Implementation Of Perturb and Observe MPPT in the PV System with Buck - Boost Converters

Syed Nadir Ali[1] Ashish Tiwari[2]
[1]Student [2]Professor
[1,2]Vindhya Institute of Technology & Science, Indore, India

Abstract— Renewable energy is best option for fulfilling energy requirements in rural and needy areas. The main problem with its implementation is cost and efficiency. As far as cost is concerned it has been suppressed by advancement in Indigenous Technology and support form Govt. of India, whereas increment in efficiency is different matter. For increasing the efficiency of renewable sources like Solar PV Panels various methods have been adopted, one of which is Maximum power point tracing (MPPT). MPPT system is an electronic system that may be ready to compel the utmost power from a PV system. It doesn't involve any mechanical element that ends up in the movement of the module's dynamic, their direction and create them face straight towards the sun. MPPT system may be a fully electronic system which might deliver most allowable power by varying the operative purpose of the modules electrically. In this paper we present execution of Perturb and Observe MPPT exploiting buck-boost Converters. Results for each various combination have been recorded. The simulation has been done in software of MATLAB Math works.

Keywords: Maximum Power Point Tracking, Perturb and Observe, DC-DC Converters, Photovoltaic System

I. INTRODUCTION

Expanding energy access to poor households in rural and remote areas could be a complicated development challenge. The task of increasing access to trendy energy, each for domestic and productive uses, poses a formidable challenge to planners and development practitioners. There are some limitations to the enlargement of the electricity grid similarly as transmission of electricity through the grid. There are constraints to providing acceptable and reasonable solutions to satisfy energy needs particularly within the rural and remote areas. A region of the gap is understood to be met by the utilization of diesel and kerosene that are exhaustible and extremely volatile in accessibility and prices. Use of inefficient energy conversion devices like conventional cook stoves not solely leads to indoor pollution however causes stress on natural resources similarly. There's substantial scope for the employment of renewable in bridging this gap. But the main problem with renewable sources is their lower efficiency rates.

For increasing the efficiency of renewable sources like Solar PV Panels various methods have been adopted. One of which is used by Maximum Power Point Tracking (MPPT) using P&O algorithm. Many other MPPT are also suggested in the literature; example are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods and constant voltage methods. etc. .In this paper the most popular of MPPT technique (Perturb and Observe (P&O) method, Buck and Buck- Boost DC-DC converters will involve in Implementation study. Some results such as current, voltage and output power for each various combination have been discussed. The MPPT technique will be implemented, by using MATLAB tool Simulink. This study is a novel work which could be a great help for future erection of these kind of projects.

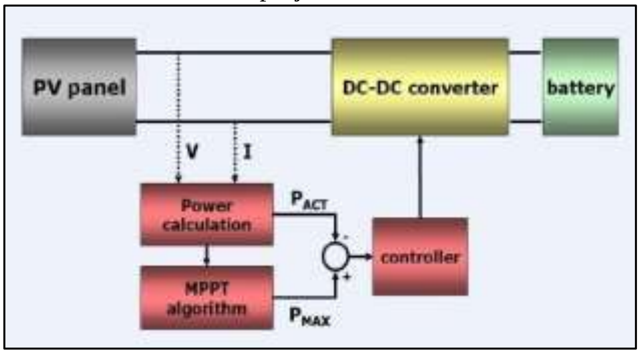
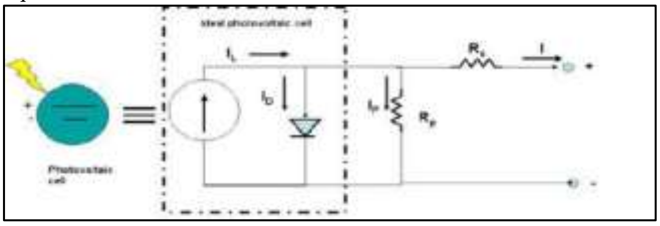


Fig. 1: PV module and dc/ dc converter with MPPT

II. PV CELL

Photovoltaic generators are neither fixed current sources nor voltage sources but can be approximated as current generators with dependent voltage sources. During darkness, the solar cell is not an active device. It produces neither a current nor a voltage. A solar panel cell essential is a p-n semiconductor junction. When exposed to the light, a current is generated (DC current).The generated current change linearly with the solar irradiance. Figure 2 show the equivalent electrical circuit of an ideal solar cell.



The I-V characteristics of the solar cell circuit can be sets by the following equations [14]. The current through diode is given by:

$$ID = IO\,[\exp(q\,(V + I\,RS)/KT)) - 1] \quad (1)$$

While, the solar cell output current:

$$I = IL - ID - I\,sh \quad (2)$$

$$I = IL - IO\,[\exp(q(V + I\,RS)/KT)) - 1] - (V + IRS)/Rsh \quad (3)$$

Where,
I: Solar cell current (A)
IL: Light generated current (A) IO: Diode saturation current (A) q : Electron charge (1.6×10-19 C)
K: Boltzman constant (1.38×10-23 J/K) T: Cell temperature in Kelvin (K)
V: solar cell output voltage (V) Rs: Solar cell series resistance (Ω) Rsh: Solar cell shunt resistance (Ω)

III. DC-DC CONVERTER ANALYSIS

A. Buck Converter

A buck converter or voltage regulator is also called a step down regulator since the output voltage is lower than the input voltage. In a simple example of a buck converter, a diode is connected in parallel with the input voltage source, a capacitor, and the load, which represents output voltage. A switch is connected between the input voltage source and the diode and an inductor is connected between the diode and the capacitor, shown in Figure 3 [15].

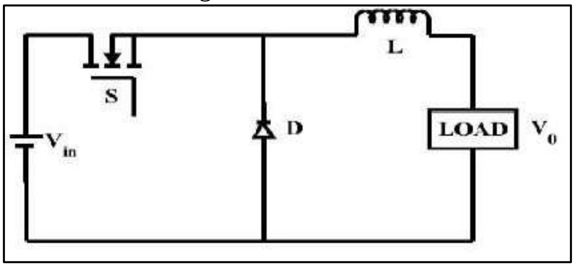


Fig. 3(a): Basic buck converter

B. Buck-Boost Converter

The last and most important type of switching regulator is the buck-boost converter. In this converter, the buck and boost topologies covered earlier are combined into one. A buck-boost converter is also built using the same components used in the converters covered before. The inductor in this case is placed in parallel with the input voltage and the load capacitor. The switch or transistor is placed between the input and the inductor, while the diode is placed between the inductor and the load capacitor in a reverse direction, shown in Figure 4.The buck-Boost converter provides an output voltage that may be less than or greater than the input voltage [15].

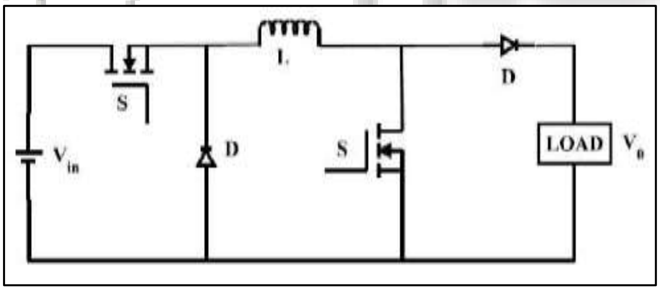


Fig. 3(b): Basic buck-boost converter

IV. PROBLEM OVERVIEW

The MPPT method consider is to automatically find the current IMPP or voltage VMPP at which a PV array should work to extract the maximum output power PMPP under a given temperature and irradiance. Most of MPPT methods respond to variations in both irradiance and temperature, but some are precisely more useful if temperature is approximately constant. Most MPPT methods would automatically respond to various in the array due to aging, though some are open-loop and would require periodic fine tuning. In our context, module will typically be connected to a power converter that can vary the current coming from the PV array to the load.

V. MPPT CONTROL ALGORITHM

The weather and load changes cause the operation of a PV system to vary almost all the times. A dynamic tracking technique is important to ensure maximum power is obtained from the photovoltaic arrays. The following algorithms are the most fundamental MPPT algorithms, and they can be developed using micro controllers.

The MPPT algorithm operates based on the truth that the derivative of the output power (P) with respect to the panel voltage (V) is equal to zero at the maximum power point. In the literature, various MPP algorithms are available in order to improve the performance of photovoltaic system by effectively tracking the MPP. However, most widely used MPPT algorithms are considered here, they are:

1) Perturb and Observe (P&O)
2) Incremental Conductance (In Cond)
3) Constant Voltage Method

A. Perturb and Observe (P&O)

The most commonly used MPPT algorithm is P&O method. This algorithm uses simple feedback arrangement and little measured parameters. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle . In this algorithm a slight perturbation is introduce to the system. This perturbation causes the power of the solar module various. If the power increases due to the perturbation then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is zero and next instant decreases and hence after that the perturbation reverses as shown in Figures 5(a) and 5(b). When the stable condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the perturbation size is remain very small. The technique is advanced in such a style that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts to transfer the operating point of the module to that particular voltage level. It is observed some power loss due to this perturbation also the fails to track the maximum power under fast changing atmospheric conditions. But remain this technique is very popular and simple.

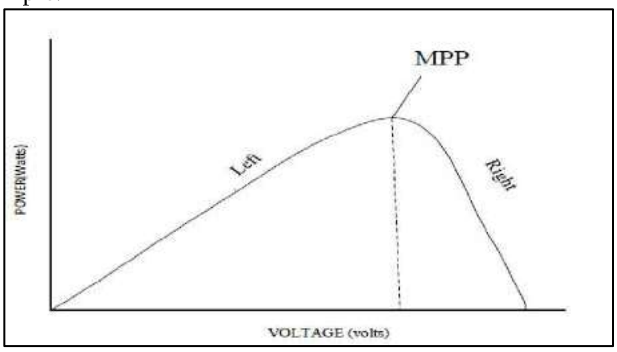


Fig. 5(a): P-V characteristics of a solarmodule

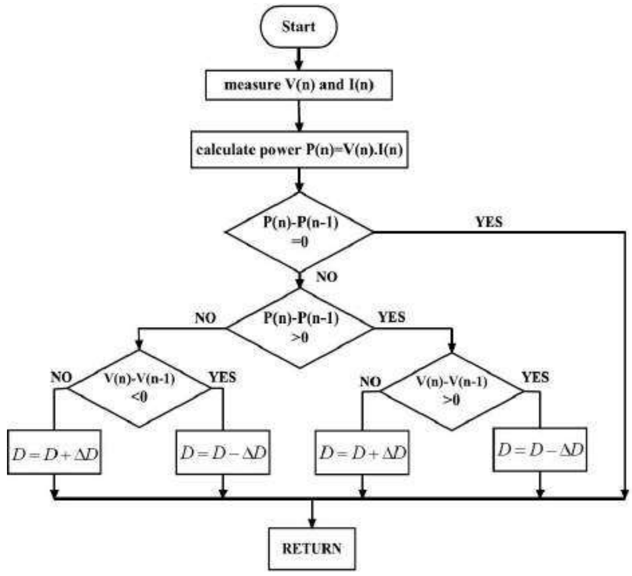


Fig. 5(b): P&O Algorithm

B. *Incremental Conductance (IC)*

The perturb oscillation around peak power point of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. The Incremental Conductance can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, 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 truth that dP/dV is negative when the MPPT is to the right side curve of the MPP and positive when it is to the left side curve of the MPP. 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 precision than perturb and observe. The disadvantage of this algorithm is the increased complexity.

C. *Constant Voltage Method*

The Constant Voltage method (CV), also in some literature called Open voltage Ratio method, uses the fact that the MPP voltage at different irradiance is approximately equal, as shown in Figure 6.

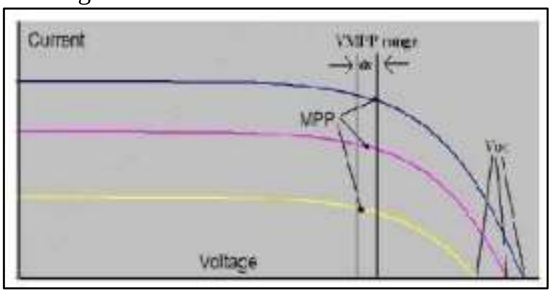


Fig. 5(c): Constant Voltage Method in V-I curve

VOC represented the open circuit voltage of the PV panel. VOC depends on the property of the solar cells. A commonly used VOC/VMPP value is 76%. This relationship can be described by equation (4) below :

$$VMPP = k * VOC \quad (4)$$

where k ≈0.76 in this case.

The solar panels are always disconnected from the converter circuit for a short duration of time for VOC measurement. The operating voltage of the MPP is then set to 76% of the measured VOC. The major advantage of this method is that the MPP may be located very quickly. However at the same time this method suffers from low accuracy, because the VOC is also affected by the temperature of the solar cells which may change the VOC/VMPP ratio significantly. Any small deviation of the VOC after the sampling can cause large difference in tracking the MPP during that sampling period. Moreover, power is lost during the short sampling time, further reducing the efficiency of constant voltage method.

VI. RESULTS AND SIMULATION

The voltage, current and output power is the main points of comparison to take into account. The complexity and simplicity of the circuit have been set based on the literature. Hardware required, convergence speed and range of effectiveness are as in.

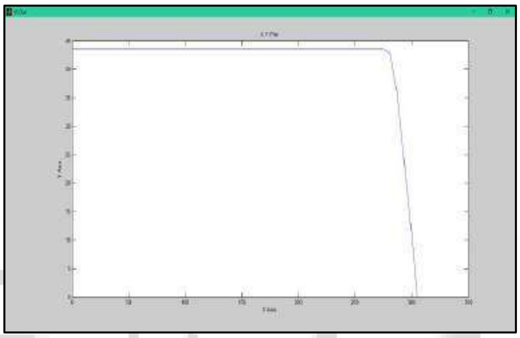


Fig. 6(a): V-I curve of photovoltaic module

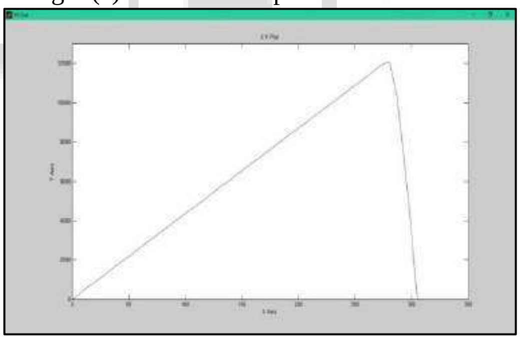


Fig. 6(b): P-V curve of photovoltaic module

Fig 6(a) & 6(b) represent the I-V and P-V characteristics of a PV module. From fig 6(a) we can see that short circuit current (Isc) of PV module is approximately 44 A and open circuit voltage (Voc) is approximately 300 volts. From fig 6(b) we can observe that maximum power is approximately 12000W and it occurs at a voltage of 270 V approximately.

A. Effect of Variation of Irradiation

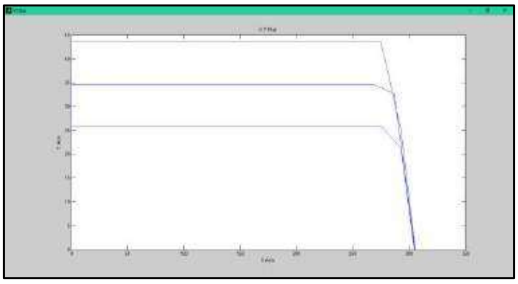


Fig. 6(c): Effect of variation of irradiation on I-V characteristics

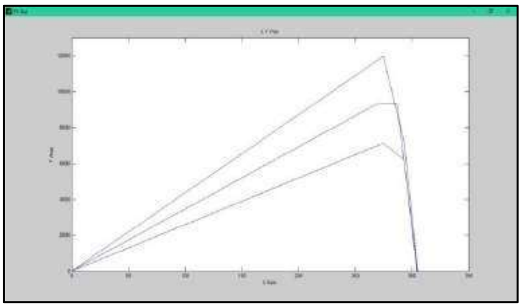


Fig. 6(d): Effect of variation of irradiation on P-V characteristics

In fig 6(c),6(d) we can see the effect of change in solar irradiation on PV characteristics. From fig 6(c) we observe that as we increase the solar irradiation short circuit current increases. Variation in Solar irradiation effects mostly on current, as we can observe from fig 6(c) as we increase solar irradiation from 800 w/m2 to 1000 w/m2 current increases from 34 A to 44 A approximately but effect of variation of solar irradiation on voltage is very less. Fig 6(d) shows the effect of variation of solar irradiation on P-V characteristics. As solar irradiation increases, power generated also increases. Increase in power is mainly due to increment in current.

B. Outputs after MPPT

Output power, output current & output voltage are manifested in the Fig. 6(e), 6(f) & 6(g) respectively. As we observe from the fig 6(b), maximum power is achieved at voltage 270 volts; from Fig 6(f) we can see we are able to track the output voltage where we can get the maximum power which is approximately 240 volts. From Fig 6(e) we can see the maximum power which is approximately 12000 watts can be tracked.

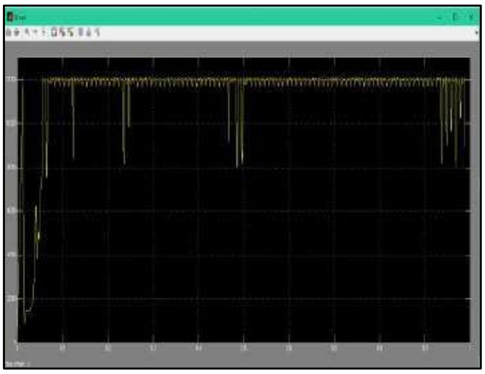


Fig. 6(e): Output power of PV module after MPPT

Fig. 6(f): Output voltage of PV module after MPPT

Fig. 6(g): Output current of PV module after MPPT

VII. CONCLUSION

P&O MPPT method is implemented with MATLAB-SIMULINK for simulation. The MPPT method simulated in this paper is able to improve the dynamic and steady state performance of the PV system simultaneously. Through simulation it is observed that the system completes the maximum power point tracking successfully despite of fluctuations. When the external environment changes suddenly the system can track the maximum power point quickly. Both buck and buck-boost converters have succeeded to track the MPP.

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