

Maximum Power Point Tracking for Photovoltaic System by Incremental Conductance Method Using Boost and Buck-Boost Converter

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ABSTRACT: Although solar energy is available throughout the day its insolation varies from morning to evening and with changing climatic conditions. As the efficiency of solar PV panel is low it becomes mandatory to extract maximum power from the PV panel at any given period of time. Several maximum power point tracking (MPPT) techniques are proposed for the purpose. Incremental conductance MPPT technique has higher steady-state accuracy and environmental adaptability. This paper investigates implementation issues of Incremental conductance MPPT algorithm. High frequency DC-DC Boost converter is used to interface PV panel with load. The Matlab Simulink model of the system is developed and results are validated with experimental results obtained using laboratory prototype of the system.

KEYWORDS: Maximum Power Point Tracking, Incremental Conductance (IC), DC-DC Converters, Photovoltaic System.

I. INTRODUCTION

The depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to meet up the present day demands. Among all the renewable energy option solar energy is clean inexhaustible and environment friendly potential source. These changes in insolation condition severely affect the efficiency and output power of the PV modules [1].

A lot of research has been done to improve the efficiency of the PV modules. A number of methods to track the maximum power point of a PV module have been proposed to overcome the limitation of efficiency . [3]. Different maximum power point tracking algorithms have been proposed including fractional open circuit voltage, fractional short circuit current , perturb and observe (P&O), incremental conductance.In high power applications, the cost of MPPT control is low as against the cost of the photovoltaic (PV) array and power converters. However, for low power applications, the implementation cost of an MPPT algorithm is a concern [3]- [4]. The very popular hill-climbing MPPT algorithm is the incremental conductance [9]-[10].

An improved MPPT algorithm for PV sources was proposed to reduce the tracking time where a dc-dc boost converter was used to track the MPP and was brought out that tracking performance depends upon the tracking algorithm used [6]. In this paper, the tracking capability of incremental with boost converter conductance at different insolation level is presented and the simulation results are verified with the experimental results.

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II. RELATED WORK

The use of efficient PV cells featured as better alternative of energy conversion, demand –side management and Renewable power. To meet these conditions we have to maintain the output power very efficiently of PV system. For this we have to track MPP by using maximum power point tracking techniques. The most popular techniques are P&O and Incremental conductance methods. By using P&O method the efficiency is reduced due to small changes in environment. So, in this paper we use incremental conductance method to track MPP at any atmospheric conditions.

III. PHOTOVOLTAIC CELL

Photovoltaic generators are neither fixed current sources nor voltage sources but can be approximated as current generators with dependant 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.[9] When exposed to the light, a current is generated (DC current). The generated current change linearly with the solar irradiance.

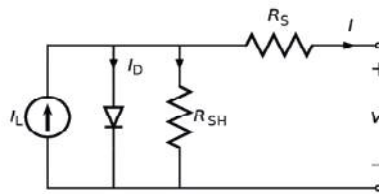


Fig.1. Equivalent circuit of a solar cell

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

$$I_D = I_S (e^{V_D/nV_T} - 1) \quad (1)$$

$$I_D = I_0 [\exp(q(V + IR_s)/KT) - 1] \quad (2)$$

While the solar cell output current;

$$I = I_L - I_D - I_{sh} \quad (3)$$

$$I = I_L - I_0 [\exp(q(V + IR_s)/KT) - 1] - (V + IR_s) / R_{sh} \quad (4)$$

Where, I : Solar cell current(A)

I_L : Light generated current (A)

I_0 : 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)

R_s : Solar cell series resistance (Ω)

R_{sh} : Solar cell shunt resistance (Ω)

IV. DC-DC CONVERTER ANALYSIS

A. Boost Converter

A boost converter is also called as step up regulator since the output voltage is higher than the input voltage .In a simple example of boost converter ,a switch is connected in parallel with input voltage source,a capacitor and the

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load, which represents output voltage. An inductor is connected between input voltage source and switch and diode is connected between switch and capacitor. shown in figure 2[5-9].

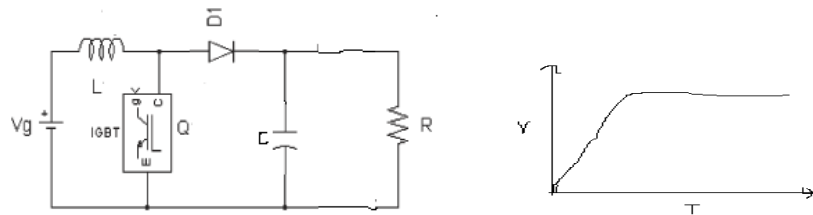


Fig.2. Basic boost converter and its characteristics

B. Buck-Boost Converter

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.3. The buck-Boost converter provides an output voltage that may be less than or greater than the input voltage [5-9].

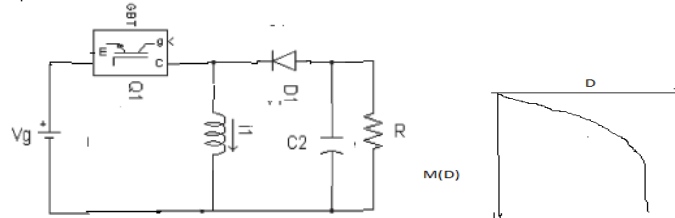


Fig.3. Basic buck-boost converter and its dc conversion ratios $M(D)$

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.[6]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:

- ❖ Perturb and Observe (P&O)
- ❖ Incremental Conductance (InCond)
- ❖ Constant Voltage Method.

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

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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 [3,4,6 and 10].

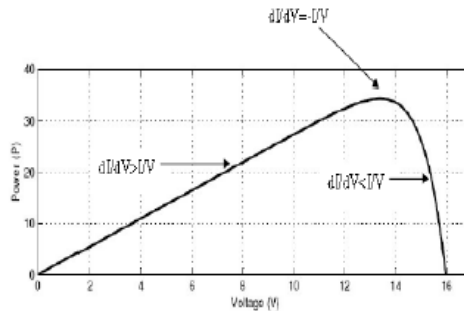


Fig:4 Power Vs Voltage for IC

$$\begin{aligned}
 dp/dv &= 0 && \text{at MPP} \\
 dp/dv &> 0 && \text{left of MPP} \\
 dp/dv &< 0 && \text{right of MPP}
 \end{aligned} \tag{5}$$

Since

$$\begin{aligned}
 dp/dv &= d(I \cdot V) / dv \\
 dp/dv &\sim I + V \cdot dI/dV = I + V \cdot \Delta I / \Delta V
 \end{aligned} \tag{6}$$

The MPP can thus be tracked by comparing the instantaneous conductance (I/V) to the incremental conductance ($\Delta I/\Delta V$) as shown in the flowchart in Fig. 5. The algorithm decrements or increments V_{ref} to track the new MPP.

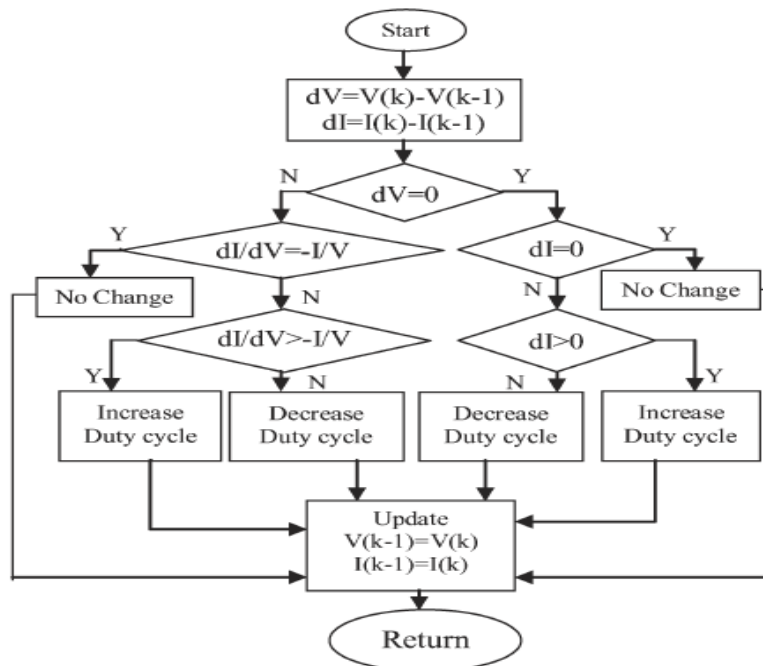


Fig.5. Incremental conductance algorithm

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VI. MATLAB/SIMULATION RESULTS

The models shown in the below figures were simulated using MATLAB® SIMULINK®. Simulation and results for boost and buck-boost converters have been recorded to make sure that comparison of the circuit can be obtained accurately. 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.

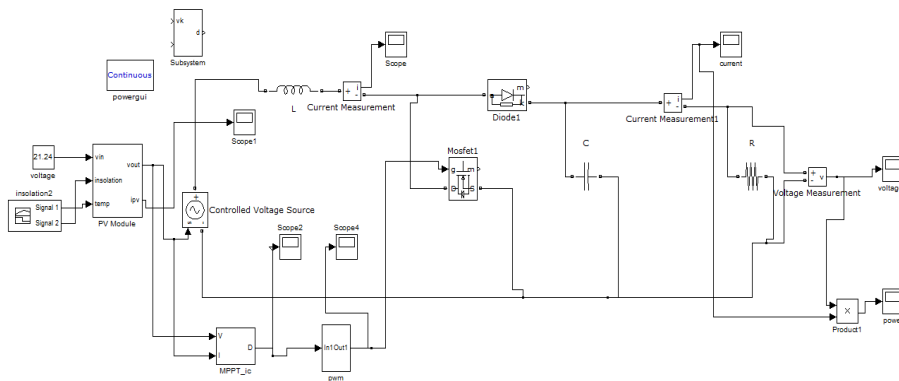


Fig.6. Incremental Conductance method for Boost converter

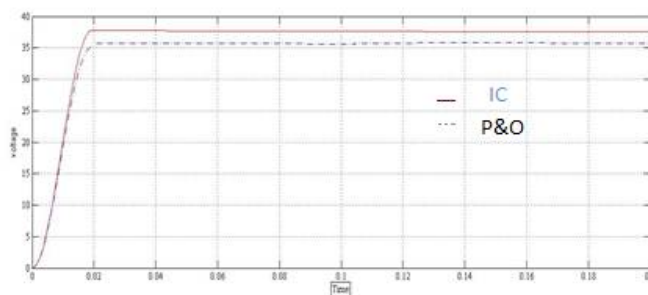


Fig .7.Comparison of output voltage of Incremental conductance and P&O methods using boost converter at constant irradiance

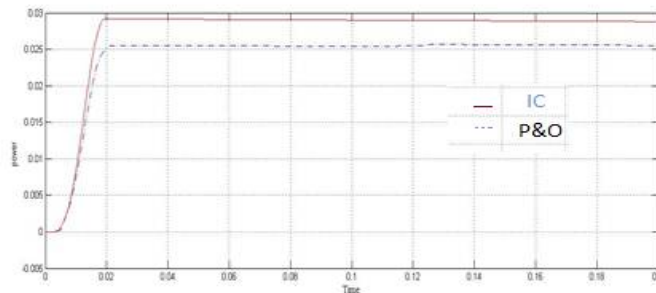


Fig.8.Comparison of output power of Incremental conductance and P&O methods using boost converter at constant irradiance

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Comparing the results it is clear that :

1. Perturb and Observe add oscillations to output value this is main draw back of using this technique.
2. Incremental conductance algorithm responds in very fast manner and its accuracy is higher than P&O method .
3. The disadvantage of incremental conductance algorithm is the increased complexity.

Table.1. Comparison of Inc.cond.and P&O method algorithms using Boost converter.

DC-DC Converter	V_{in} (V)	I_{in} (A)	P_{in} (Watt)	V_{out} (V)	I_{out} (A)	P_{out} (Watt)
IC Boost	21.24	2.55	54.16	38	1.8	40
P&O Boost	21.2	2.55	53.5	36.25	1.9	39

From the above tabular form we conclude that the incremental conductance using Boost converter is more efficient than P&O method because for same input the output power of incremental is more than the P&O method.

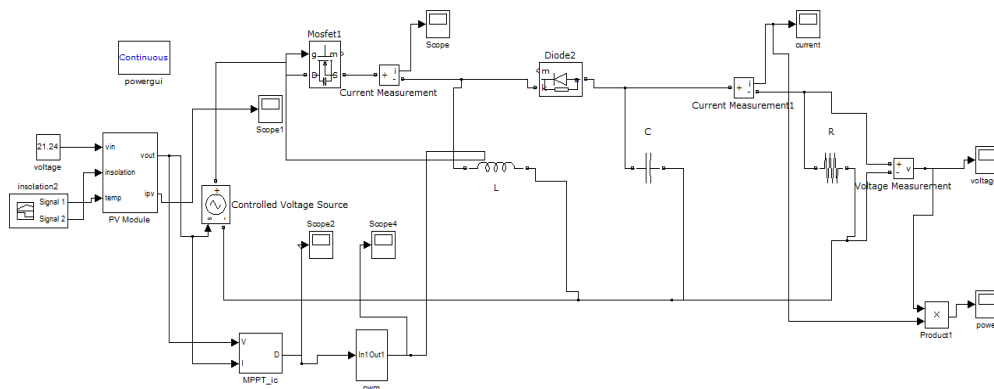


Fig.9 Incremental Conductance method for Buck-Boost converter

From the below voltage and power curves of Buck-Boost Converters using incremental and P&O methods the inc.method gives better result than Hill Climbing of P&O method.

From the below table 2 we observe that by using the two hill climbing techniques incremental is better than P&O method by using buck-boost converter.

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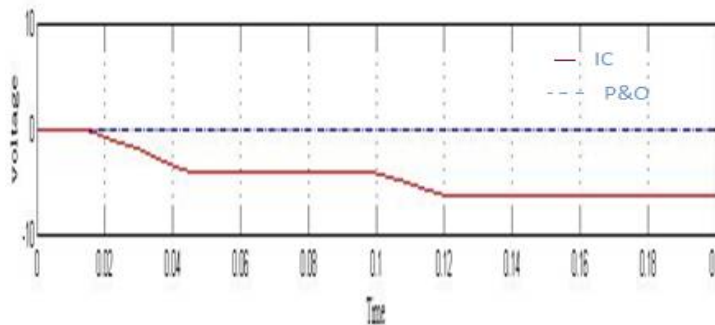


Fig:10 Output voltage curves of Inc.cond.and P&O using buck –boost converter

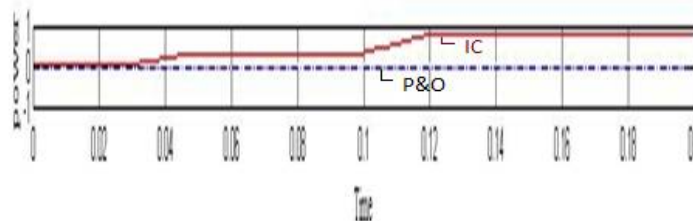


Fig.11. Output power curves of Inc.cond.and P&O using buck –boost converter

DC-DC Converter	V _{in} (V)	I _{in} (A)	P _{in} (Watt)	V _{out} (V)	I _{out} (A)	P _{out} (Watt)
IC Buck-Boost	21.2	2.55	54	-34	-0.8	38
P&O Buck-Boost	21.24	2.5	54.14	-32	-1.4	36

Table.2. Comparisionof Inc.cond.and P&O method algorithms using buck-boost converter.

VII. CONCLUSION

A standalone PV system connected with boost converter and IC algorithm for extracting maximum power at different environmental condition is proposed. We realize that the basic function of DC-DC converter in PV system is like intermediate power processor which changes the current and voltage levels such that maximum power can be extracted from the PV array. Changing voltage and current level is nothing but converting a given fixed load to a variable load. Hence the results obtained at different environmental condition are found to be satisfactory as they validate the experimental results too. IC algorithm responds in very fast manner and its accuracy is higher than P&O method that it reaches to steady state very quickly.

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BIOGRAPHY



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