Design and Development of an Efficient Photovoltaic System with Maximum Power Point Tracking Technique

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***Abstract*— With the increasing in the energy demand conservation and utilization of energy are very essential. Hence Solar charge controller helps in increasing the efficiency of the solar power transferred to the battery. Photovoltaic modules show nonlinear output characteristics because of different system losses. Maximum power point tracking (MPPT) is an intelligent technique for reducing these losses by driving the system at its maximum operating point. DC/DC converter is an essential part of a MPPT controlled photovoltaic (PV) system which functions as an interface between PV system and the load. These Converters are mostly Dc Choppers which converts fixed Dc voltage to a variable Dc source. These Regulators are used in case of Solar Charge Controllers to increase or decrease the PV panel voltage to as that required by Battery. The DC voltage from the PV panel varies with the light intensity which depends on time of day and temperature. Similarly, on the Battery side the voltage varies depending on the load connections. Thus, for optimal charging of battery it is important that the voltage of the PV panel and the current matches the battery charging state at any instant. There are various types of Dc-Dc Converter of which Buck Boost Converter is taken into consideration. In this project work we propose an efficient photovoltaic system which will be designed, developed and the results will be validated in real time.**

Keywords*— Buck-Boost; Maximum Power Point Tracking; Photovoltaic System.

I. INTRODUCTION

DC-to-DC regulators are also known as Switching Regulators which uses power switches like an inductor, a capacitor and a diode to transfer power from input to output. These regulators do not produce power. In fact, some of the input power according to their efficiency is consumed by these Regulators. Therefore, considering ideal case to maintain the same power level the adjusted voltage level affects the current level. Since current and voltage are both directly proportional to power therefore in buck mode the voltage is reduced as the current increases. While in boost mode the voltage is increased as the current decreases. The Dc- Dc Converter is one among the major component of the controller which receives the input voltage from the PV panel and converts the voltage without use of transformer and gives the desired output as that required for various charging stages of Battery. Solar Charge Controllers are the controllers which regulate the power output or the Dc output voltage of the solar panels to the batteries. These controllers take the Dc output voltage as the input voltage converts it into same Dc voltage but as that required for Battery charging. These are mostly used in off grid scenario and uses MPPT i.e. Maximum Power Point Tracking scheme which maximizes the output efficiency of the Solar Panel. In Battery charging the output voltage Regulation plays an important factor as batteries require specific charging method with various voltage and current levels for specific stage. These charging processes enhance battery performance and battery life. Standard Charge controllers are used where the solar panel voltage used as input are higher than the output voltage. Thus, keeping the current constant, the voltage will be reduced by the controller. This results in loss of power. MPPT based solar charge controllers use smart technologies such as microcontrollers to compute highest possible power output at any given time i.e. voltage will be monitored and regulated without power loss. The Controller will lower the voltage simultaneously increase the current, thereby increasing the efficiency.

II. METHODOLOGY

A. Block diagram

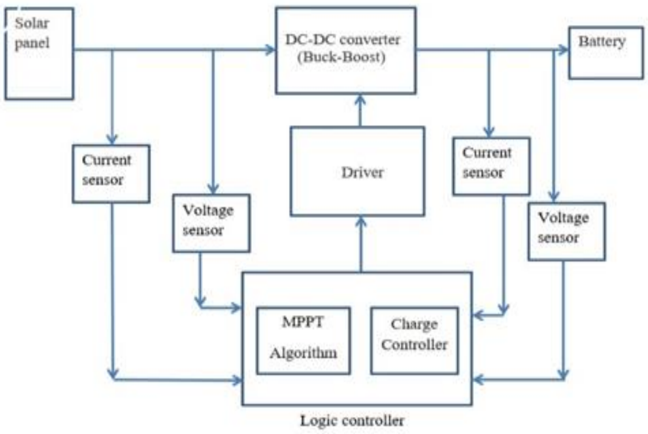

Fig. 1. Block diagram of the proposed system

B. Buck-Boost Converter

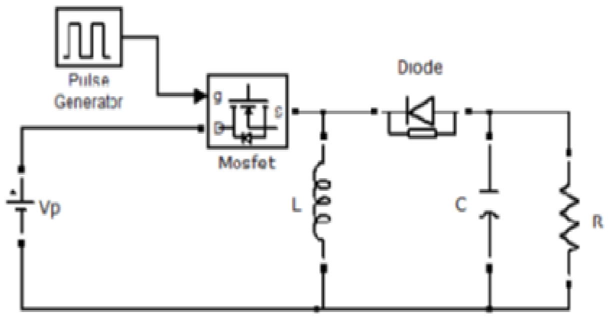

Fig. 2. Circuit diagram of buck boost converter

Buck-Boost Converter is a Dc Converter in which the output voltage can be increased or decreased than the input voltage. One of the striking features of this regulator is that it provides output voltage polarity reversal without the use of transformer. It is also called an Inverting Regulator. It has high efficiency and the output short circuit protection can be easily implemented. However, it shows discontinues input current and high peak current flows through the switch.

The principle of operation of the buck–boost converter is simple:

1) While in the On-state, the input voltage source is directly connected to the inductor (L) resulting in accumulating of energy in L. In this stage the output load is supplied with energy from the Capacitor.

2) While in the Off-state, the output load and capacitor are connected with the Inductor, so energy is transferred from L to C and R via Diode D.

C. Perturb And Observe Method

In this method the controller adjusts the voltage by a small amount from the array and measures power, if the power increases, further adjustments in the direction are tried until power no longer increases. This is called P&O method. Due to ease of implementation it is the most commonly used MPPT method.

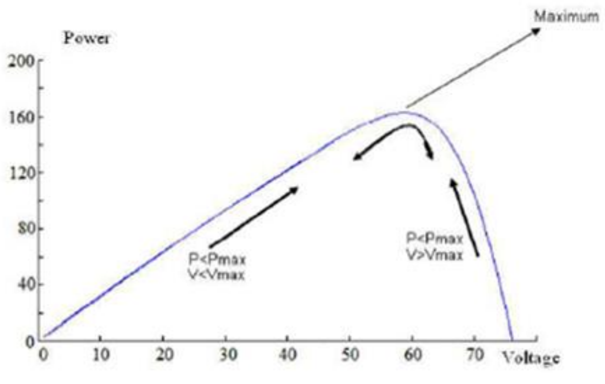

Fig. 3. output power using P&O method.

III. WORKING

MPPT is measuring the power of the solar panel at given intervals and making sure it is always at its maximum power. A measurement is taken from the solar panel and the power is calculated. After a specified interval, another measurement is taken. These two measurements are compared, and adjustments are made to the solar panel to ensure that the most recent measurement will lead to the maximum power. These values correspond to a particular load resistance, R= V/I, as specified by Ohm's Law. The power P is given by P = V*I. From basic circuit theory, the power delivered from or to a device is optimized where the derivative of the I-V curve is equal and opposite the I/V ratio. This is known as the maximum power point (MPP) and corresponds to the "knee" of the curve. The load with resistance R=V/I, which is equal to the reciprocal of this value and draws the maximum power from the device is sometimes called the characteristic resistance of the cell. This is a dynamic quantity which changes depending on the level of illumination, as well as other factors such as temperature and the age of the cell. If the resistance is lower or higher than this value, the power drawn will be less than the maximum available, and thus the cell will not be used as efficiently as it could be. Maximum power point trackers utilize different types of control circuit or logic to search for this point and thus to allow the converter circuit to extract the maximum power available from a cell. For our project we choose the Perturb and observe algorithm as it has more advantages over drawbacks. The oscillation problem can easily be minimized using minimization techniques by controller.

A. Algorithm

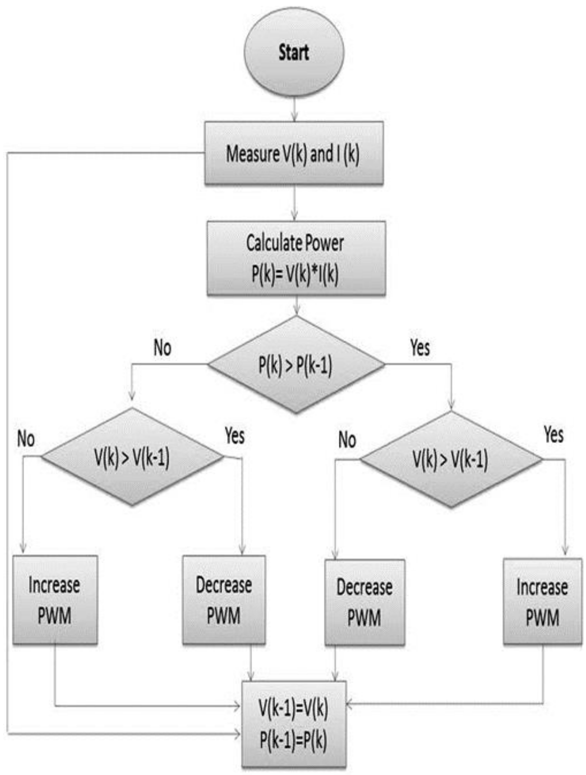

Fig. 4. Flowchart of the proposed algorithm.

IV. SIMULATION AND RESULTS

A. Software used

MATLAB R2016a – 'Matrix Laboratory'
It is a programming environment for algorithm development, data analysis visualization and numerical computation, developed by Mathwork.

B. Simulation

Based on the input and output topologies of solar panel and battery that we are using we have calculated the values for buck-boost power stage is simulated and its results are analyzed.

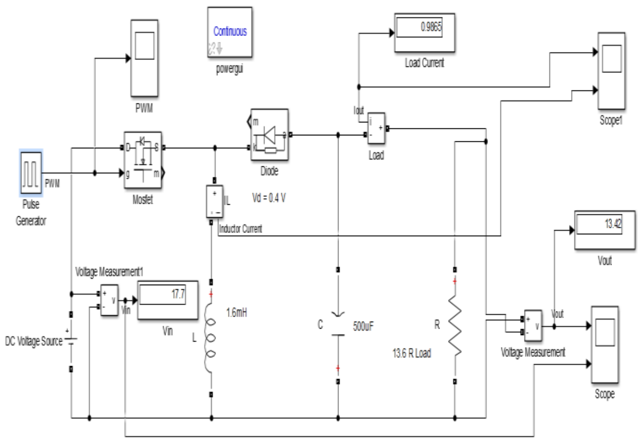

Fig. 5. Simulation Circuit diagram.

C. Simulation results

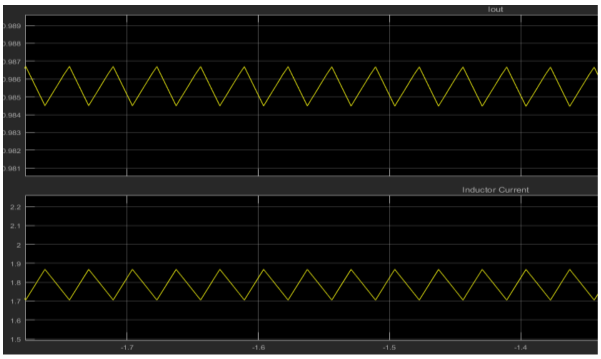

Fig. 6. Waveform of output current and inductor current.

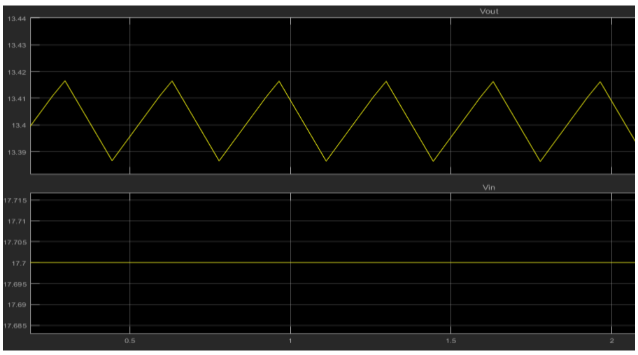

Fig. 7. Waveform of output voltage.

V. CONCLUSION

As, our aim was to design a system which can extract maximum output power, so we explained about maximum power point (MPP) and maximum power point tracker (MPPT). Researches for different method of algorithms for are done. For better result we compared the Incremental conductance method with Perturb and observe method. Perturb and observe method shows narrowly better performance. The problems solving techniques are also here. This thesis adopts the direct control method which employs the P&O algorithm but requires only two sensors (voltage sensing and current sensing) for output. This control method offers another benefit of allowing steady-state analysis of the DC-DC converter. This study presents a simple but efficient photovoltaic system with maximum power point tracker. Description of each component like solar panel, DC-DC converter and charge controller is presented here.

VI. FUTURE SCOPE

The only algorithm tested and used was the P&O algorithm, though it tracks the maximum power point, it theoretically is simplest and the fastest under rapidly varying atmospheric conditions. Testing other robust and complex algorithms such as current sweep, fuzzy logic and neural network methods and finding the most efficient way to track the maximum power point or even creating a hybrid can be a future improvement work to this project and greatly enhance the software design robustness.

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