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Modelling and Comparison of Different MPPT Algorithms for a Solar Charge Controller

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ABSTRACT: This paper focuses on the comparative study of Maximum Power Point Tracking (MPPT) algorithms, with different combinations of DC-DC converters. Due to poor efficiency of Photovoltaic (PV) system and having a non-linear V-I characteristics, with changes in irradiance and temperature, different MPPT algorithms were proposed by many researchers. All MPPT methods follow the same goal that is maximizing the PV system output power by tracking the maximum power on every operating condition. In this paper maximum power point tracking techniques (Perturb& Observe Incremental Conductance) for photovoltaic systems were introduced to maximize the power produced. The MPPT algorithm is very effective, electronic means to operate the PV array at its MPP regardless of changing environmental conditions. The effectiveness of the MPPT algorithm in standalone PV system with different types of dc-dc converters is represented through simulation results in this work.

KEYWORDS: Buck, Boost, Perturb and Observe method, Incremental Conductance, Maximum power point tracking, Solar PV Array.

I. INTRODUCTION

The electrical energy supplied by national grid is not enough to meet demand. But human being needs electricity for sustainable development and poverty reduction. It affects practically all aspects of social and economic development including: livelihoods, water, agriculture, population, health, education, job creation and environmental concerns. Due to the awareness of global warming and climate change, nations are concerned of the planet's carbon emissions from fossil fuel used. Renewable energy is a natural energy which does not have a limited supply, can be used again and again, and will never run out [2].As the solar energy is non-conventional and large amount of availability without pollution. Unfortunately, PV generation systems have two major problems: the conversion efficiency of electric power generation is very low (9-16%), especially under low irradiation conditions and the amount of electric power generated by solar arrays changes continuously with weather conditions. Moreover, the solar cell V-I characteristic is nonlinear and changes with irradiation and temperature. In general, there is a point on the V-I or V-P curve only, called the Maximum Power Point (MPP), at which the entire PV system operates with maximum efficiency and produces its maximum output power. The location of the MPP is not known, but can be located, either through calculation models or by search algorithms. MPPT techniques are used to maintain the PV array's operating point at its MPP. In the survey, the maximum energy extracted from the sun without MPPT is only about 30-40 %. MPPT's are most effective under these conditions.

II. SYSTEM CONFIGURATION

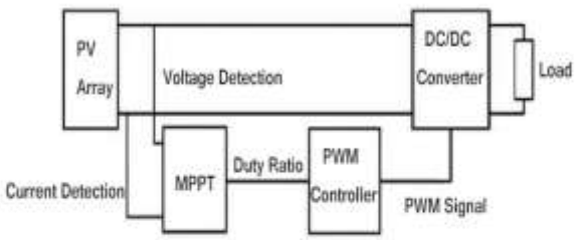

Fig 2.1. Block Diagram of Proposed Work

The PV array many applications such as electric vehicle, battery charging satellite power station, standalone power system, water pumping and so on. The PV array is to reduce the cost of the overall system because of the low conversion system by using high-efficiency power conversion processor. The DC-DC converter is used in power processor it is energy processing system is used in DC-DC converter and it's operated as MPPT. The Maximum Power Point Tracking system (MPPT) is to maximize the possible power for increasing the rate of PV array by utilization its output does not constant of DC voltage.

The proposed system includes PV strings, boost converters, inverters, transformers, and the grid. The schematic representation of the proposed system is shown in Fig.2.1. Therefore, the step converter is used to increase the PV voltage. The power generated by the PV panel varies due to the different temperature and irradiation conditions. To track the extreme power of the PV section, the Maximum Power Point Tracking (MPPT) algorithm was used, and thus the Perturb and Observe the Maximum Power Point (P & O) was specified.

The tracking algorithm (MPPT) is used for efficient energy conversion. The proposed system in MPPT algorithm in P and O method is used. The output of the inverter has a stepped waveform and a sine wave signal is required to connect to the grid. A step-up transformer is used to increase the magnitude of the AC signal, and the insulation is also provided in the transformer to avoid a short circuit. In order to perform the off-grid operation circuit breaker and the local parallel RLC load. Whenever the power switch is de-energized, island operation is initiated and the inverter feeds the local load and is automatically reconnected when there is enough power in the grid.

III. PV MODELING

A solar cell, which is basically a p-n semiconductor junction directly, converts light energy into electricity. PV cells are grouped in larger units called PV modules, which are further interconnected in a parallel-series configuration to form PV arrays or generators. The photovoltaic cell considered can be modeled mathematically using the following procedure:

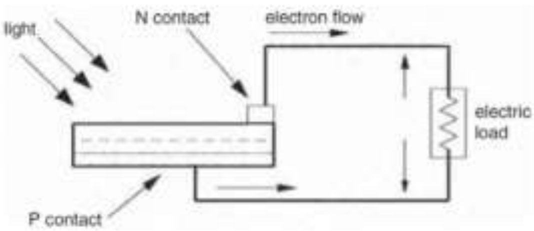

Fig.3.1. PV effect converts the photon energy into voltage across the PN junction

A. Ideal PV Cell (Diode Equation)

The equivalent circuit of solar cell show in Figure.3.2. The characteristics equations show that the current produced by the current solar cell is equal to the current source, which flows through the diode, which flows from the shoot resistor.

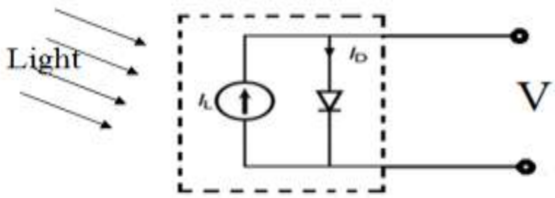

Fig.3.2. Ideal PV Cell

$$I = I_L - I_D - I_{Sh} \qquad 3.1$$

$$I_D = I_0\left(\frac{q^{V_d}}{e^{akT}} - 1\right) \qquad 3.2$$

Where,

I_d = Diode current in Amp

q^{V_d} = Chagre of elctron in coloumbs

T = Temperature in kelvine

K = Boltzman constant (1.38×10^{-23})

a = Diode Idealy factor (1 and 2)

I_0 = Reverse saturation current in Amp

B. Ideal PV Cell (Diode Equation)

Illustrates the single diode model of PV cell show in figure 3.3

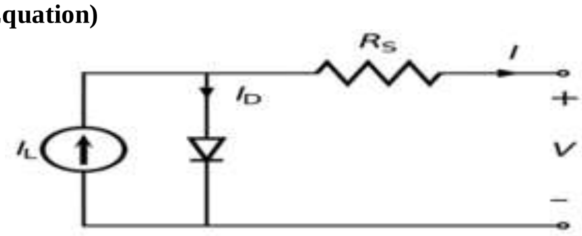

Fig.3.3. Series Resistance

$$I = I_L - I_0\left(\frac{V - IR_s}{e^{akT}} - 1\right) \quad 3.3$$

Now,

$$V_j = V - IR_s \quad 3.4$$

$$I = I_L - I_0\left(\frac{V_j}{e^{akT}} - 1\right) \quad 3.5$$

Where,
I_L = Photogenerated curren in Amp
V = Voltage across output terminal in Volt
R_s = Series resistence in Ohm
V_j = Voltage across both diade and resistor R_{sh}

C. Shunt Resistance

Illustrates the single diode model of PV cell in shunt resister is connected in parallel show in figure 3.4

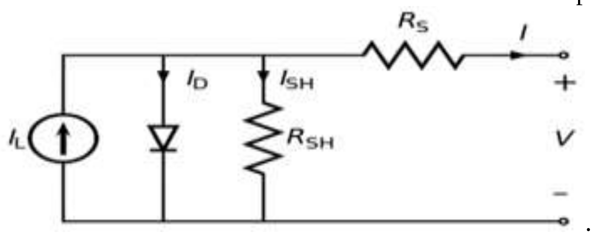

Fig.3.4. Shunt Resistance

$$I_{R_{sh}} = \frac{V_j}{R_{sh}} \quad 3.6$$

Where,
R_{SH} = Shunt resistence in Ohm

$$I = I_L - I_0\left(\frac{V_j}{e^{akT}} - 1\right) - \frac{V_j}{R_{sh}} \quad 3.7$$

The last term is ground drain current. Basically, it is negligible to compare I_L and I_D and so ignore. The saturation current of the diodes can be determined by applying the output voltage V to the cell in the dark and measuring the current in cell. This current is called reverse diode saturation current or dark current. Characteristics of solar cells I-V Curves are a graphical representation of the operation of a solar cell or module, which summarizes the relationship between current and voltage in existing radiation and temperature conditions. The I-V curves provide the information necessary to tune the solar system so that it can work as close as possible to the maximum power point (MPP).

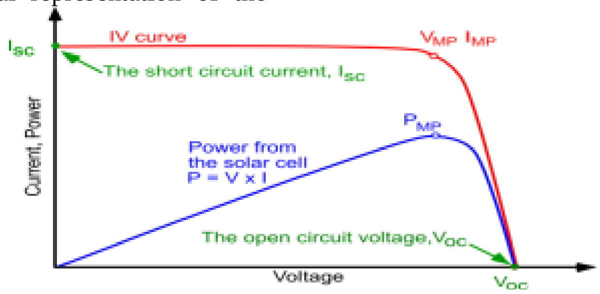

Fig.3.5. I-V curve for solar cell to get the maximum output for solar cell

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The short circuit current as shown in fig 3.5 on Y-axis is denoted by the I_{SC}. When $I_{SC} = I_L$ then maximum possible current are flowing the PV cell because of series resistance R_S is very small. The I_{SC} is depend on the irradiance level. The short circuit condition in short circuit current is maximum and open circuit voltage is zero. The open-circuit voltage shown in fig.3.10 on X-axis it is denoted by the V_{OC}. When the maximum possible voltage from the PV cell with zero external currents. The V_{OC} is depended on the quality of the material.

The maximum electrical power that a solar cell can deliver to the standard test state. If we attract the v-i characteristics of a solar cell, the maximum power will occur at the point of bending of the characteristic curve. It is shown in fig.3.10.

IV. MPPT TECHNIQUES

A. Perturbation and Observation

P&O algorithms are widely used in MPPT because of their simple structure and the few measured parameters which are required. They operate by periodically perturbing (i.e. incrementing or decrementing) the array termed voltage and comparing the PV output power with that of the previous perturbation cycle. If the power is increasing, the perturbation will continue in the same direction in the next cycle, otherwise the perturbation direction will be reversed. This means the array terminal voltage is perturbed every.

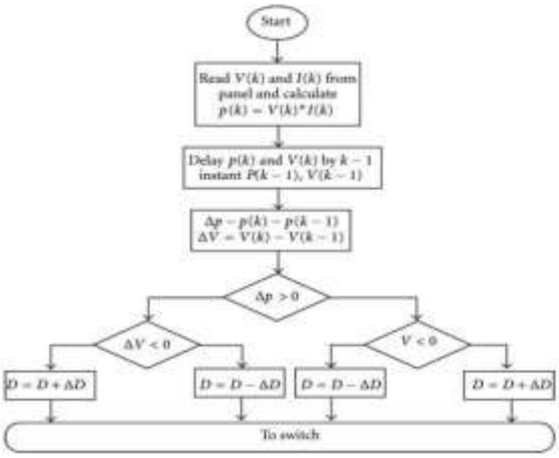

Fig.4.1. Flowchart of P & O Algorithm

B. Incremental Conductance

In the incremental conduction method of the array terminal voltage is always adjusted according to MPP voltage is based on incremental and the instantaneous conduction of the PV module.

$$\frac{I}{V} = \frac{dI}{dV} \qquad 3.8$$

Where,

$\frac{I}{V}$ = is instantenious conductance

$\frac{dI}{dV}$ = is incremental conductance

Now,

$$\frac{dP}{dV} = 0 \qquad 3.9$$

The equation (2) is change in power with respect to change in voltage is equal to zero.

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I\frac{dV}{dV} + V\frac{dI}{dV} \qquad 3.10$$

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V\frac{dI}{dV} \qquad 3.11$$

The MPPT reached when $\frac{dP}{dV} = 0$ and

$$0 = I + V\frac{dI}{dV} \qquad 3.12$$

That is,

$$\frac{dI}{dV} = \frac{-I}{V} \qquad 3.13$$

The slope of PV array power curve is zero at the MPP, the MPP is increase on left hand side and the MPP is decrease on right hand side. The basic equation of this method is as fallows.

$$\frac{dI}{dV} = \frac{-I}{V}$$

$$\frac{dI}{dV} > -\frac{I}{V}\ \text{MPP is increase in left h}\textit{and side}$$

$$\frac{dI}{dV} < -\frac{I}{V}\ MPP\ is\ increase\ in\ left\ right\ side$$

The different operating point of MPP is as follows,

$$\frac{\Delta P_{PV}}{\Delta V_{PV}} > 0\ then\ < MPP\ \text{voltage}$$

$$\frac{\Delta P_{PV}}{\Delta V_{PV}} = 0\ \text{then}\ V_p = \text{equal MPP voltage}$$

$$\frac{\Delta P_{PV}}{\Delta V_{PV}} < 0\ \text{then}\ V_p > \text{MPP voltage}$$

Where I and V are the output current of the P-V array output voltage and current respectively. His left side the equations represent the incremental conduction of P-V module and right side represent instantaneous conduction. When the change report in the output conduction is equal to the negative result conductivity, solar array will work at maximum power point.

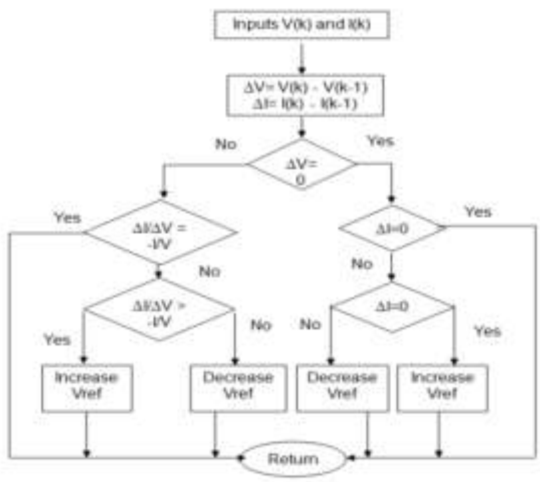

Fig.4.2. Flowchart of P & O Algorithm

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V. RESULTS AND DISCUSSION

V.I. Simulation Results

The simulation uses PV array is connected to DC/DC boost converter, Maximum Power Point Tracking (MPPT) is implemented in the boost converter by means of a Simulink model using two different techniques. The average model contains the following components.

- PV array delivering a maximum of 250 volt and 360 amp current at 1000 W/m2 sun irradiance and 50^{o}c temperature.
- DC-DC boost converter

A. Simulation of INC as MPPT algorithm

In incremental conductance (INC) algorithm, the controller measures incremental changes in PV array voltage and current to predict the effect of a voltage change. It has been implemented in the Matlab/simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with Boost DC-DC Converter using I.C Algorithm for a resistive load R=201.6 Ω. The Boost Converter increases the input voltage to a greater value of output voltage according to the duty cycle applied to its gate of the MOSFET in the Boost converter so that whenever there is a change in the irradiance or temperature, the duty cycle of the converter can be adjusted in order to get maximum power at the load side. The simulation has been performed for a progressive change of solar irradiance from 600 to 1200 W/m2 for different values of temperature such that varies from 25° c to 40° c

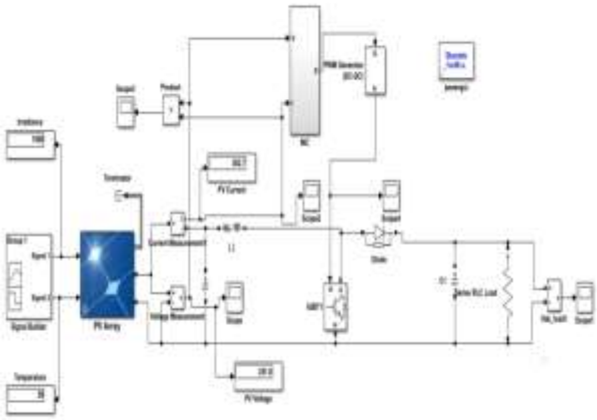

Fig.5.1. Simulation of P & O Algorithm

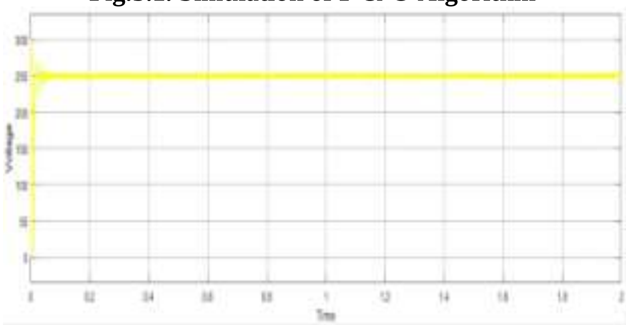

Fig.5.2. PV Output Voltage

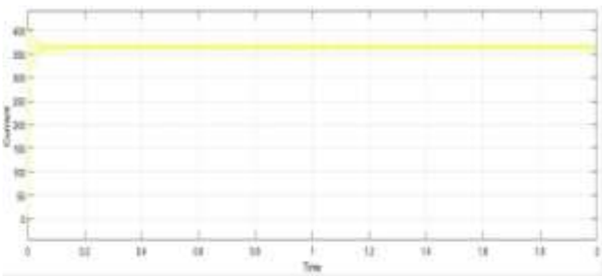

Fig.5.3. PV Output Current

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Fig.5.4. System Output with Boost Converter Output

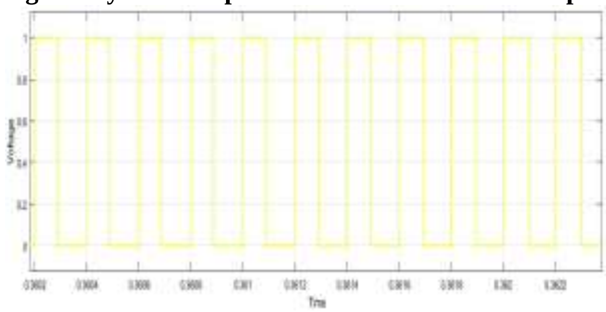

Fig.5.5. MPPT Duty Cycle Output

The figures above show the output voltage, current and power for irradiance varying from 600W/m2 to 1000W/m2 and temperature varying from 30°C to 50°C for a PV System working with a Boost Converter using Incremental conductance Algorithm. The system has been designed for a duty cycle of 0.5. Hence, the input voltage of 362.6V and current is 365 amp has been increased to 470 V and 400 amp respectively under standard conditions i.e. 1000w/m2irradiance and 30°C temperature. It can be noticed that the current, voltage and power are at their maximum at 1000W/m2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m2 to 600W/m2 and temperature increases from 30°C to 40°C.

B. Simulation of P & O as MPPT algorithm

It has been implemented in the Matlab/simulink. The figure above shows the simulation of MPPT of solar photovoltaic system with Boost DC-DC Converter using P&O Algorithm for a resistive load R=201.6Ω. The Boost Converter increases the input voltage to a greater value of output voltage according to the duty cycle applied to its gate input of the MOSFET in the Boost converter so that whenever there is a change in the irradiance or temperature; the duty cycle of the converter can be adjusted in order to get maximum power at the load side. The simulation has been performed for a progressive change of solar irradiance from 600 to 1000 W/m2 for different values of temperature varying from 30°c to 50°c.

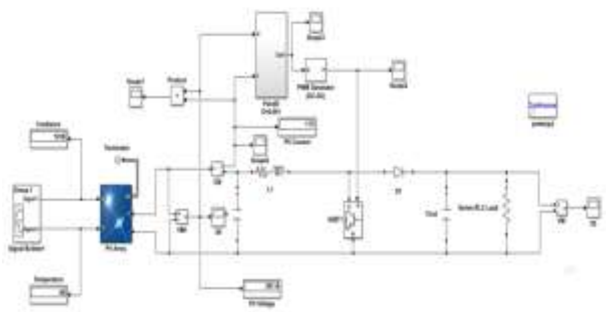

Fig.5.6. Simulation of P & O Algorithm

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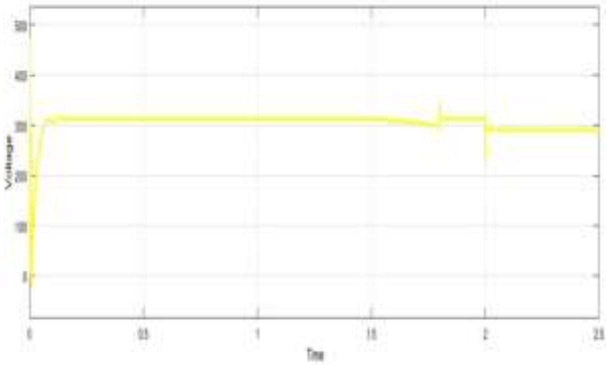

Fig.5.7. PV Output Voltage

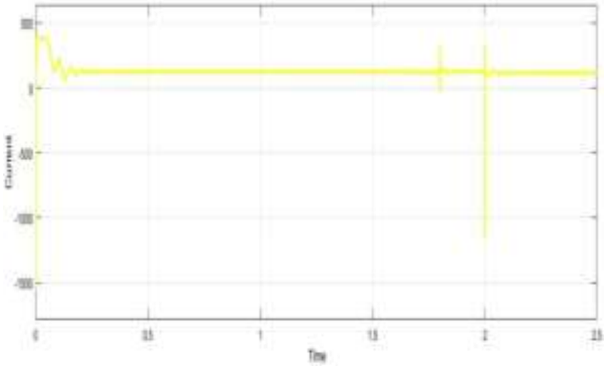

Fig.5.8. PV Output Current

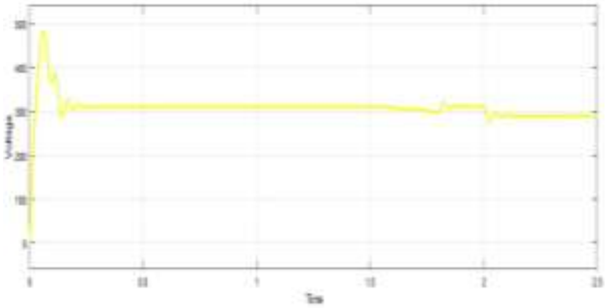

Fig.5.9. System with Boost Converter Output

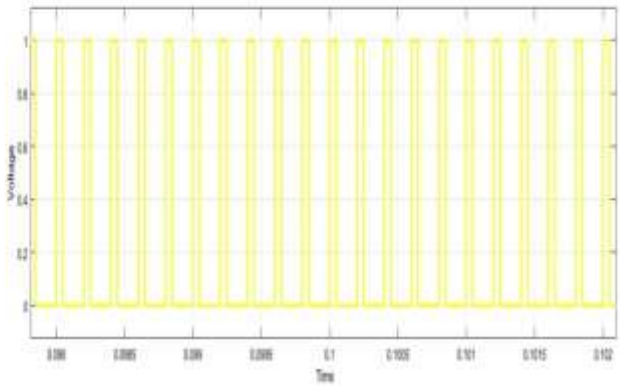

Fig.5.10. MPPT Duty Cycle Output

The figures above show the output voltage, current and power for irradiance varying from 600 W/m2 to 1000W/m2 and temperature varying from 25°C to 40°C for a PV System working with a Boost Converter using Perturb and Observe Algorithm. The system has been designed for a duty cycle of 0.5. Hence, the input voltage of 325.6 V has been increased to 586.4 V under standard conditions i.e.

1000w/m irradiance and 30°C temperature. It can be noticed that the current; voltage and power are at their maximum at 1000W/m2 and 30°C. They decrease as the value of irradiance decreases from 1000W/m2 to 600W/m2 and temperature increases from 30°C to 50°C.

VI. COMPARISION OF TWO MPPT TECHNIQUES

Parameter	P & O MPPT	INC MPPT
PV Array Depending	No	No
True MPPT	Yes	Yes
Analog or Digital	Both	Digital
Periodic Time	No	No
Convergence Speed	Varies	Varies
Implementation Complexity	Low	Medium
Sensed Parameter	V, P	V, I
Dynamic Response	Poor	Medium
Transient Flections	Bad	Bad
Steady Oscillation	Large	Moderate
Static Error	High	High
Control Accuracy	Low	Accurate
Tracking Speed	Slow	Slow
Overall Efficiency	Medium	Medium

Table.6.1 Comparisons of P & O and INC Algorithm

VII. CONCLUSION

When the external environment changes suddenly the system cannot track the maximum power point quickly. With the use of different types of dc to dc converter it is possible to track the maximum power point (MPP) with increase in efficiency of the system, but on the other hand with the excess use of dc to dc converter there can be decrease in overall efficiency of the system. Moreover from the results obtained by varying irradiance and temperature it can be concluded that as the irradiance decreases or increases less amount of solar energy is received by the photovoltaic system and hence the output current; voltage and power reduces or raises. The Incremental Conductance method is more efficient than Perturb and Observe method because panel terminal voltage is changed according to its value relative to the MPP voltage. Perturb and observe method can fail under rapidly changing atmospheric conditions. Incremental conductance method eliminates the problem in Perturb and Observe method. The power extracted by Inc. Cond MPPT is more regulated than PO algorithm. At different weather conditions, comparison of two MPPT algorithms with four dc-dc converters taking the output values of the current, voltage, power, ripple voltage and their efficiencies. By comparing in efficiency the incremental conductance with buck converter is the best and it has a less percentage of ripple voltage also. According to applications view the P&O is preferred than I.C method because it is having low cost and easy implementation.

REFERENCES

[1]. Aman Sharma, Shivam Gupta "Modeling and Comparison of Different MPPT Algorithms for a Standalone PV System" IEEE transaction on power electronics.2020
[2]. Parag K. Atri Nikhil Shashikant Gujar "Comparison of Different MPPT Control Strategies for Solar Charge Controller" IEEE transaction on power electronics.2020.
[3]. Saravana Selvan, Girish Kumar, "Comparative Study of perturb and Observe and Fuzzy logical Control Based MPPT Algorithm" IEEE International Journal 2015.
[4]. Kshitijaa Ranjan, Narendra Kumar, "Modelling and Simulation of Perturb and Observe Algorithm on Solar PV System using Different Converters in MATLAB/Simulink" 1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems (ICPEICES-2016).
[5]. B.Subudhi and R. Pradhan "A Comparative Study on Maximum Power Point Tracking Techniques for Photovoltaic Power Systems", IEEE Transactions on Sustainable Energy, Vol. 4, No. 1, pp.89-98, 2013.
[6]. Aman Sharma, Shivam Gupta "Modeling and Comparison of Different MPPT Algorithms for a Standalone PV System" IEEE transaction on power electronics.2020.
[7]. S. Khadidja, M. Mountassar, and B. M'Hamed, "Comparative study of incremental conductance and perturb & observe MPPT methods for photovoltaic system," Int. Conf. Green Energy Convers. Syst. GECS 2017, 2017

[8]. N. K. Raghavendra and K. Padmavathi, "Solar Charge Controller for Lithium-Ion Battery," Proc. 2018 IEEE Int. Conf. Power Electron. Drives Energy Syst. PEDES 2018, pp. 1–5, 2019.
[9]. U.Srikanth, p.Pavan Kumar, k.V.V.Prasad "A Comprehensive Comparison of Mppt Algorithms With Dc-Dc Converters For Solar PV Array" September 2017, Volume 4, Issue 09 JETIR (ISSN-2349-5162).