



Maximum Power Point Tracking Simulation based on Perturb and Observe Algorithm for PV array Using Boost Converter

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Abstract - To extract maximum energy from the Photovoltaic (PV) Systems the Maximum Power Point Tracking (MPPT) is a technique which is applied in various electronic circuits. In present scenario, due to various advantages such as less maintenance, environment friendly operations and requires no fuel, photovoltaic solar system has become more essential in power generation utilities. However, the two major limitations with the use of PV system are low energy conversion efficiency and high initial cost. In order to attain better energy efficiency of PV solar array, it is essential that PV solar array works at that point where maximum power can be reached. This paper provide the details on the implementation of Perturb and Observe MPPT using boost Converters. The simulation has been accomplished using MATLAB software.

Keywords: Photovoltaic Array (PVA), MPPT, Boost Converter

I. INTRODUCTION

The photovoltaic system shows non-linear current-voltage and power-voltage characteristics that continuously varies with temperature and irradiance. The continuously varying maximum power point of the solar array is tracked using MPPT (maximum power point tracking) control technique. This can be easily understood by Voltage-Current characteristics curve of the solar panel as shown in Fig.1.

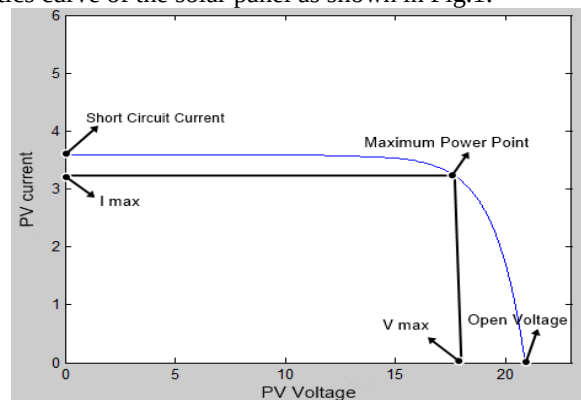


Figure 1. Solar Panel Voltage-Current characteristics Curve

The main function of a maximum power point tracking (MPPT) network is to continuously tune the photovoltaic (PV) system so that it draws maximum power from the solar array regardless of weather or variations in load conditions. The solar energy received using PV solar array has problems that arise from the change in insulation conditions and these changes in insulation conditions effect the efficiency and output power of the PV modules. Many researches have been made to improve the efficiency of the photovoltaic system and several methods have been suggested to solve the problem of efficiency and products using these methods have been made and is commercially available for consumers [1-2].

A maximum power point tracker is used for obtaining the maximum power from the solar PV module and conversion to the load. A non-isolated DC-DC converter is used for the purpose of conversion of maximum power to the load. A DC-DC converter acts as an interface between the load and the module. By varying the ratio of duty cycle the impedance of load as it appears by the source is varied and matched at the peak power point with the source so as to conversion the maximum power [4-5].

The maximum power point tracker methods are used to maintain the PV array's working at its MPP. Many MPPT methods have been suggested, examples are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods and constant voltage methods etc. [6-12]. In this paper the most popular among

various MPPT technique, Perturb and Observe (P&O) method with Boost DC-DC converters will involve in implementation study.

II. PV SYSTEM

A PV system comprises of different component including modules, electrical interconnections, mechanical connection, and mountings for other components. PV system is made up of photovoltaic cell; a semiconductor device which directly converts the light energy into electrical energy. To get more amounts of voltage and current PV cells are connected in series and parallel known as PV module and if many modules are connected to obtain desired amount of current and voltage then it is called as PV array [15]. A general simulation model of photovoltaic cells is adopted proposed by [16] in this paper. The general model of a solar cell is shown in Fig.2

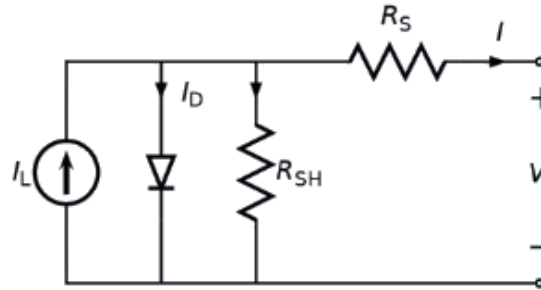


Figure 2. Solar Cell Model with its circuit components

The I-V characteristics of the solar cell circuit can be sets by the following equations [13].

The current through diode is given by:

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

While, the solar cell output current:

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

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

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)

III. PV SYSTEM WITH MPPT CONTROL

The operation of MPPT can only be achieved when a tune able matching network is used as interface for load and the PV array. The main constituent components of a PV system are power stage and controller as shown in fig.3. The power stage is optimized using switch mode DC-DC converters (boost, buck-boost), employing pulse width control. The control parameter which is used for synchronizing the network for maximum extraction of power is duty ratio δ .

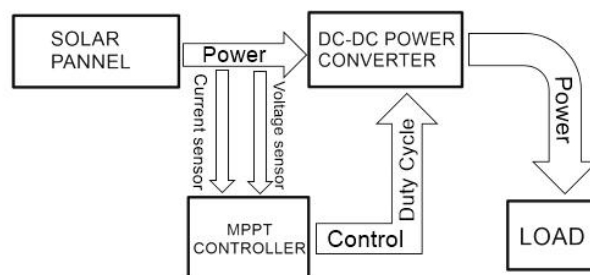


Figure 3. Block Diagram of PV System with MPPT Control

IV. MPPT

Commercially available solar panel can convert only 30 to 40 percent of solar irradiance into electrical energy. In order to increase the efficiency of the solar panel maximum power point technique is implemented. According to theory of maximum power transfer, when internal impedance from source side becomes equal to value of the load impedance the power transferred to the load is maximum [1]. Various techniques have been developed to approach maximum power point. [11] Among these, P & O is popular one and is very easy to implement and its tracking technique includes repetition of step size with a fixed value. But this method has its own limitations such as oscillation around maximum power point and errors due to change in atmospheric conditions.

V. PERTURB & OBSERVE

The P&O algorithm is most popular algorithm used to determine maximum power point from solar array. P&O looks for the perturbation in operating voltage of DC channel to bring change in duty cycle (D) adjustment connecting solar array and DC-DC converter circuit. It works periodically by incrementing and decrementing array terminal voltage $v(t)$ and current $i(t)$ and comparing the present output power $P(t)$ for any instant (t) with previous power $P(t-1)$. In case operating voltage changes and power increases then operating point is shifted by control method in that direction otherwise in opposite direction and in this manner algorithm continued for different perturbation cycle. This process keeps on repeating until the maximum point is tracked. After that operating point keeps on oscillating around the MPP. Depending upon these facts and techniques this algorithm is established [3]. Flow chart of the algorithm is shown in Figure 4.

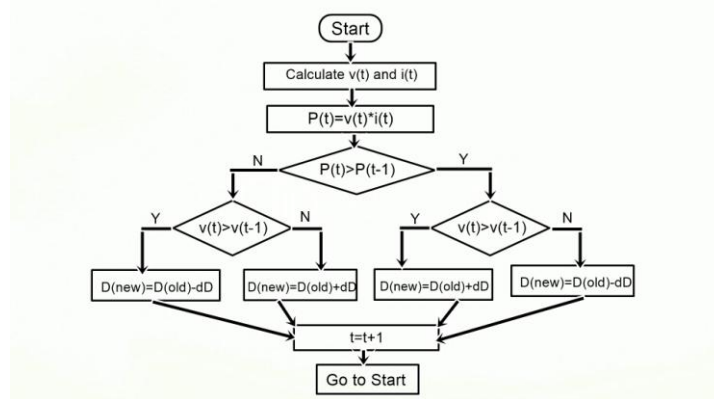


Figure 4: Algorithm

VI.

VII. BOOST CONVERTER

The output voltage of the boost converter can be greater than the input voltage V_{in} . The switch operates at high frequency to produce a chopped output voltage [17]. The power flow of the boost converter is controlled by adjusting the on/off duty cycle of the switching. Boost converter amplifies the magnitude of voltage to achieve output voltage at its maximum constant value independent to change in different conditions of solar irradiance and temperature.

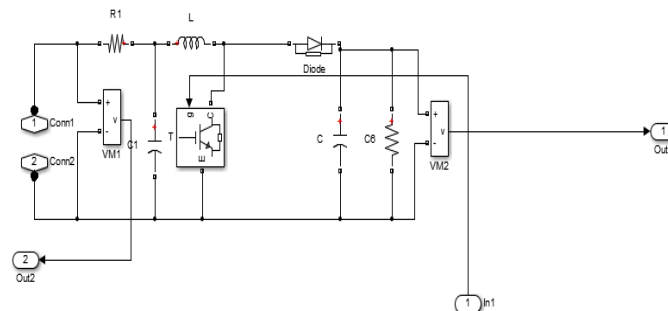


Figure 5. Simulink Model of Boost converter

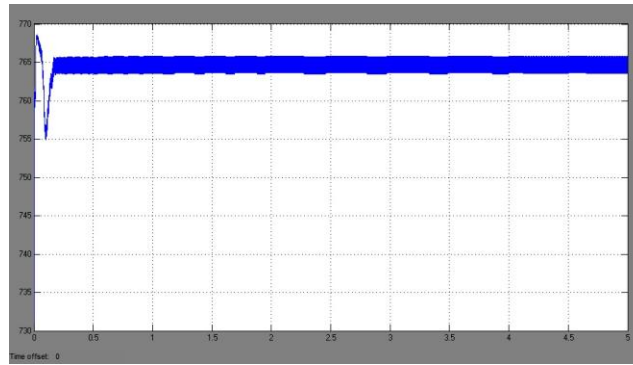


Figure 6. Voltage without Boost Converter

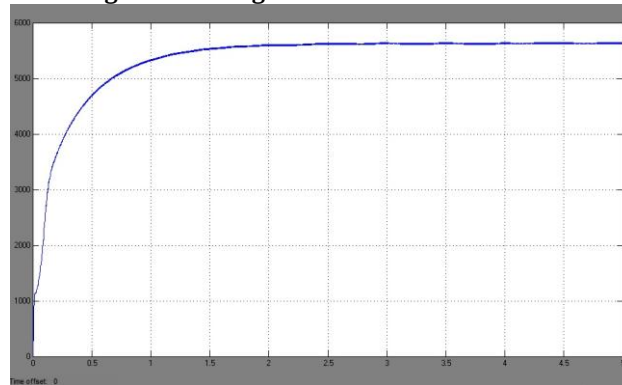


Figure 7. Voltage with Boost Converter

VIII. MATLAB-SIMULINK ENVIRONMENT

The simulink model developed using MATLAB based on Perturb and Observance algorithm using Boost converter is shown in Figure 8. This model includes PV panel, P&O based MPPT embedded function block and boost-converter.

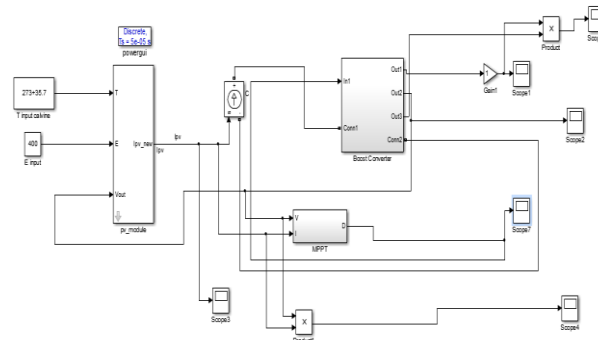


Figure 8. MATLAB/Simulink Model for MPPT analysis

Results for MPPT technique has been analyzed using SIM POWER SYSTEMS toolbox. Some results are presented for understanding comparative analysis on power stability using Boost converter.

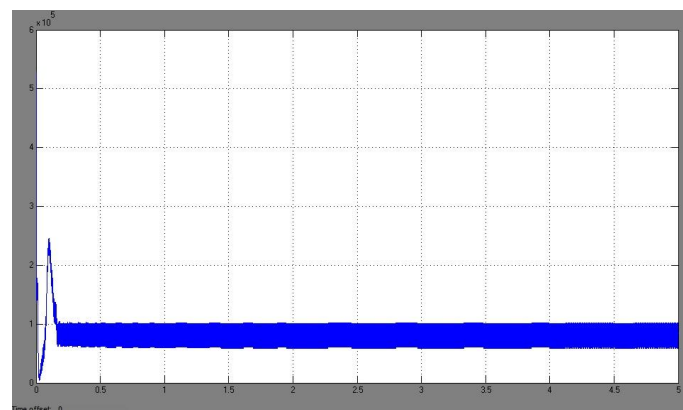


Figure 9. Power Tracking without using MPPT controller

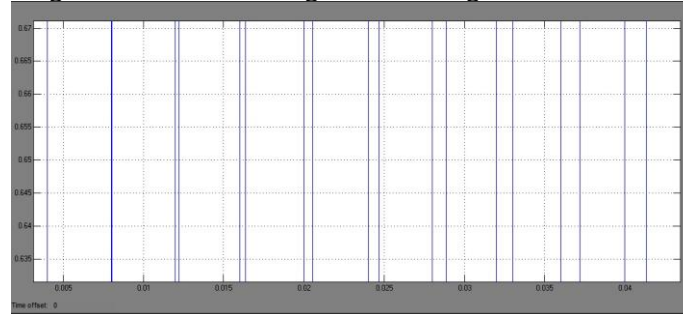


Figure 10. Duty Cycle adjustment based on P&O algorithm

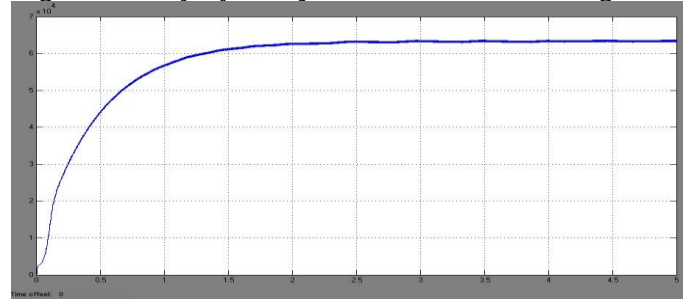


Figure 11. Power Tracking Using P&O based MPPT technique

IX. CONCLUSION

P&O MPPT method is implemented with MATLAB Simulink. Through simulation it is observed that output of the PV panels clearly changes due to change in the duty cycle with the help of P&O technique established by use of boost-converter. It shows better response over dynamic and steady state. As a result better power curve with lesser transients and more stable operating point is obtained.

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