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Simulation and Analysis of Perturb and Observe MPP Tracking Algorithm under Uniform and Non-Uniform Irradiation

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Abstract*: The PV array generating power is always directly affected by various conditions such as angle of inclination, temperature, irradiation of sun, shading effect, and solar array configuration. In practice, PV arrays are commonly partially shaded by trees, clouds, nearby buildings, bird droppings and other utilities which leads to multiple peaks appear in the P-V curve, a global maximum and one or several local peaks. In this paper, the "perturb and observe" (P&O) maximum power point tracking (MPPT) algorithm employed for tracking the maximum power point under uniform and non-uniform irradiation conditions. Initially, this paper presents the P and O algorithm operation, later the boost converter performance details and finally the combination of a boost converter with P and O algorithm. The evaluation process has been carried systematically for the uniform and non-uniform solar irradiance and finally, the results are analyzed.

Index Terms: Solar Photovoltaic array (PV); Uniform and non Uniform irradiation; Partial shading; Maximum Power Point tracking (MPPT); Perturb and Observe (P&O); Boost Converter.

I. INTRODUCTION

Solar energy is the best suitable alternative to fossil fuels. The solar is an excellent available source for power generation. It is pollution free and freely available. But the solar power generators i.e., PV panel is non-linear in the sense low as well as fluctuating, so it is not capable to access the grid for the direct connection [1-3]. To generate the maximum power the PV panel always need peak solar irradiation. But in regular practice, the solar irradiation is low in the morning and evening high in the midday and zero during the night. Along with the variation in the irradiation, the temperature also varies which results in the variation of the power also. Therefore to extract maximum power from the panel MPPT algorithm is used in many systems [4-5]. By integrating PV array and MPPT with traditional boost converter is work as a small micro-grid. But the classical boost converters operated with a higher duty cycle to attain high transformation ratio results in heavy conduction losses [6-8]. The switched capacitor technique based converters and voltage lift technique based converters can attain high transformation ratio [9-13]. Coupled inductor based converter can attain high voltage gain increasing the terms ratio. It causes higher voltage notches on the switch due to leakage energy. An additional clamping circuit is required to recycle the energy [14]. Various step-up converters with passive clamp circuit have been proposed to additional switch produces conduction losses and increases cost of converter [15].In [16], to attain high transformation ratio step-up converters based on multiplier cell have been proposed. But it has the main drawback: with the increment in the high transformation result in an increment of the circuit complexity and cost. PV integrated voltage lift DC-DC converter based on multiplier cell can also provide large voltage conversion ratio and higher efficiency [17-18]. Another PV and MPPT integrated isolated structure based converter can attain high voltage gain. But to attain more voltage gain additional interleaving cells are necessary, which results in the increase overall cost of the system [19-20]. And an another approach is proposed to allocate the effect of partial shading on the PV array without altering the electrical connections of PV modules just only by the change of physical location their performance improvement has been discussed in [21]. In this paper, MPPT based boost converter for PV systems under uniform and non-uniform irradiation is discussed.

II. PHOTOVOLTAIC MODULE MODELING:

A. Mathematical Equation of a Solar Cell:

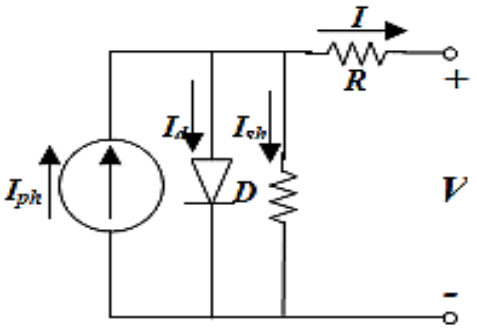

Fig.1: Equivalent circuit of a single solar cell.

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The equivalent circuit modeling and the mathematical cryptography of the PV system was discussed in detail in [22].

III. PERTURB AND OBSERVE (P and O) MPPT ALGORITHM:

The MPP of array varies according to the irradiation & temp. To attain maximum output from PV array, tenacious follow-up of MPP should be required. Through MPPT algorithm, high voltage can be achieved which is further used to separate duty cycle of the converter. The P & O is algorithm flow chart is shown in Fig.2. it can easily understand the process of miniature perturbation. If PV systems voltage is perturbed by little enhancement of ΔV which results in the small change in ΔP. Now, suppose ΔP is positive, then there is need to perturb of PV voltage in the similar direction of the enhancement. In conflict, ΔP is negative, there is need to perturb PV voltage in the opposite direction of enhancement. The developed Simulink model of P and O MPPT algorithm is unveiled in Fig.3.

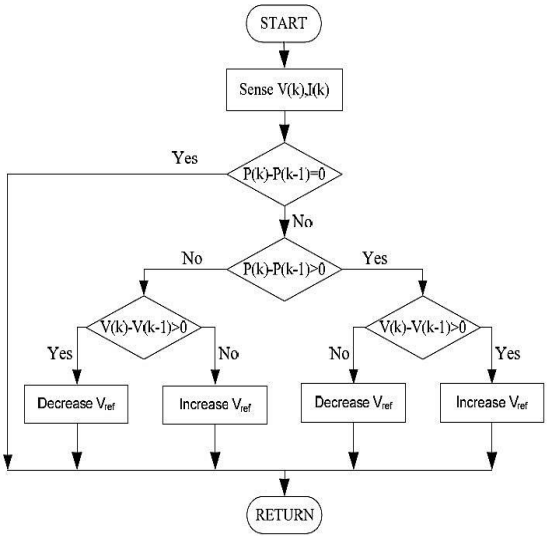

Fig.2: P & O algorithm flowchart.

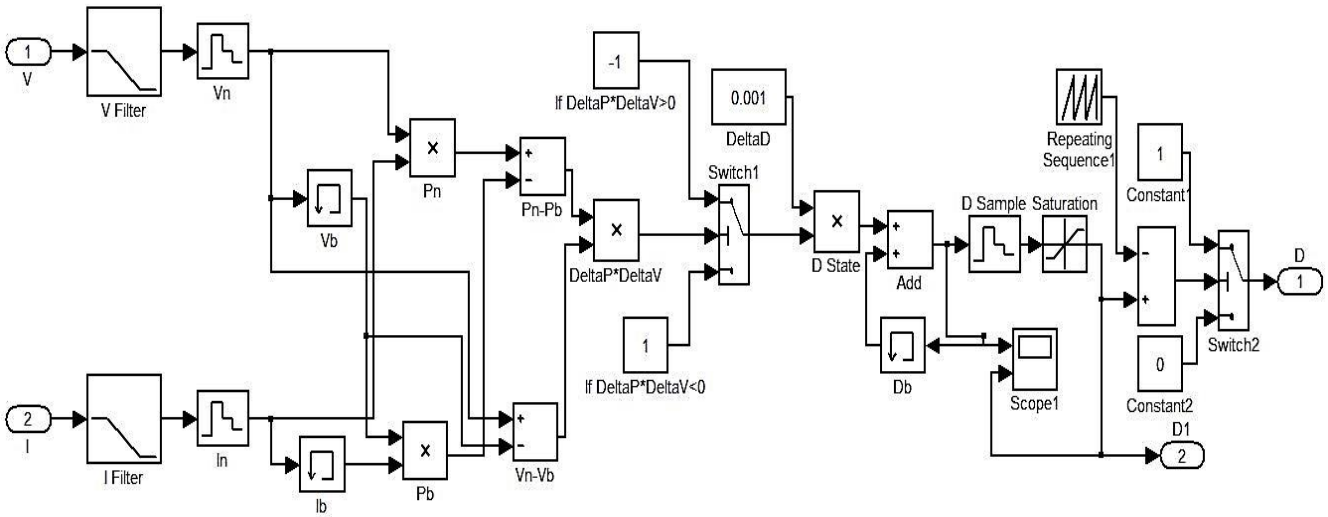

Fig.3: Simulink model of P and O MPPT algorithm

IV. BOOST CONVERTER :

The importance of selecting the boost converter is that, it provides High transformation ratio, Low voltage stresses across elements, unique polarity output voltage, Unidirectional output current, Easy to analyze and understand, Low cost and Higher efficiency. Fig 4 represents the a pulse width modulation based boost converter, consists of controlled switch as a IGBT and the series diode(D), filter capacitor(C), inductor L for boosting, load resistor R with the PV array output voltage as input for the Vg . When the switch is operated i.e IGBT is triggered and brought to conducting state, the current which is present in the inductor of a boost converter circuit is sequentially suit up, in this ongoing process diode D is in non conductive state. As soon as the IGBT switch if turned OFF the energy which is stored in the boost inductor is obviously passed through the diode D and hence the output C with the load resistor.

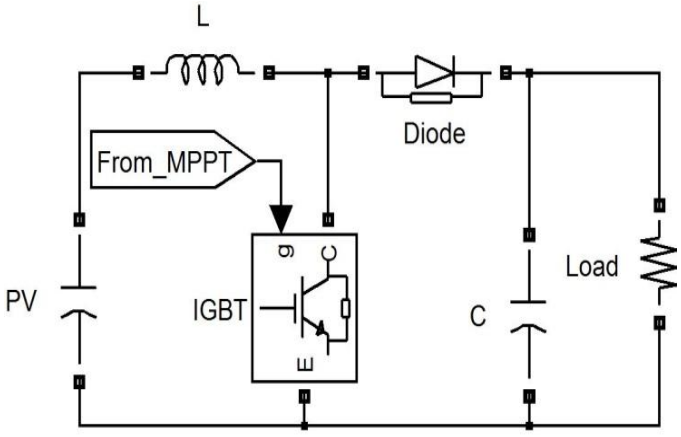

Fig.4: Boost converter circuit.

When the switch is ON, the inductor is charged from the input voltage source Vg and the capacitor discharges across the load. The duty cycle, where .

From the steady-state calculation of the Boost converter, the values for the L and C of the boost converter is obtained as L=0.01H C=2mF. Switching frequency (fs) of the boost converter is 3000Hz.

V. RESULTS AND DISCUSSIONS:

The P & O algorithm has been developed with a keen codes in MATLAB simulation. With a operating switching frequency of 3kHz for the boost converter which is to be operated in a continuous conduction mode is as shown in Fig.5. A sufficient amount of concerned to be considered to make the different conditions of irradiance such as uniform and non uniform irradiance while performing with simulation. This is fundamental requirement for the proposed technique since its performance is estimated based on the operating conditions only.

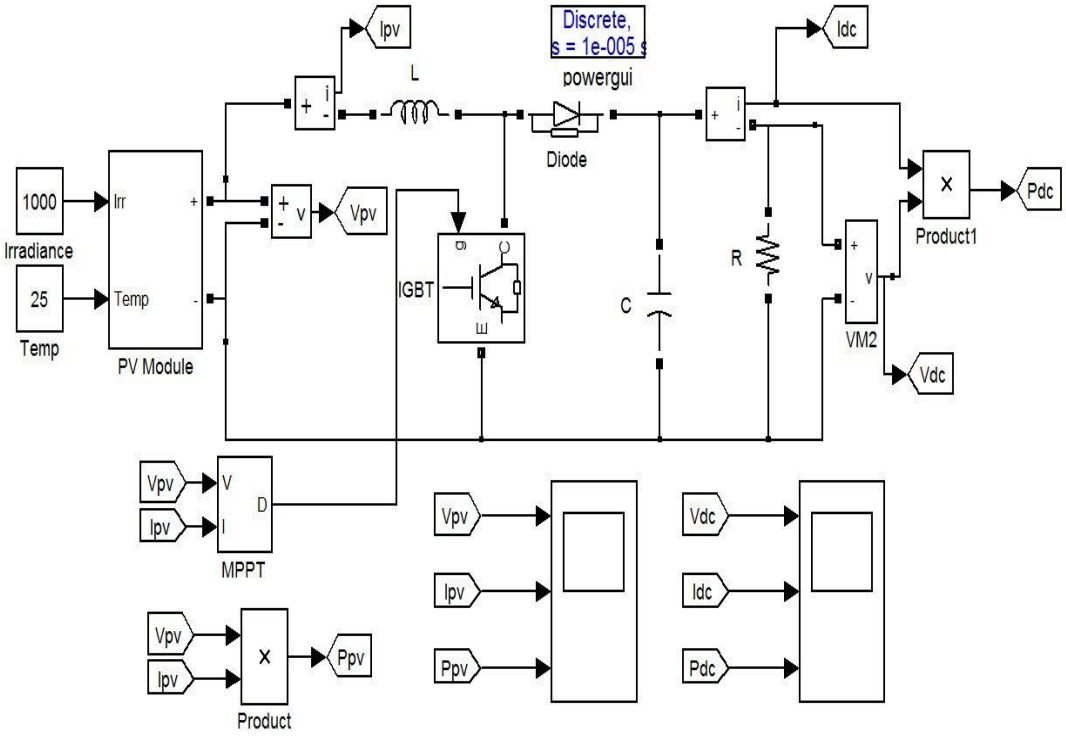

Fig.5: Representation of simulation blocks of boost converter, controller (MPPT) with the solar PV modules

Uniform and non uniform irradiance used for the simulation process is shown in Fig.6. in fig.6 the top trace shows the uniform irradiance and bottom trace shows the non uniform irradiance.

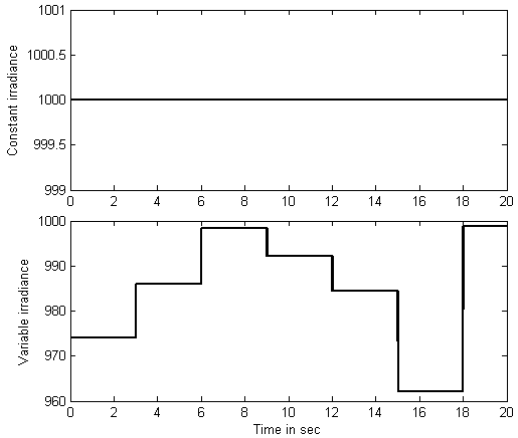

Fig.6: Uniform and non uniform irradiance.

Uniform irradiation condition :

Simulation results computed voltage, current, and power tracked waveforms under uniform irradiation for P and O algorithm is presented in Fig. 7-10. The results presented are of the superior visibility with different instances for the comparison with nonuniform irradiance conditions. The irradiation is maintained at 1000 w/m2 and the temperature of the system is also maintained constant at 25 degrees. In the Fig.7 at the initial state that is at 0 to 0.6 seconds, it is observed that variation takes place in the voltage is resulted in power. These results are obtained from PV system without boost converter. Fig. 8 shows the results of the PV system output without boost converter system during the steady period that is at 2 to 20 sec. In the Fig.9 at the initial state that is at 0 to 0.6 seconds it is observed that the voltage is not reached to zero or near to zero point there for the resulted power is not a zero value. These results are obtained from PV system with the boost converter. Fig 10 shows the results of the PV system output with boost converter system during the steady period that is at 2 to 20 sec.

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Non Uniform Irradiation Condition:

The tracked output waveforms of the voltage, current and the power which are obtained from the simulation results under the non uniform irradiance to the P and O algorithm is presented in Fig.11-14.

The irradiation is varied between 900 to 1000 w/m2 and the temperature of the system is also maintained constant at 25 degrees. In the Fig.11 at the initial state that is at 0 to 0.6 seconds it is observed that variation takes place in the voltage resulted in a power of the PV system. These results are obtained from PV system without boost converter. Fig 12 shows the results of the PV system output without boost converter system during the steady period that is at 2 to 20 sec. In the Fig.13 at the initial state that is at 0 to 0.6 seconds, it is observed that a smooth increment in voltage, as well as power, can be observed. These results are obtained from PV system with a boost converter. Fig 14 shows the results of the PV system output with boost converter system during the steady period that is at 2 to 20 sec.

Fig 7 to 14 represents the results of voltage, currents and tracking power which are simulated using P and O algorithm at different conditions like uniform and non uniform irradiations with and without boost converter during steady state.

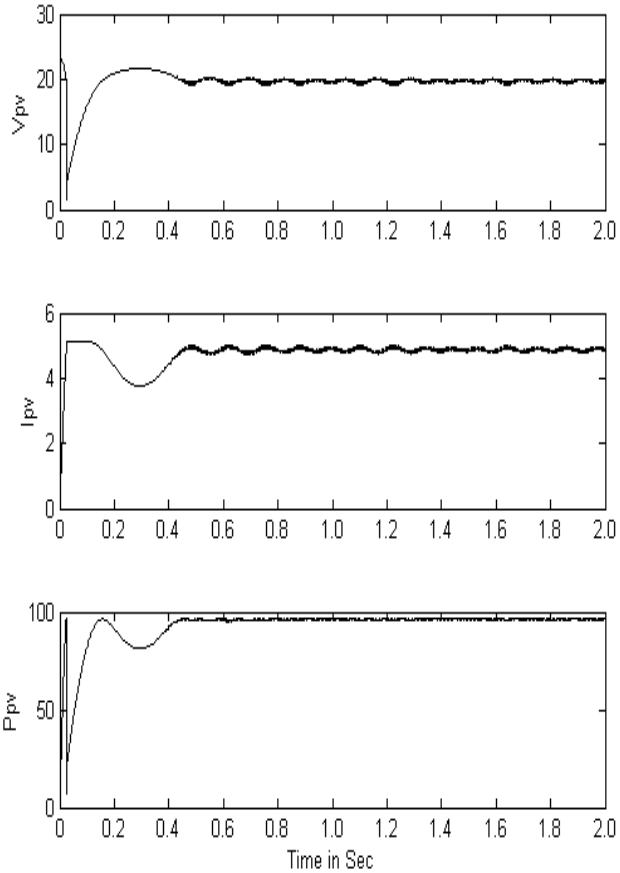

Fig.7: Results of uniform irradiation condition of PV system without boost converter.

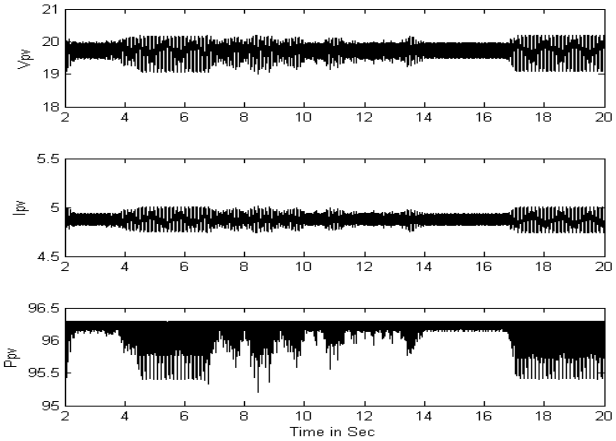

Fig.8: Results of uniform irradiation condition of PV system without boost converter during the steady state.

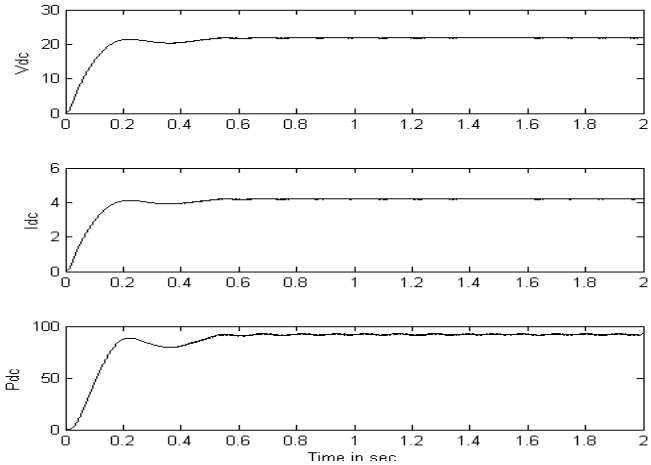

Fig.9: Results of uniform irradiation condition of PV system with boost converter.

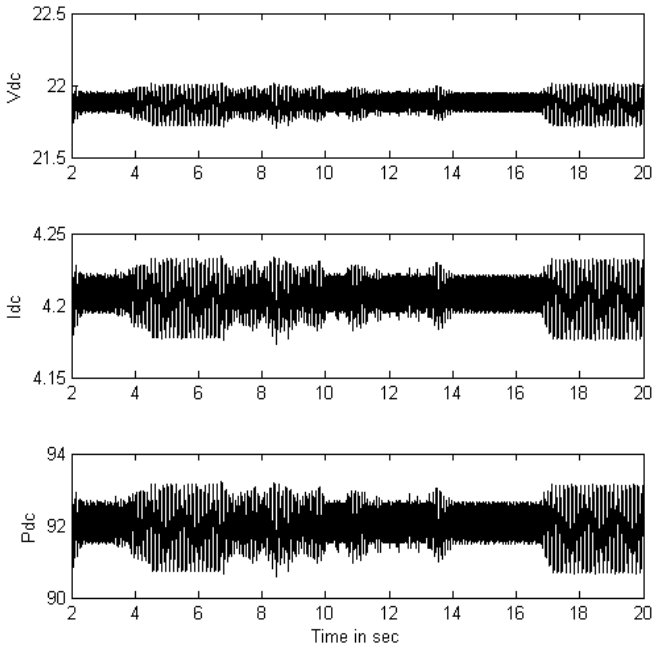

Fig.10: Results of uniform irradiation condition of PV system with boost converter during the steady state.

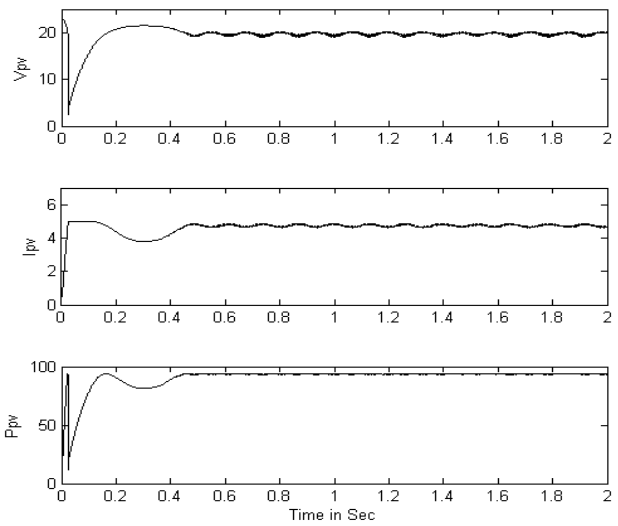

Fig.11: Results of non uniform irradiation condition of PV system without boost converter.

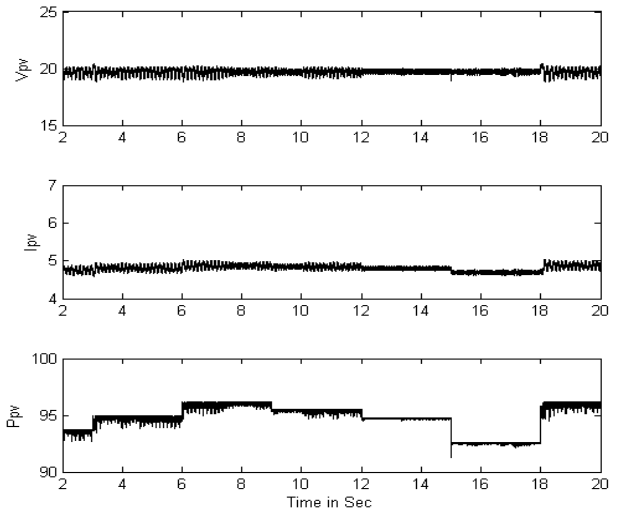

Fig.12: Results of non uniform irradiation condition of PV system without boost converter during the steady state.

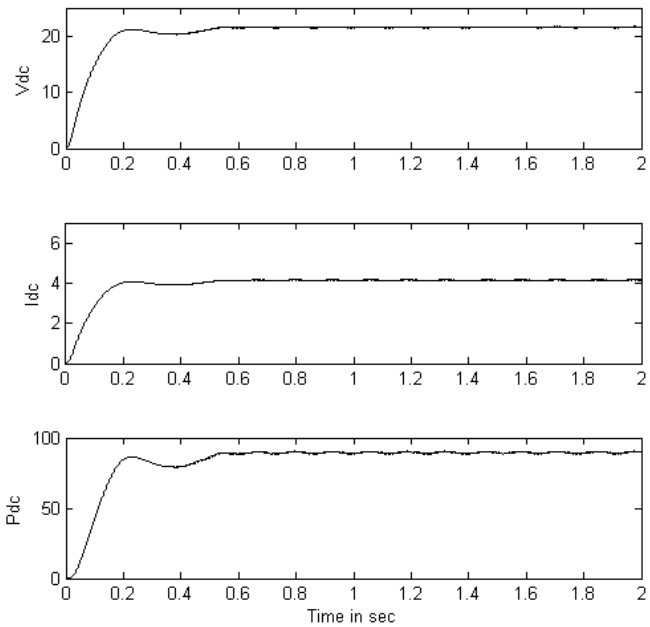

Fig.13: Results of non uniform irradiation condition of PV system with boost converter.

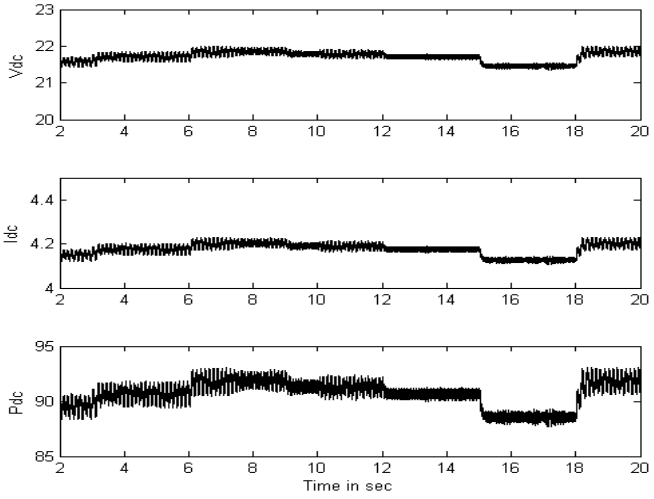

Fig.14: Results of non uniform irradiation condition of PV system with boost converter during the steady state.

VI. CONCLUSION :

In this paper, the "perturb and observe"(P&O) type maximum power point tracking (MPPT) algorithm technique for tracking a maximum power point under uniform and non-uniform irradiation is presented. With the simulation results the proposed (P and O) method is easy to implement with the boost converter system and the better tracking capability even under the uniform and non-uniform irradiation conditions are employed. Because of this simplicity of implementation and fast response, the P and O algorithm with Boost converter system combination can be extended in the grid-connected PV system applications.

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