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PV Systems Based DC-DC Converters for Different MPPT Algorithms

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ABSTRACT: The comparative study between two most popular algorithms technique which is incremental conductance algorithm and perturbs and observe algorithm. Two different converters buck and boost converter use for comparative in this study. Few comparison such as voltage, current and power output for each different combination has been recorded.MATLAB Simulink tools have been used for performance evaluation on energy point.

KEYWORDS: Maximum power point tracking (MPPT), Photovoltaic (PV), Direct current (DC), Converter, Efficiency.

I. INTRODUCTION

The rapid increase in the demand for electricity and the recent change in the environmental conditions such as global warming led to a need for a new source of energy that is cheaper and sustainable with less carbon emissions. Solar energy has offered promising results in the quest of finding the solution to the problem. The harnessing of solar energy using PV modules comes with its own problems that arise from the change in insulation conditions. These changes in insulation conditions severely affect the efficiency and output power of the PV modules[1,3].A great deal of research has been done to improve the efficiency of the PV modules. A number of methods of how to track the maximum power point of a PV module have been proposed to solve the problem of efficiency and products using these methods have been manufactured and are now commercially available for consumers [1,3]. As the market is now flooded with varieties of these MPPT that are meant to improve the efficiency of PV modules under various insolation conditions it is not known how many of these can really deliver on their promise under a variety of field conditions. This research then looks at how a different type of converter affects the output power of the module and also investigates if the MPPT that are said to be highly efficient and do track the true maximum power point under the various conditions [1,3].

A MPPT is used for extracting the maximum power from the solar PV module and transferring that power to the load [4, 5]. A dc/dc converter (step up/ step down) serves the purpose of transferring maximum power from the solar PV module to the load. A dc/dc converter acts as an interface between the load and the module shown in Fig 1. By changing the duty cycle the load impedance as seen by the source is varied and matched at the point of the peak power with the source so as to transfer the maximum power [5].

Therefore MPPT techniques are needed to maintain the PV array's operating at its MPPT [6]. Many MPPT techniques have been proposed in the literature; example are the Perturb and Observe (P&O) methods [4, 6, 9], Incremental Conductance (IC) methods [7, 10,12], Fuzzy Logic Method [2, 4], etc. In this paper two most popular of MPPT technique (Perturb and Observe (P&O) methods and Incremental Conductance methods) and three different DC-DC converter (Buck and Boost converter) will involve in comparative study [1,3].

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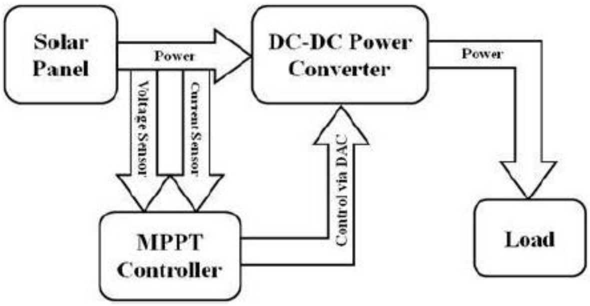

Fig.1 DC – DC converter for operation at the MPP

Few comparison such as voltage, current and power output for each different combination has been recorded. Multi changes in duty cycle, irradiance, temperature by keeping voltage and current as main sensed parameter been done in the simulation. The MPPT techniques will be compared, by using MATLAB tool Simulink, considering the variant of circuit combination.

This paper is organized as follows: Section I gives the Introduction to the MPP Techniques. Section II gives the PV array introduction. Section III gives the DC-DC Converter Information. Section IV gives the Problem Overview. Section V gives the MPPT algorithms and Section VI and VII give the results and the conclusion respectively.

II. PV ARRAY

A solar panel cell basically is a p-n semiconductor junction. When exposed to the light, a DC current is generated. The generated current varies linearly with the solar irradiance [8] [14]. The equivalent electrical circuit of an ideal solar cell can be treated as a current source parallel with a diode shown in Fig 2.

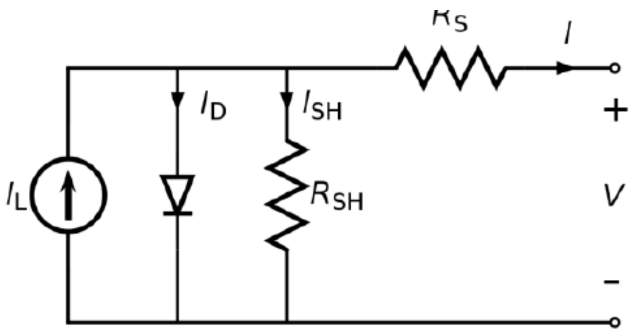

Fig. 2 Equivalent electrical circuit of a solar cell

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

$$I_D = I [\exp (q(V + I R_S)/KT)) – 1] \quad (1)$$

$$I = IL – ID – Ish \quad (2)$$

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

Where:
I : Solar cell current (A)
I: Light generated current (A) [Short circuit value assuming no series/ shunt resistance]

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ID: 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)

II. DC-DC CONVERTER

A.Buck Converter

The buck converter can be found in the literature as the step down converter [15,16]. This gives a hint of its typical application of converting its input voltage into a lower output voltage, where the conversion ratio M = Vo/Vi varies with the duty ratio D of the switch [15]. An ideal buck converter is shown in Fig 3.

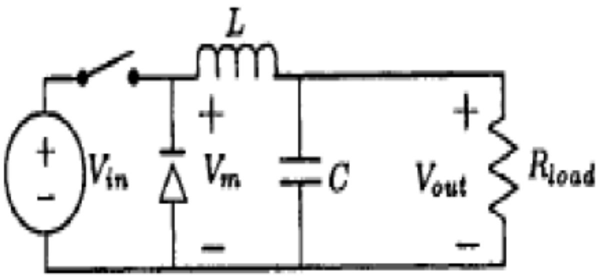

Fig. 3: Ideal buck converter circuit

B.Boost Converter

The boost converter is also known as the step-up converter. The name implies its typically application of converting a low input-voltage to a high out-put voltage, essentially functioning like a reversed buck converter [13] [16]. An ideal boost converter is shown in Fig 4.

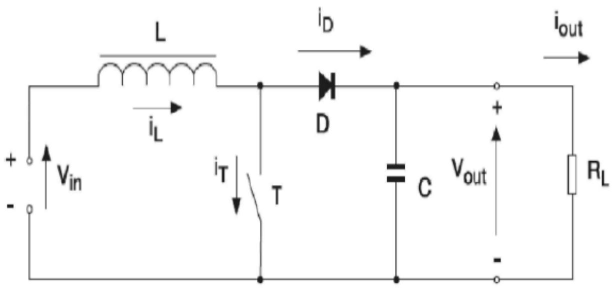

Fig. 4: Ideal boost converter circuit

III. SIMULATION RESULTS

All simulation and result for every converter have been recorded to make sure the comparison of the circuit can be determined accurately [11] [17]. The input, output, voltage, current and power is the main comparison to take into consideration.. Convergence speed, hardware required and range of effectiveness. Fig.5 take an insolation of 100 and temperature 50 as initial value.

A. PV Panel Simulation

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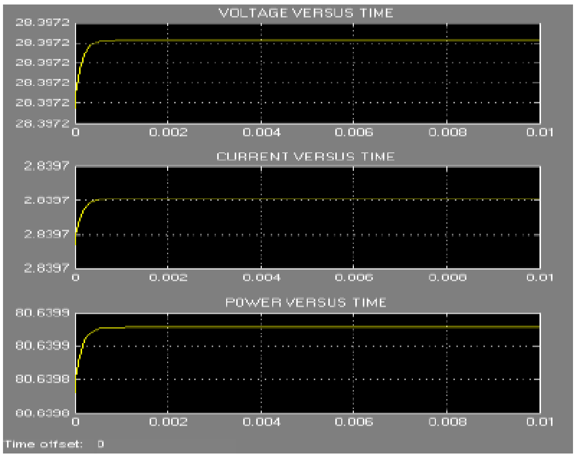

Fig. 5: Output Voltage, Current and Power for PV panel

Converter	Analysis	Theoretical Value(V)	Simulation value (V)	Percentage Difference (%)
Buck	Vin	12	12	0
	Vout	5	5.087	1.74
Boost	Vin	12	12	0
	Vout	24	21.92	8.7

Table 1: Output Value for PV Panel

Output Voltage	Output Current	Output Power
28.4 V	2.84 A	80.64 W

Table 2 : Comparison between Three Converter in Theoretical and Simulation Value

Result for insolation = 100 and temperature = 48^o

From table 2 calculate theoretical result and simulation result can be observe. The percentage between theoretical value and experimental value also can be seen from the simulation output. All three simulations give difference type of curve [20]. Theoretical value calculated from the basic equation of converters.

B Buck Converter Simulation With Perturb and Observe Controller

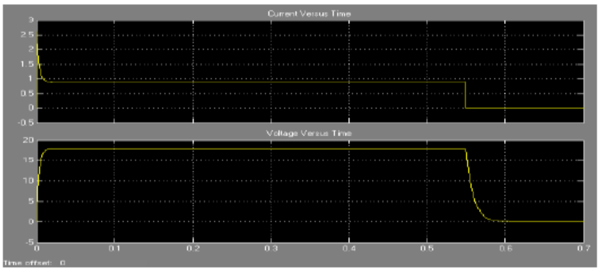

Fig 6: Output current and voltage for Buck and P&O Controller

C Buck Converter Simulation With Incremental Cond.Controller

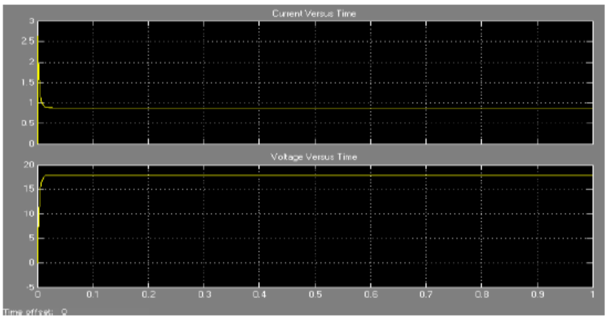

Fig 6: Output current and voltage for Buck and In Con Controller

Buck the connected with P&O give a value of 26.8 V therefore buck that connected with incremental conductance give value of 17.87V shown in Table 3. In Incremental Conductance controller the output voltage and current is not change between input and output value [18]. The Perturb and Observe Controller give a difference for input and output value. The output value behave as Buck converter behave. The voltage will drop from 26.8V to 16.8V and finally the voltage value is 534mV. In this system show that incremental conductance controller will work better with buck controller than perturb and observe controller. The incremental conductance controller will have the stable value from start to end of the simulation [19].

Table 3: Comparison Output Value Between Perturb & Observe and Incremental Conductance in Buck Converter

Controller	**V_{in} (V)**	**I_{in} (A)**	**V_{out1} (V)**	**V_{out2} (V)**	**I_{out1} (A)**	**I_{out2} (A)**
P&O	26.8	0.97	16.8	0.0534	0.97	0.007
IC	17.9	0.84	17.87	17.87	0.84	0.8391

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D Boost Converter Simulation With P&O Controller

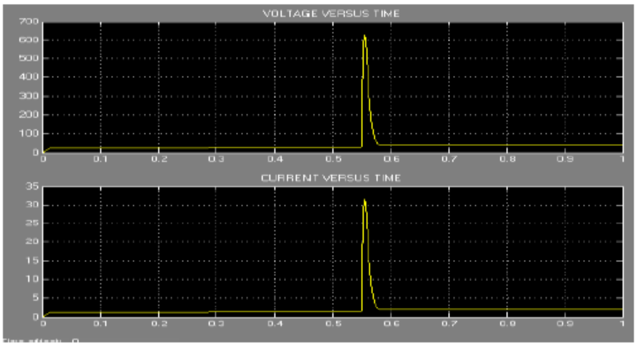

Fig 7: Output current and voltage for Boost and P&O Controller

E Boost Converter Simulation With Incremental Condition Controller

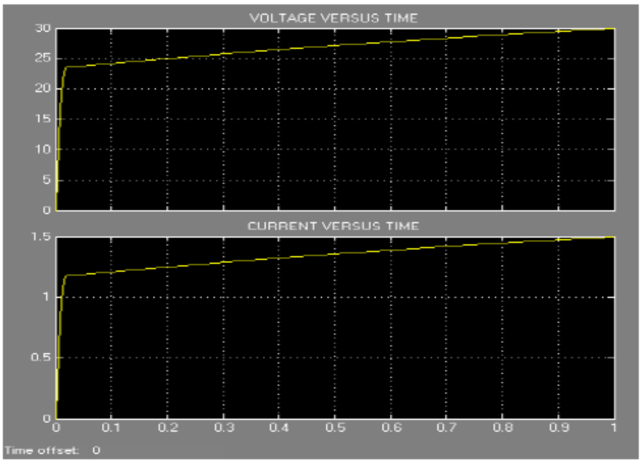

Fig 8: Output current and voltage for Boost and IC Controller

Table 4: Comparison Output Value Between Perturb & Observe and Incremental Conductance in Boost Converter

Controller	V_{in} (V)	I_{in} (A)	V_{out1} (V)	I_{out1} (A)
P&O	38.79	1.9	37.99	1.9
IC	38.62	175.3	29.92	1.496

From the simulation show that voltage input for both controller is almost the same. Perturb and Observe Controller shows a unstable condition [21]. During the simulation the current and voltage decrease rapidly and at last came to same value. From the simulation result , the controller that connected with Boost converter which will give a stable output is the incremental conductance controller [22]. Perturb and Observe controller can achieve maximum output value at 37.99 V better than incremental conductance controller.

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IV. CONCLUSION

This paper has presented a comparison of two most popular MPPT controllers, Perturb and Observe Controller with Incremental Conductance Controller. This paper focus on comparison of two different converters which will connect with the controller. Solar panel has been included in the simulation circuit. From all the cases, the best controller for MPPT is incremental conductance controller. This controller gives a better output value for buck and boost converter In simulation Buck converter shows better performance. The controller work at the best condition using buck controller.

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