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Comparative Analysis between Ps/O & I/C Based MPPT Techniques for Optimal Electricity Generation from Solar Energy

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***Abstract*: -- Maximum power point tracking (MPPT) is an algorithm used to track the maximum power under the varying external atmospheric conditions such as irradiance, temperature, at a point where maximum power is obtained is called the maximum power point. This paper presents the comparative analysis between perturb & observe method and incremental conductance techniques. Perturb & observe technique is used to detect current and voltage of the PV array and it also calculates that operating point which gives the maximum power by using its algorithm. Incremental Conductance measure incremental changes in current and voltage and MPP is obtained at a point where conductance of PV array and incremental conductance are same. MATLAB software used for the performance evaluation of both techniques under varying atmospheric conditions.**

***Index Terms* — Perturb & Observe Incremental Conductance, MPPT Maximum Power Point Tracking, and PV Panel.**

I. INTRODUCTION

Electric power play a very important role in our life and its demand is increasing day by day at a fast rate. The total installed capacity of power plant in India is 310 GW which includes Thermal power plant (69.4%), Hydro (13.9%), Renewable (14.8%) and Nuclear (1.9%). Second most energy producing sources in the power sector are renewable energy after the thermal power. In India total estimated potential of renewable energy resources is 900GW i.e from wind power plant 102 GW, Small Hydro power plant 20 GW of power, from bioenergy we obtains 25 GW and 750 GW from solar power plant till end dec 2016.[1] The data discussed above is summarized in fig 1.

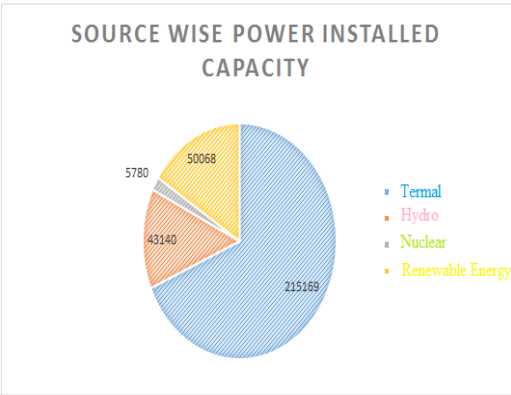

Fig 1 Pie chart of recent scenario

The Government of India targets to achieve the 175GW installed power capacity from renewable resources by the year 2022 i.e 100 GW from solar, 60GW from wind, 10GW from bio-power and 5GW from small hydro power plant. Rooftop (40GW) and grid connected (60GW) solar power system are used to achieve the target of generating 100GW power from solar plant under the National Solar Mission (NSM). With the completion of this target, India will be the largest Green Energy producer in the world. [1] From the sun we get energy in the form of light and heat. Light energy is converted into electric energy with the help of PV cell using photovoltaic phenomenon. PV cells or module alone cannot produce efficient power, so to use them efficiently MPPT techniques are introduced. These techniques track that point of the P-V curve where the power is maximum by using its algorithm. This paper proposes the comparative analysis of "perturb and observe" and "incremental conductance" MPPT technique for optimal generation of electricity from solar energy.

II. EQUIVALENT CIRCUIT OF SOLAR CELL

The process of converting the light energy into electric energy by using the PV cell is known as photovoltaic phenomenon. A number of solar cells are connected together is called solar modules, these modules can be connected in series and parallel combination as per user's requirement. These series and parallel combinations of solar cells are known as PV array. Parallel connection is used to increase the current in the array and similarly for enhancement in the voltage series connections are used. Fig 2 is circuit diagram of a solar cell which shows the parallel combination of a current source, inverted diode and a resistance, this combination is further connected to a series resistor.

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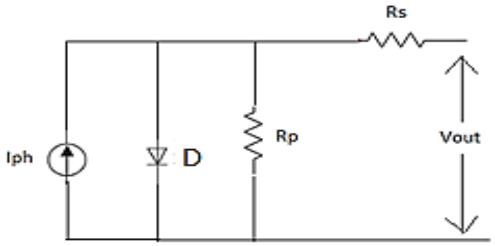

Fig 2 Equivalent Circuit of PV cell

Mathematical modeling of PV cell can be represented with the help of several eq_n. These eq_n are described below:-
Output Voltage of PV cell is:

$$V_{pv} = \left[\frac{N_s AKT}{q}\right] \ln\left[\frac{N_p * I_{ph} - I_{pv} + N_p * I_o}{I_o}\right] - I_{pv} * R_s \quad (1)$$

Output Current of PV cell is :

$$I_{pv} = N_p I_{ph} - N_p I_o * \left[\exp\left\{\frac{q(V_{pv} + I_{pv} * R_s)}{N_s AKT}\right\}\right] - 1 \quad (2)$$

$$I_{ph} = I_{scr} + \{K_t(T - 298)\} * {}^{\lambda}/_{100} \quad (3)$$

Power Output of PV cell is:

$$P_{pv} = V_{pv} * I_{pv} \quad (4)$$

$$P_{pv} = V_{pv} N_p I_{ph} - V_{pv} N_p I_0 * \left[\exp\left\{\frac{q(V_{pv} + I_{pv} R_s)}{N_s AKT}\right\}\right] - 1 \quad (5)$$

V_pv	PV Voltage
I_pv	PV Current
R_s	Series resistance
R_sh	Shunt resistance
A	Ideality factor
T	Cell temperature
Q	Electron charge
N	Number of cells
Is	Saturation current
λ	PV cell illumination
I_or	Saturation current
E_go	Band gap for silicon
K	Boltzmann constant
I_o	PV saturation current
N_s	Number of modules in series
N_p	Number of modules in parallel
I_ph	Phase current PV cell
K_i	Short - circuit current temperature coeff. of solar cell

III. BOOST CONVERTER

DC-DC Boost Converter is used to step up the input DC voltage up to the required DC output voltage. It consists of inductor, diode, capacitor and a switch (MOSFET/IGBT) and a load resistor. Capacitors are used at the output to reduce the ripple of output voltage. The working of boost converter totally depends on the duty cycle provided to the switch.

$$\frac{V_o}{V_i} = \frac{1}{1 - D} \quad (6)$$

$$D = 1 - \frac{V_o}{V_i} \quad (7)$$

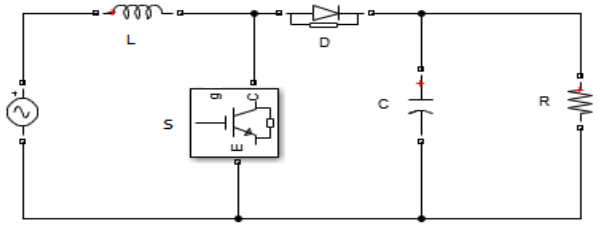

Fig 3 Boost Converter

V_o	Boost converter output voltage
V_i	Boost converter input voltage
D	Duty cycle

When switch is ON the voltage source is short circuited by the inductor i.e charging of inductor took place, simultaneously discharging of capacitance occurs through load, making the load current constant. During the OFF state when switch is open, the inductor current flows through load and equivalent of voltage drop across are stored in capacitor in form of charge.

IV. MAXIMUM POWER POINT TRACKING

MPPT is not a mechanical system but it is an electronic system that automatically makes variation of the electrical operating point of the PV module with the help of its algorithm so that module is able to produce maximum power output under changing climatic conditions. The output power of PV module is a function of temperature, radiation, position of the panel and product of voltage and current. By varying these parameters the power can be varied and for achieving the maximum power point with these variations, MPPT are used, hence increases efficiency of operation. On the P-V

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curve, PV cell generation of maximum power through the PV cell always occurs at one point and that point is knee point of the curve i.e maximum power point (MPP). The algorithm of this technique is shown in fig 6. There are different MPPT techniques such as perturb and observe, incremental conductance method, open circuit voltage, short circuit current, fuzzy logic control, artificial neural network etc. In this paper, a discussion about perturb and observe, incremental conductance techniques and its simulink model is done.

IV(A). PERTURB AND OBSERVE

The P&O method detects the change in voltage and current of PV module and compares the previous and present values of power corresponding to these changes. If the PV array operating voltage changes and power increases (dP/dV>0), then control system will make the PV array operating point to move in the same direction, otherwise the operating point will move in the opposite direction. This process will continue in the same manner until the MPP of system is reached. The drawback of this technique is that when the MPP is reached, the output power oscillates around its operating point. To reduce the oscillation, the perturbation step size should be reduced such that when the operating point is away from the MPP, the step change in duty cycle should be large, when it nears the MPP.

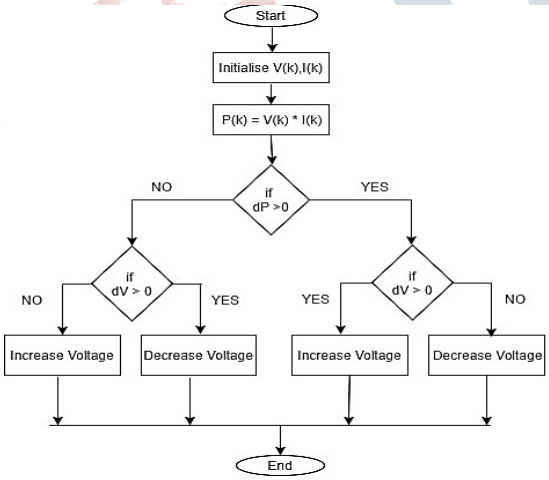

Fig 4 Flowchart of P & O

IV (B). INCREMENTAL CONDUCTANCE

The IC method measures the small changes in the PV array's current and voltage to estimate the change in power. The following equation describes the algorithm of incremental Conductance (IC):-

$$\frac{dI_{pv}}{dV_{pv}} + \frac{I_{pv}}{V_{pv}} = 0 \qquad (8)$$

Vpv	PV array voltage
Ipv	PV array current
$\frac{Ipv}{Vpv}$	Array Conductance
$\frac{dIpv}{dVpv}$	Incremental Conductance

When$\frac{dI_{pv}}{dV_{pv}} + \frac{I_{pv}}{V_{pv}} < 0$, the operating point will be at the right side of the MPP, if $\frac{dI_{pv}}{dV_{pv}} + \frac{I_{pv}}{V_{pv}} > 0$, then operating point will be at the left side of the MPP, when $\frac{dI_{pv}}{dV_{pv}} + \frac{I_{pv}}{V_{pv}} = 0$, then the operating point is at the MPP. The IC method is used to obtain the maximum power point by comparing the incremental conductance and array conductance PV system.

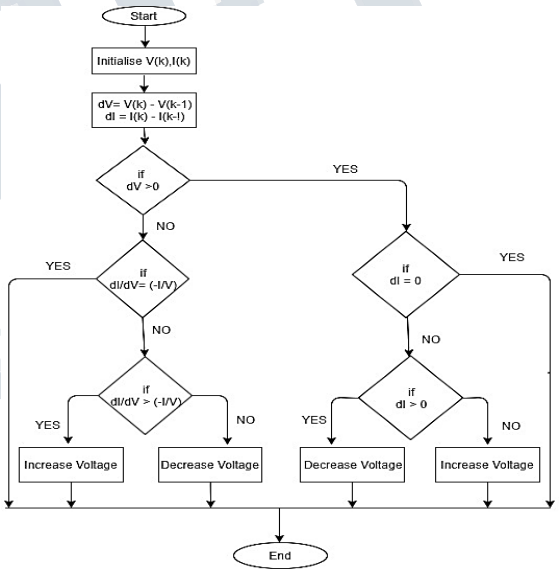

Fig 5 Flowchart of IC method

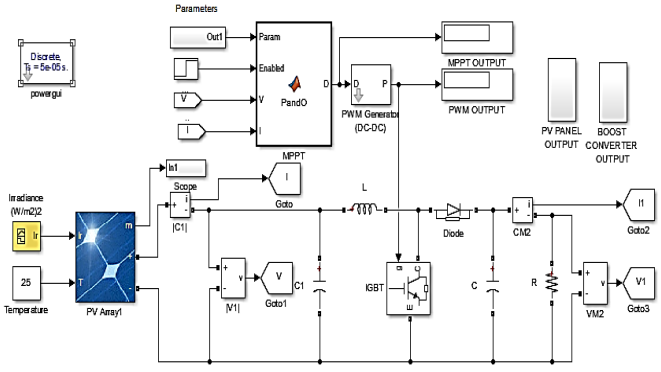

Fig 6 Simulink model of P&O

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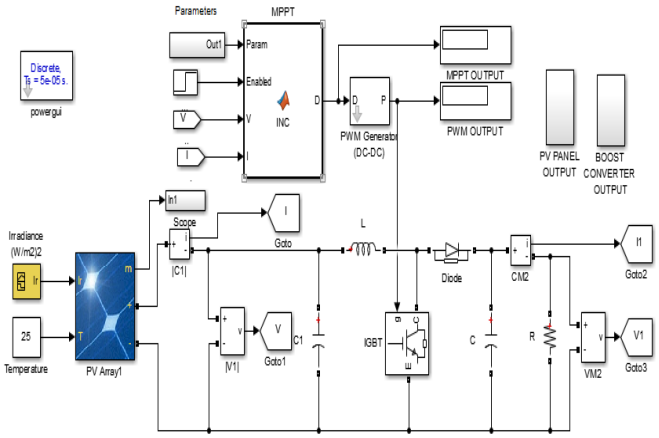

Fig 7 Simulink model of IC

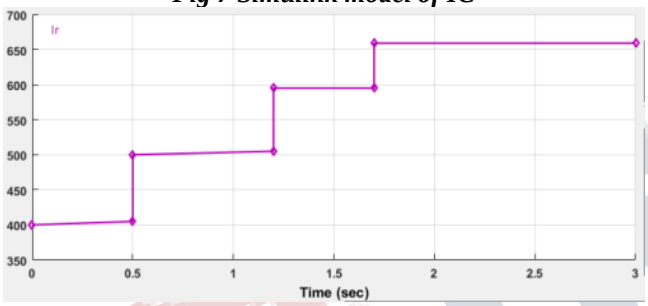

Fig 8 Irradiance w.r.t time

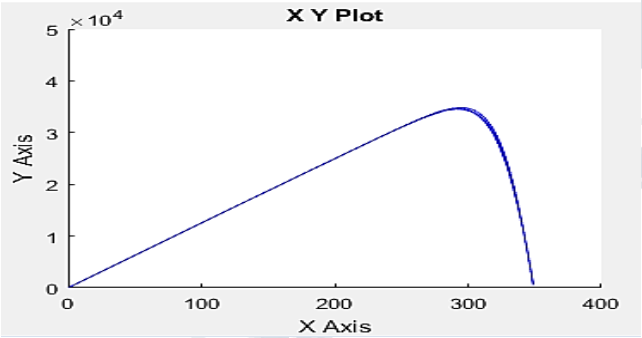

Fig 9 P-V curve of PV panel

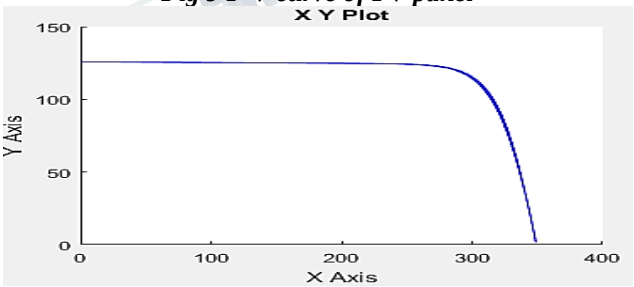

Fig 10 I-V curve of PV panel

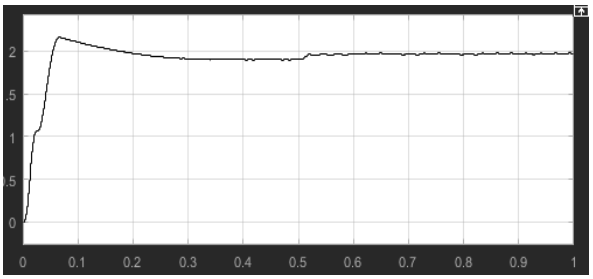

Fig 11 Current of Boost Converter for P&O

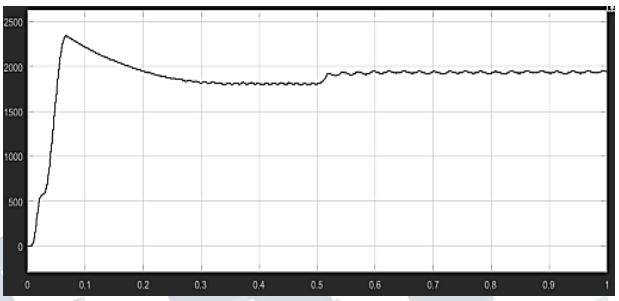

Fig 12 Power of Boost Converter for P&O

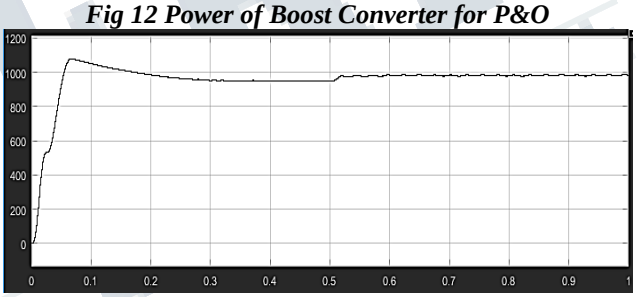

Fig 13 Voltage of Boost Converter for P&O

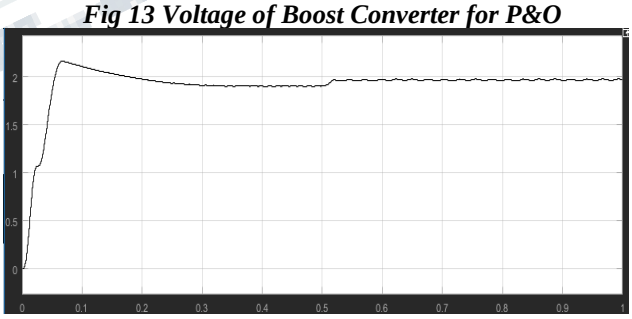

Fig 14 Current of Boost Converter for IC

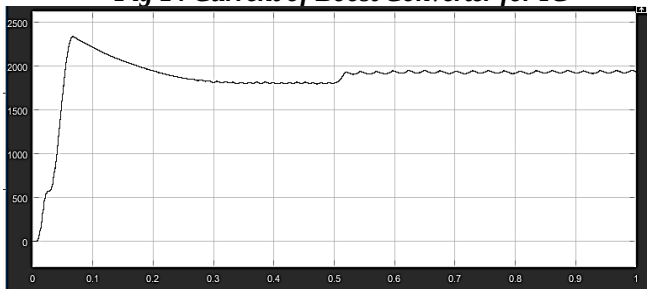

Fig 15 Power of Boost Converter for IC

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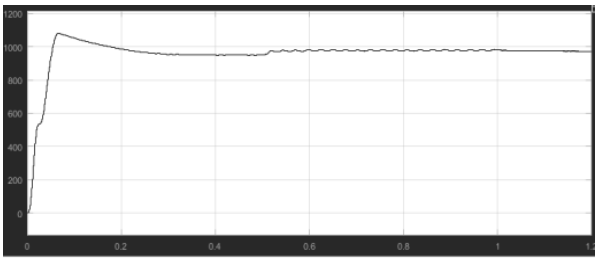

Fig 16 Voltage of Boost Converter for IC

VI. CONCLUSION

Parameters	P&O Method	IC Method
PV Current(A)	21.48	20.04
PV Voltage (V)	347	347.2
PV Power(W)	7455	6959
Boost Current(A)	1.899	1.9
Boost Voltage(V)	949.4	950
Boost Power(W)	1803	1805

Table displaying the parameters of P&O, IC Technique

In this paper we discussed about Simulink model of perturb and observe and incremental conductance technique. In perturb and observe technique, its maximum power point oscillates not in incremental conductance technique. IC technique gives better performance. Among both of them IC technique gives more favorable result under varying atmospheric conditions. Both the techniques give the promising results (voltage, power, current).

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