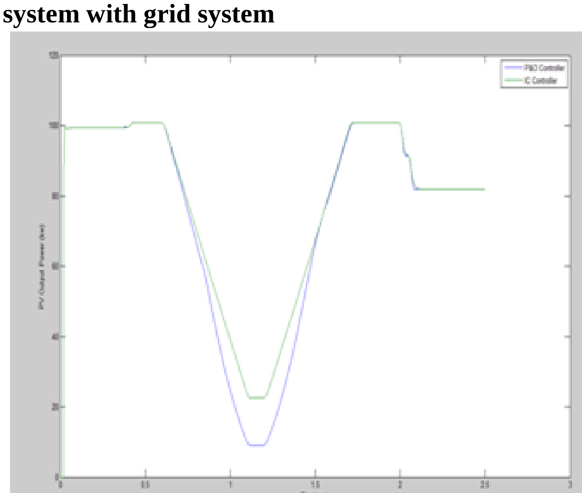

**Figure.10. PV output Power**

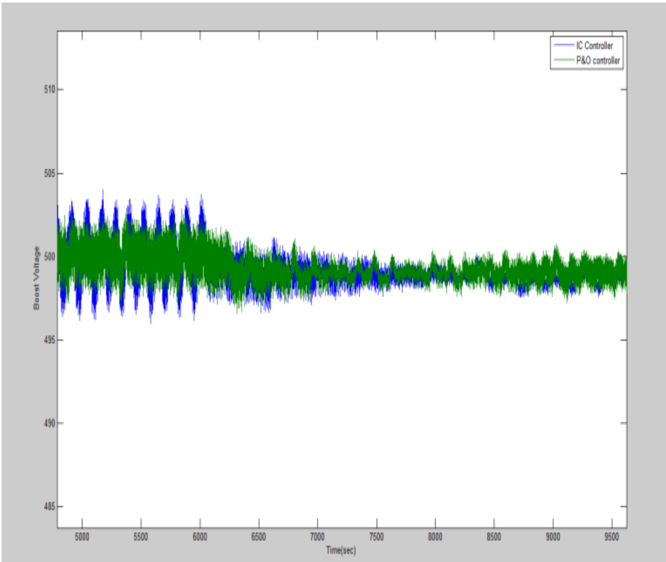


**Figure.12. Boost Voltage**

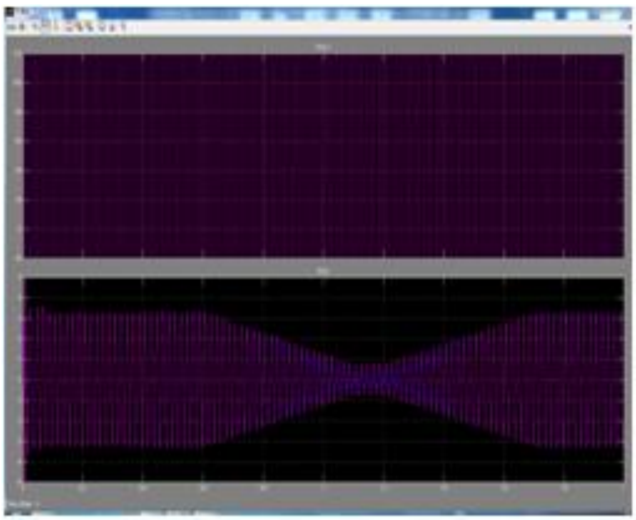

Fig 13 Grid Voltage and current

**Figure.13. Grid Voltage and Current**

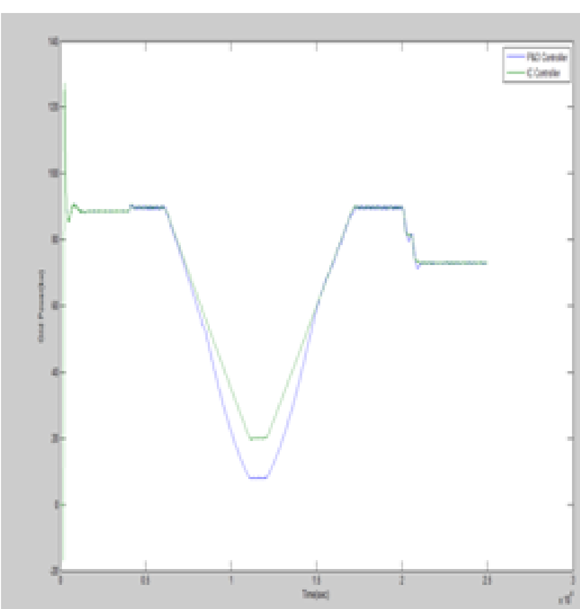


**Figure.11. Grid output Power**

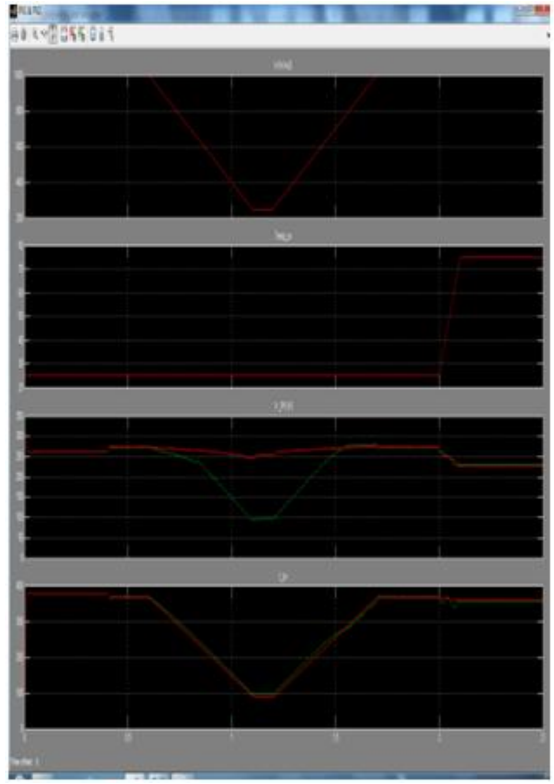

**Figure.15. Temprature,Irradiantion ,voltage and current of PV Array**

## VI. CONCLUSION:

This paper has presented a comparison of two most popular MPPT controllers, Perturb and Observe Controller with Incremental Conductance Controller. The matlab\simulink result show that for the power tracking the Incremental conduction gives fast response as comparision to P&O controller when the atmospheric condition is variable.

## VII. REFERENCES

[1]. M.E.Ahmad and S.Mekhilef, "Design and Implementation of a Multi Level Three-Phase Inverter with Less Switches and Low Output Voltage Distortation," Journal of Power Electronics, vol. 9, pp. 594-604, 2009.

[2]. S. Chin, J. Gadson, and K. Nordstrom, "Maximum Power Point Tracker," Tufts University Department of Electrical Engineering and Computer Science, 2003, pp. 1-66.

[3]. R. Faranda and S. Leva, "Energy Comparison of MPPT techniques for PV Systems," WSES Transaction on Power Systems, vol. 3, pp. 446-455, 2008.

[4]. Vikrant.A.Chaudhari, "Automatic Peak Power Traker for Solar PV Modules Using dSpacer Software.," in Maulana Azad National Institute Of Technology vol. Degree of Master of Technology In Energy. Bhopal: Deemed University, 2005, pp. 98.

[5]. T. P. Nguyen, "Solar Panel Maximum Power Point Tracker," in Department of Computer Science & Electrical Engineering: University of Queensland, 2001, pp. 64.

[6]. B. S, Thansoe, N. A, R. G, K. A.S., and L. C. J., "The Study and Evaluation of Maximum Power Point Tracking Systems," International Conference on Energy and Environment 2006 (ICEE 2006), pp.

[7]. C. S. Lee, " A Residential DC Distribution System with Photovoltaic Array Integration.," vol. Degree of Honors Baccalaureate of Science in Electrical and Electronics Engineering, 2008, pp. 38.

[8]. T. Esram and P. L.Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," in 9. Urbana.

[9]. E. I and O. Rivera, "Maximum Power Point Tracking using theOptimal Duty Ratio for DC-DC Converters and Load Matching in Photovoltaic Applications," IEEE, pp. 987-991, 2008.

[10].J. Leema Rose and 2B. Sankaragomathi,' Design, Modeling, Analysis and Simulation of a SEPIC Converter' Middle-East Journal of Scientific Research 24 (7): 2302-2308, 2016

[11]." Prof.Dr.A P Vaidya An Incremental Conductance Based Maximum Power Point Tracking for a PV Array Operating under No uniform Irradiance'' IJIRST –International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 9 | February 2015 ISSN (online): 2349-6010

12]. E. I and O. Rivera, "Maximum Power Point Tracking using theOptimal Duty Ratio for DC-DC Converters and [Load Matching in Photovoltaic Applications," IEEE, pp. 987-991, 2008.

[13]. Guan-Chyun Hsieh , J. C. Hung, , "Phase Lock Loop Techniques - A Survey", IEEE Transactions on Industrial Electronics, vol. 43, no. 6, pp. 609 - 615, Dec. 1996

[14]. K. H. Hussein, I. Muta, T. Hoshino, and M. Osakada, "Maximum photovoltaic power tracking: An algorithm for rapidly changing atmospheric conditions," Proc. Inst. Elect. Eng., Gener., Transmiss. Distrib., vol. 142, no. 1, pp. 59–64, Jan. 1995

[15]. Villalva MG, Gazoli JR. Comprehensive approach to modeling and simulation of photovoltaic arrays. IEEE T Power Electr, 2009; 24

[16]. S.Mekhilef, "Performance of grid connected inverter with maximum power point tracker and power factor control," International Journal of Power Electronics, vol. 1, pp. 49-62

**VIII. BIOGRAPHY**

Sandeep kumar singh Received his B.Tech Degree from SIET Allahabad, (UP) India in 2015. Now, he is pursuing his M.Tech in Electrical Engineering, S.H.U.A.T.S, Allahabad

Dr. Jyoti Shrivastava has done her graduation in Electrical Engineering and her post graduation in Design of Heavy Electrical Equipments. At present she is serving as an Senior Assistant Professor in Electrical engineering department at college of Engineering And Technology ,SHUATS Allahabad, India. SHE has several international And national paper to her credit