COMPARISON STUDY OF MPPT ALGORITHMS FOR SOLAR PHOTOVOLTAIC CHARGE CONTROLLERS

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Abstract— Solar cells have non-linear V-I characteristics. The efficiency of PV module is very low and power output depends on solar insolation level and ambient temperature, so maximization of power output with greater efficiency is of special interest. Maximum Power Point Tracking (MPPT) is widely used control technique to tract maximum power available from the solar cell of photovoltaic (PV) module. Moreover there is great loss of power due to mismatch of source and load. So to extract maximum power from solar panel a MPPT needs to be designed. The objective of this paper is present the comparative studies between two most popular algorithms technique which are incremental conductance algorithm and perturbs and observe algorithm. A boost converter use to develop MPPT in this study. Few comparisons such as voltage, current and power output for each different combination have been recorded.

Keywords— solar panel, DC-DC boost converter, Maximum power point tracking (MPPT), Perturb and observe (P&O) method, Incremental & conductance (I&C) method

I. INTRODUCTION

Conventional sources of energy are rapidly depleting and the cost of energy is rising, photovoltaic energy becomes a promising alternative source. Among its advantages are that it is: 1) abundant; 2) pollution free; 3) distributed throughout the earth; and 4) recyclable. The main drawbacks are that the initial installation cost is considerably high and the energy conversion efficiency is relatively low. To overcome these problems, the following two essential ways can be used: 1) increase the efficiency of conversion for the solar array and 2) maximize the output power from the solar array.

Various methods of maximum power tracking have been considered in photovoltaic power applications. Of these, the perturbation and observation method (P&O), which moves the operating point toward the maximum power point by periodically increasing or decreasing the array voltage, is often used in many photovoltaic systems]. It has been shown that the P&O method works well when the insolation does not vary quickly with time; however, the P&O method fails to quickly track the maximum power points.

The incremental conductance method (IncCond) is also often used in photovoltaic systems. The IncCond method tracks the maximum power points by comparing the incremental and instantaneous conductance's of the solar array. The incremental conductance is estimated by measuring small changes in array voltage and current. These small changes may be induced by deliberate control action. A method which improves the IncCond method and can identify the incremental conductance of the array more rapidly has been proposed.

MPPT techniques are needed to maintain the PV array's operating at its MPP. In this paper two most popular of MPPT technique Perturb and Observe (P&O) methods and Incremental Conductance methods (I&C) and different method of DC-DC Boost converter (open loop & close loop) were designed to evaluate the converter performance. The tracking efficiencies of different MPPT controls and the performance of different DC-DC Boost converters are evaluated through simulations in PSIM Software.

II. DC-DC BOOST CONVERTER

The input voltage can be lower than the output voltage this converter present obvious design advantages. this DC-DC converter is an increasingly popular topology, particularly in battery powered application.. In this work, for implementation of maximum power point tracker, this working mainly in continuous conduction mode is used as power processing unit. The power flow controlled by adjusting the on /off duty ratio of the switch S.
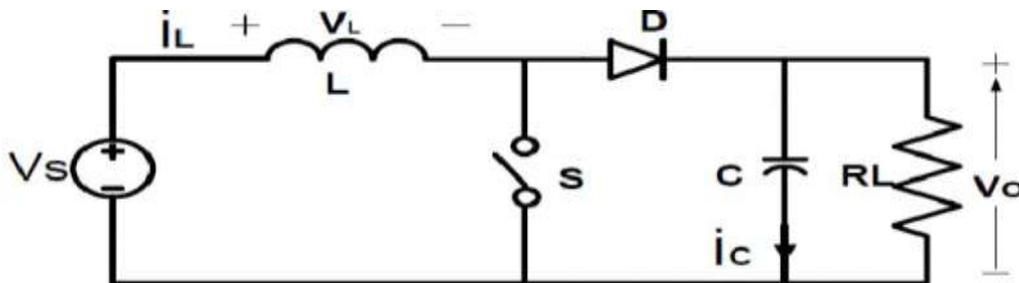

Figure :1 Step – up Boost Converter basic circuit

Fig. 1 shows the schematic of the DC-DC converter implemented. When the switch is closed, The source voltage is applied across the inductor and the rate of rise of inductor current is dependent on the source voltage VS and inductance L.

When the switch is open, the voltage across the inductor is:

$$V_L = Vs - Vo$$

Using the PV panel with the following characteristics:
Maximum power P_{max} = 25 W,   Open circuit voltage Voc = 21.6 V, Short circuit current Isc = 1.54 A,   maximum power voltage Vm = 17.8 V, maximum power current = 1.41 A.

The DC-DC Boost Converter design starts with the selection of inductors L.
Input voltage Vin = 17.8 V, output voltage Vout = 28 V, switching frequency Fs = 5 KHz, Duty cycle D = 0.36, inductor L = 10 uH.[18]

III. CONTROL ALGORITHMS FOR MPPT

Many control algorithms for MPPT have been proposed. Two algorithms often used to achieve the maximum power point tracking are: (1) The perturbation and observation method and (2) The incremental conductance method

PERTURB AND OBSERVE
Perturbation causes the power of the solar module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses shown in fig 2 & 3. 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. A PI controller then acts moving the operating point of the module to that particular voltage level. 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.
INCREMENTAL AND CONDUCTANCE
The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. The IC can determine that the MPPT has

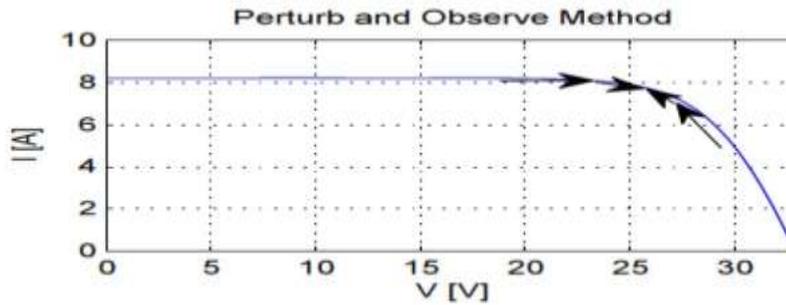reached the MPP and stop perturbing the operating point. If this condition is not met,

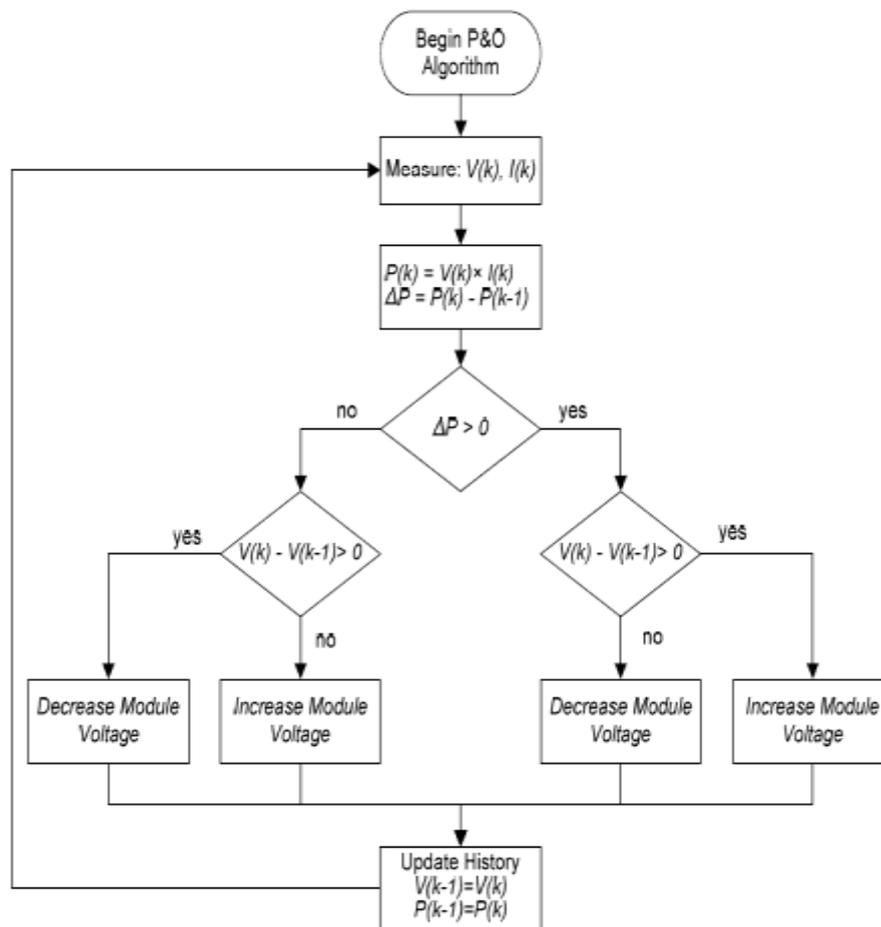**Figure. 2.   Graph Power versus Voltage for Perturb And Observe Algorithm**

Figure. 3 P & O A l g o r i t h m s

The direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dI/dV and –I/V this relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP shown in fig 4 & 5. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where   P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than perturb and observe. One disadvantage of this algorithm is the increased complexity when compared to P&O.
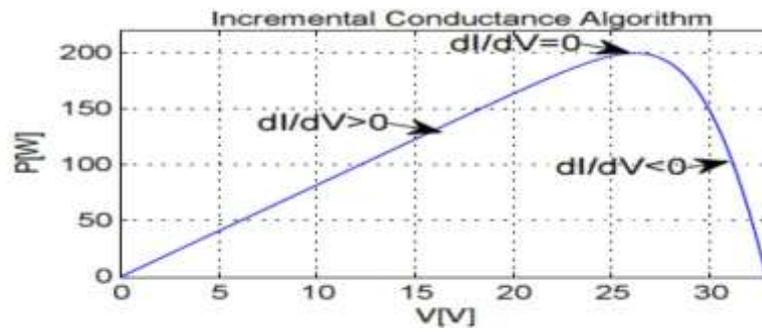
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Figure. 4. Graph Power versus Voltage for IC Algorithm

IV. RESULTS AND SIMULATION

All simulation and result for every converter have been recorded to make sure the comparison of the circuit can be determined accurately. In this paper simulation of open loop and closed loop controlled boost converter system for solar installation system. PSIM models for open loop and closed loop systems are developed using the blocks of simulink and the same are used for simulation studies. These converters, when operated under open loop condition, it exhibits poor voltage regulation and unsatisfactory dynamic response, and hence, this converter is generally provided with closed loop control for output voltage regulation (shown in figure 6)[4]
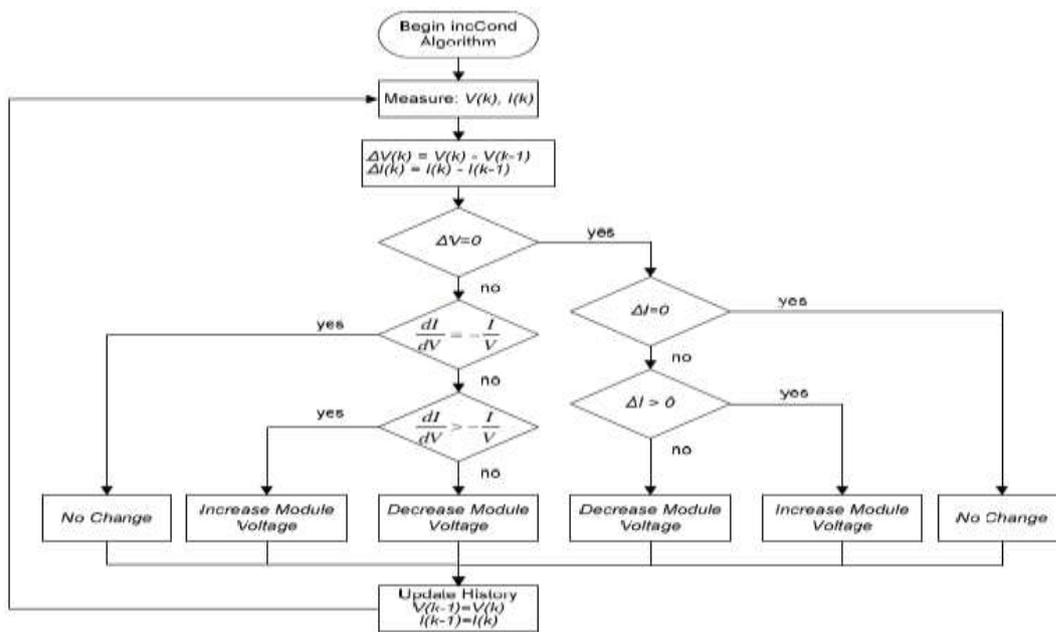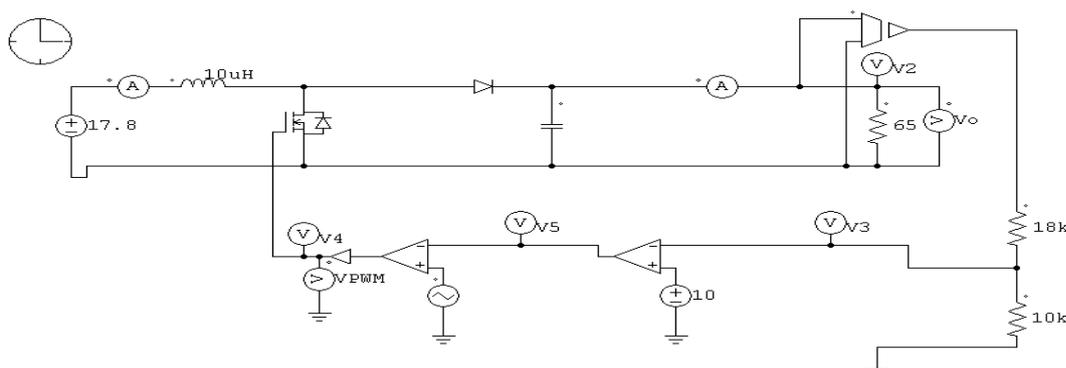

Figure 5: IC Algorithm

Figure 6: Circuit diagram of close loop boost converter

The closed loop system is able to maintain constant voltage. This converter has advantages like reduced hardware and good output voltage regulation. A comparative study of Open Loop and Close loop Configuration of DC/DC Boost Converter is shown in Figure 7 (For 25 v as input) , Figure 8 (For 17.8 v as input) and Figure 9 (For 10 v as input) as well as Table No 1. The mode of operation of the converter varies from ON to OFF state of the power switch and traditionally small signal linearization techniques have largely been employed for controller design.

COMPARISION OF OUTPUT VOLTAGE OPEN LOOP DC DC BOOST CONVERTER & CLOSE LOOP DC DC BOOST CONVERTER.

OPEN LOOP DC DC BOOST CONVERTER   CLOSE LOOP DC DC BOOST CONVERTER
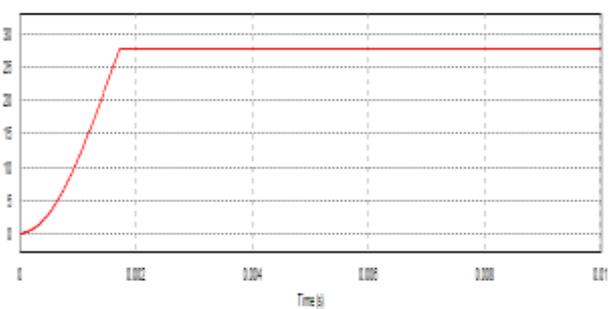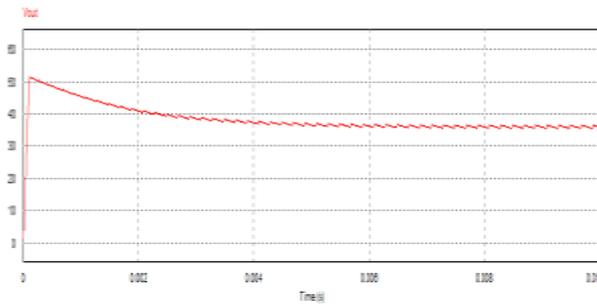

Figure : 7 Output voltage for open loop Boost Converter & close loop Boost converter when 25 V input
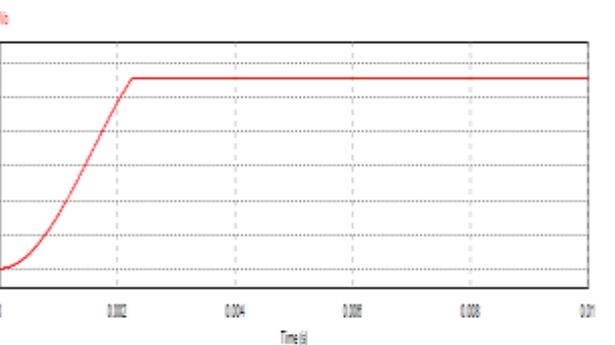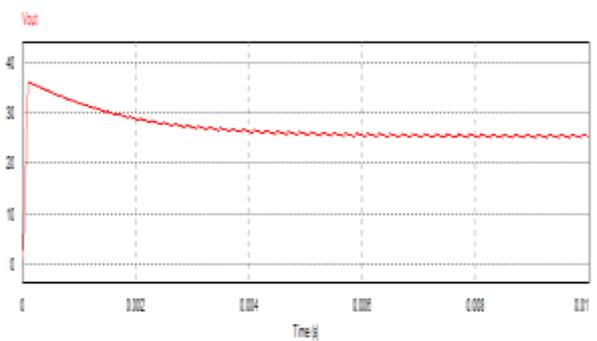

Figure : 8 Output voltage for open loop Boost Converter & close loop Boost converter when 17.8 V input
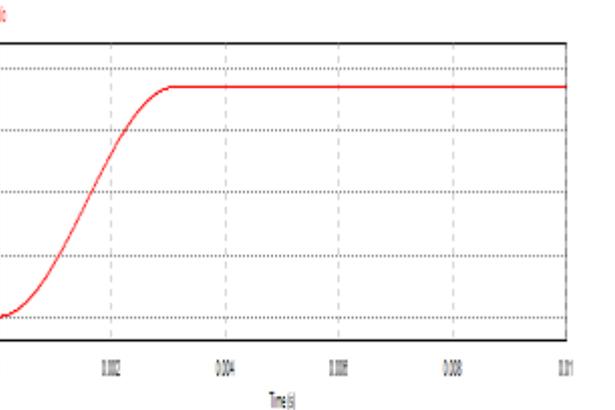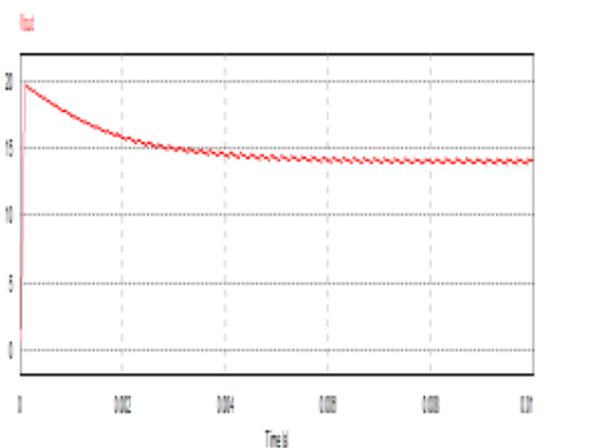

Figure : 9 Output voltage for open loop Boost Converter & close loop Boost converter when 10 V input

TABLE 1   COMPARISION OF OUTPUT VOLTAGE OPEN LOOP DC DC BOOST CONVERTER & CLOSE LOOP DC DC BOOST CONVERTER

INPUT VOLTAGE	OPEN LOOP OUTPUT VOLTAGE	CLOSE LOOP OUTPUT VOLTAGE
25 V	35	28 V
17.8 V	28 V	28 V
10 V	14	28 V

COMPARISON OF PERTURB & OBSERVE AND INCREMENTAL & CONDUCTANCE CONVERTER WITH DC DC BOOST CONVERTER.
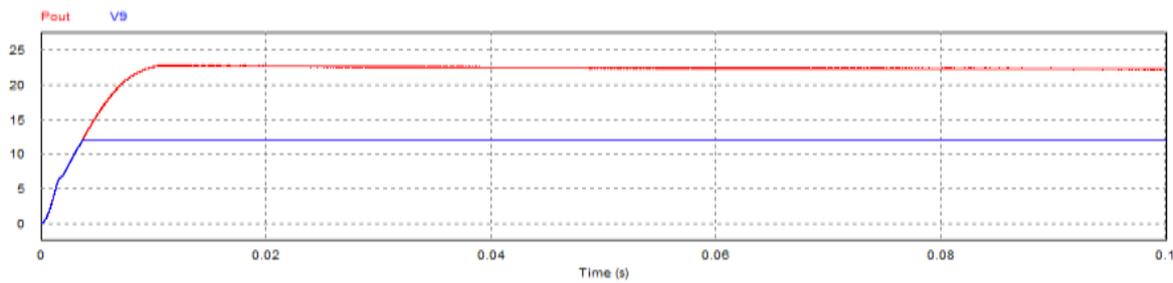

Figure : 10 Comparison of the output power with & without the perturb & observe algorithms
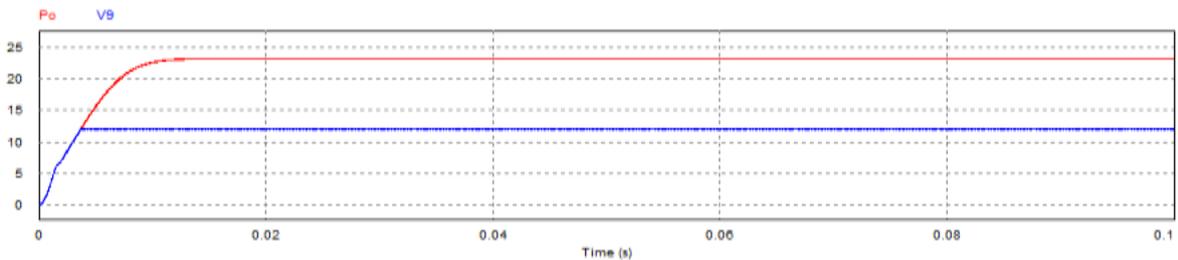

Figure : 11 Comparison of the output power with & without the incremental & conductance algorithms

TABLE: 2 COMPARISON OUTPUT POWER BETWEEN DC-DC CONVERTER P&O AND I&C CONTROLLER

Controller	Vin	Iin	Vout	Iout	Pout
DC-DC Boost Converter	17.8 V	1.5 A	28 V	0.43 A	12.04 W
DC-DC Boost Converter with MPPT (P&O)	17.8 V	1.5 A	37.8 V	0.58 A	22.2 W
DC-DC Boost Converter with MPPT (I &C)	17.8 V	1.5 A	38.92	0.68	23.31 W

From the simulation show that voltage input for both controller is the same. Perturb and Observe Controller shows a not stable condition. Figure 10 shows a Comparative study of power with & without perturb & observe algorithm and same for figure 11 but with & without incremental

conductance algorithm. (Refer table 2). From the simulation result is shows that controller that connected with Boost converter which will give a stable output is the incremental conductance controller. Incremental conductance can achieve maximum output power at 23.31W in 25W solar PV cell. Incremental & conductance controller can achieve maximum output power and stable output result better then the perturb & observe controller. shown in fig 12 & 13
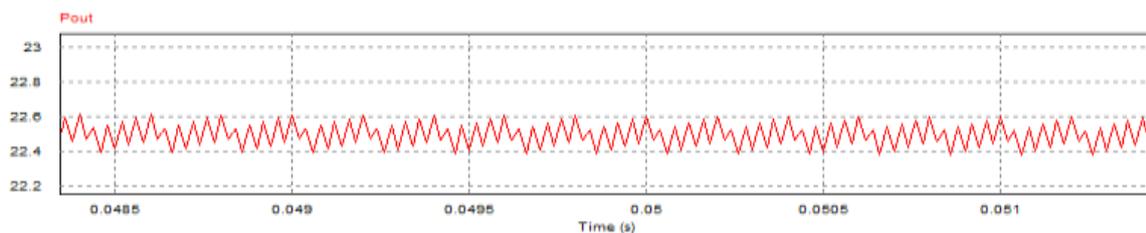

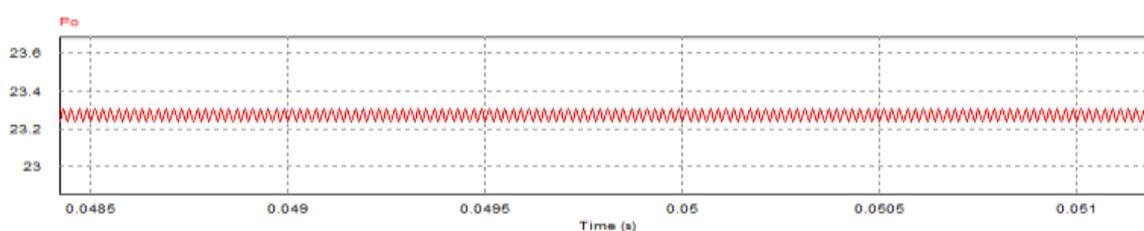**Figure: 12 Output power of perturb & observe method**

Figure : 13 Output power of incremental & conductance method

V. CONCLUSION

This paper shows that open loop configuration is not able to maintain the output voltage where as close loop configuration is able to provide constant output irrespective of change in input of solar panel which has standard values of parameters. Then this paper has showed the comparison between two most widely used MPPT algorithms namely Incremental Conductance and Perturb & Observe. This comparative study has showed (Refer Table 2) that the output Power Flow in Incremental Conductance is more reliable and less distorted as compared to Perturb & Observe.

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