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Effect of switching frequency on performance of dc-dc converter on PV solar system

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ABSTRACT:
Photo Voltaic (PV) system performance depends on how effectively the impedance matching is maintained under climatic changes. The Perturb and Observe (P&O) method is Maximum Power Point Tracking (MPPT) controller with buck converter are used to maintain the desired impedance matching. The switching frequency of buck converter play an important role in the overall performance of PV system. Due to the change in the switching frequency, various parameters such as maximum power, PV voltage, load voltage values are affected. The influence of switching frequency on the performance of the photovoltaic system with controller is discussed in this paper. MATLAB/SIMULINK is used for simulation studies of solar PV system with P&O controller. The performance of P&O controller at different three switching frequencies is been analysed. This paper validates the performance of PV system based on P&O MPPT algorithm with the usage of Buck Converter under changing irradiance and temperature conditions.

KEYWORDS: impedance matching, switching frequency, P&O, PV system

I. INTRODUCTION

Solar photovoltaic is clean and green energy technology in renewable energy system plays a vital role to fulfill the power shortage of any country[1]. Photovoltaic system is the low-cost source of electrical power in high solar energy regions. The benefits of PV system are like nonpolluting and minimum maintenance. Solar energy changes as per irradiance and temperature and also one factor which reduces the power output is the partial shading in the cells. Hence, various algorithms are put forth to obtain the maximum power from the PV arrangement and dc-dc converters intend to regulate the supply. The photovoltaic system mainly depends on the solar irradiance and temperature for generating power and hence direct connection between panels to load will not possible. The variation in generating energy from solar is caused mainly due to atmospheric changing conditions. To reduce the effects and to improve the generating powers efficiency from PV, Maximum Power Point Tracking (MPPT) techniques are included in the system design. It is essential to track the maximum power from the panel to improve the power generation for the load condition [2]. MPPT techniques used by various researchers are hill climbing method, Perturb and Observe (P&O) method , Fuzzy logic controller, Incremental Conductance (INC), Neural Networks, Genetic Algorithms and so on. The power converter consists of the buck , the boost , the buck-boost , the SEPIC converters [3-6] etc. The converter does the function of switching frequency pulses generated with the help of PWM.

P&O based MPPT method was widely used because of its simplicity and effectiveness. In this method the power of PV system present and past perturbation is compared, based on that the controller will decide the next perturbation size.

To reduce this variable size perturbation method, adaptive perturb method, and Multivariable P&O methods were used. DC/DC converters are used to connect the PV panel with the load. The DC/DC converters follow both step up and step down principle. It is used to maintain the constant output voltage for the load condition during any varying climatic condition occurs for PV system. The converter depends upon duty cycle which was generated from the MPPT according to the PV panel condition [7].

This paper validates the performance of PV system based on P&O MPPT algorithm with the usage of Buck Converter under different

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switching frequency and changing irradiance conditions. The mathematical models of the entire system were simulated using MATLAB/Simulink

II. PV SYSTEM

The PV module model is the main element in the simulating the solar PV system. The equivalent circuit of a PV cell is shown in Fig. 1.

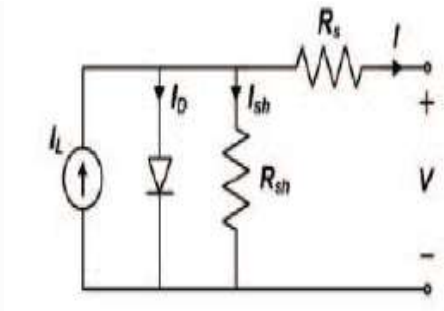

Fig. 1. PV cell equivalent circuit

The current source I_L represents the cell photocurrent. R_{sh} and R_s are the intrinsic shunt and series resistances of the cell, respectively. Usually the value of R_{sh} is very large and that of R_s is very small, hence they may be neglected to simplify the . Practically, PV cells are grouped in larger units called PV modules and these modules are connected in series or parallel to create PV arrays which are used to generate electricity in PV generation systems

III. MPPT ALGORITHM

The main goal of an MPPT controller is to extract maximum power from PV system in all weather conditions. This can be done using a precise MPPT algorithm with a proper converter that helps the PV module to operate at its MPP. This MPP algorithm determines the MPP .

A. P & O Algorithm

This method is an iterative technique; to detect voltage and current in PV array only two sensors are required, so that the power produced by those two parameters can be measured. The principle operation depends on perturbing by a slight increment, the terminal voltage of the array, and compares the power of the terminal array to the previous perturbation cycle. If the deviation progresses to a decrement or increment in panel power, the corresponding deviation is done in the opposite or same direction. In that way, the tracker is always looking for a maximum power position.

Fig.2. shows the flowchart of P & O algorithm

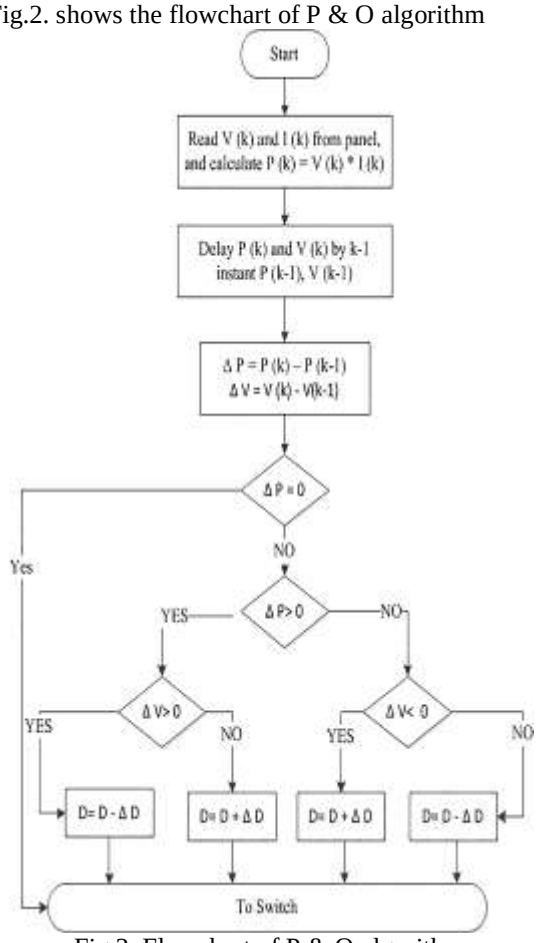

Fig.2. Flowchart of P & O algorithm

B. Buck converter

A buck converter (step down coverter) is the most basic SMPS topology.

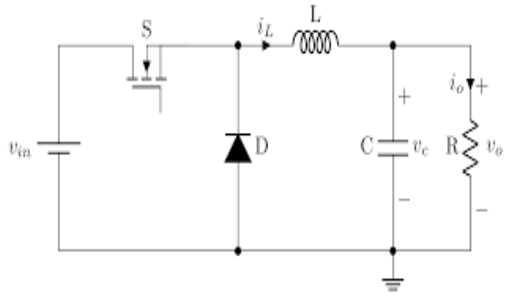

Fig.3. Buck converter

It is widely used throughout the industry to convert a higher input voltage into a lower output voltage. Fig.3. shows the buck converter

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Table. 1. Specifications

Input voltage	40V
Output voltage	12V
Maximum power	500W
Switching frequency	30kHz, 40kHz,50kHz
Inductor current ripple	10%
Output voltage ripple	10mV

For the conditions given in Table 1 the inductor value should be:

$$L = \frac{V_{out}}{f_{sw}} . \frac{1-D}{\Delta I_{L1}} \quad (1)$$

Minimum output capacitance

$$C_{out} = \frac{1-D}{\frac{\Delta V_{cout}}{V_{out}} 8L(f_{sw})^2} \quad (2)$$

IV. SIMULATION RESULTS

Using P & O algorithm PV module is simulated and evaluated using Matlab/Simulink tool [8]. The Simulink model is depicted in Fig.4

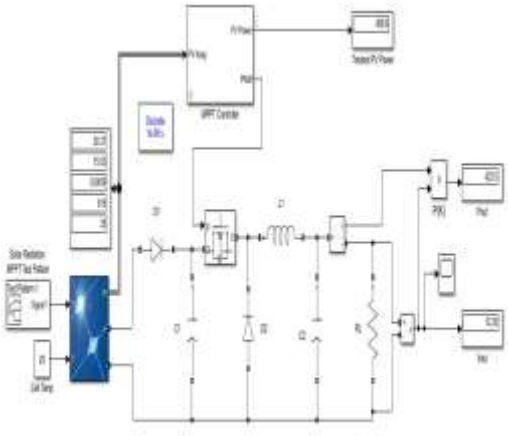

Fig.4. Simulation model

Simulation results of the overall system are analyzed at three different switching frequencies and change in irradiance using P & O algorithm at 30kHz, 40kHz and 50kHz

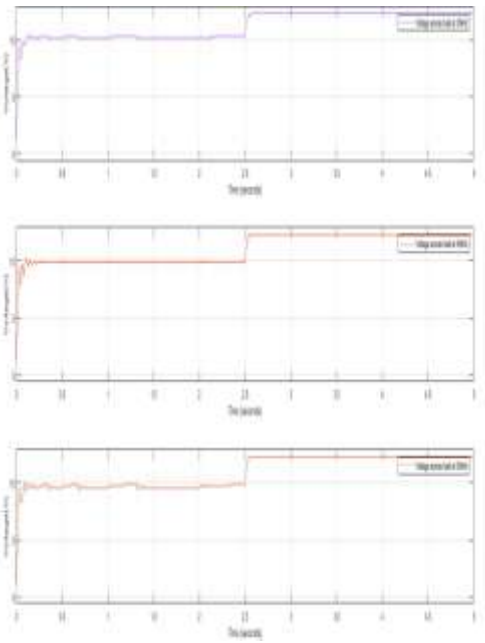

Fig.5.Voltage across load

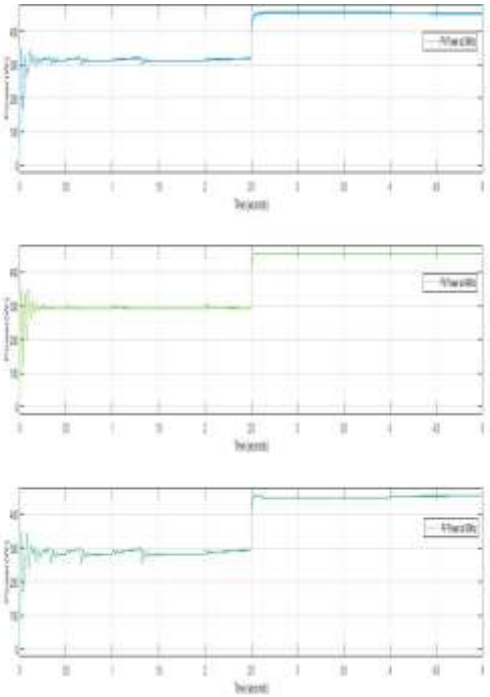

Fig.6. PV Power

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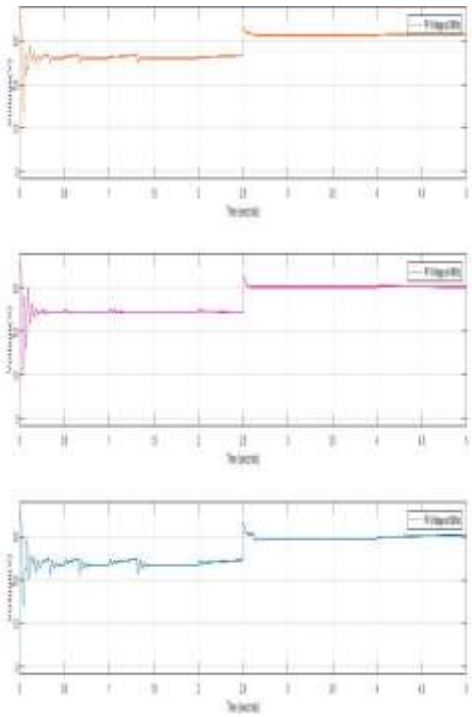

Fig.7. PV voltage

The load voltage, PV power and PV voltage are shown in Fig.5, Fig.6 and Fig.7 respectively

Table 2. Performance analysis

Performance parameters	Switching frequency		
	30kHz	40kHz	50kHz
Load Voltage(V)	11	10	9.5
Output Power (W)	310	300	290
PV voltage(V)	27	25	24

From Table 2, As the switching frequency increases the load voltage. Output power and PV voltage gets decreased. After the time 2.5sec the irradiance is changed.

At high irradiance the switching frequency is not having much effect. Output is almost same for all the frequencies

V. CONCLUSION

PV system performance depends on how effectively the impedance matching is maintained under irradiation and temperature .The switching frequency of buck converter play an important role in the overall performance of PV system. Due to the change in the switching frequency, various parameters such as maximum power, PV voltage, load voltage values are affected. At low irradiance the output power, load voltage and PV voltage get decreased as the switching frequency is increased.

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