

# A PV FED HIGH STEP UP CONVERTER WITH PID CONTROLLER

*Ms. P.Niranjana Devi*  
PG Scholar,  
Akshaya College of  
Engineering and Technology,  
Coimbatore, India.

*Ms. M.R.Shri suvega*  
PG Scholar,  
Akshaya College of  
Engineering and Technology,  
Coimbatore, India.

*Ms. M.Gokilavani*  
PG Scholar,  
Indus College of  
Engineering ,  
Coimbatore, India.

*Mr. A.Vidyasekar*  
Assistant Professor,  
Akshaya College of  
Engineering and Technology,  
Coimbatore, India.

**Abstract**— *Now-a-days, renewable energies are becoming very attractive; because of lack of conventional energy sources. Solar energy is one of the all time freely available renewable source and also it is eco-friendly. Solar energy can be extracted using solar panels and it converts the solar radiation into electrical energy. A high step up converter is used to boost up the dc output voltage produced by the solar panels because most of the renewable sources produce minimum voltage and it is not sufficient to drive any practical loads. In this paper a high efficiency step up converter is designed to improve the Dc voltage produced by the PV panels. PID based MPPT controller is used to maintain constant voltage which is fed to the high step up converter even in the presence of variations in solar radiation. The simulation is done in MATLAB. In this system the non linearity of the solar energy is tracked by using MPPT controller. PID controller based MPPT controller assures fast system settling while comparing with PI controller based MPPT controller. The simulation results assure the regulation of high step up converter is good and it can be used for high voltage DC applications.*

**Keywords**— *Conventional, High Step Up Converter, MPPT, PID Controller.*

## I. INTRODUCTION

Renewable sources of energy are increasingly valued worldwide because of energy shortage and environmental contamination. There are many renewable energy applications like solar energy, wind energy and hydro energy. Among them solar energy is clean, quiet, and maintenance-free. Solar energy with less carbon emission is renewable and clean energy for our living environment. Due to increased society awareness of environmental impacts from the widespread utilization of fossil fuels the solar energy became very popular. Also in the research of renewable energy sources, the PV arrays energy is quiet dominant.

Solar energy can be converted into electricity using photovoltaic devices. In solar system, many PV cells should be connected in parallel and series to obtain the require load current and Voltage. Since Solar panels have a nonlinear Voltage-current characteristic, which depends on the

environmental factors like temperature and irradiation. And in order to continuously harvest maximum power from the solar panels they have to employ a power electronic controller with some method for Maximum Power Point Tracking (MPPT). Basically MPPT controller is DC to DC converter which is used to convert the variable DC Voltage into a fixed DC to match load requirements.

The maximum used algorithms for large and medium size photovoltaic (PV) applications are perturb and observe algorithm, Incremental conductance algorithm . The voltage generated at the terminals of a photovoltaic panel can feed to high step up converter through MPPT converter.

DC-DC converters are used to convert one DC voltage to other. The converters are drastically used in industry as well as in research. The high step-up converter performs importantly among the system because the system requires a sufficiently high step-up conversion. The conventional step-up converters, like boost converter and fly back converter, cannot achieve high step- up conversion with high efficiency. Conventional step-up converters with a single switch are inadequate for high-power applications.

An asymmetrical interleaved converter is used for high step-up and high-power applications .One of the simple ways for achieving high step-up gain is by revising a boost-fly back converter and is achieved through a coupled inductor. An asymmetrical interleaved high step-up converter that combines the advantages of the conventional converters is used in this work is shown in fig 5. In this converter, the turn's ratio of coupled inductors can be designed to extend voltage gain.

One of the main limitations of this converter is unregulated supply of voltage and current. To overcome this problem there are various control techniques used in combination with these converters. Thus, a power converter with proper control is required to regulate its output power.

**II. PV MODULE**

A photovoltaic cell module used to convert light energy of the sun into electricity is shown in figure 1. The main device of the photovoltaic system is photovoltaic cell which is grouped together in series and parallel to form modules. Photovoltaic may be of current or voltage source depending on the operating point. The device has a series resistance  $R_s$  whose influence is stronger when the device operates in the voltage source region, and a parallel resistance  $R_{sh}$  is with stronger influence in the current source region of operation. These resistances are the sum of several structural resistances of the device. The mathematical expression of PV cell is given below,

$$I = I_{ph} - I_0 \cdot \left[ \exp\left(\frac{V + I R_s}{V_T}\right) - 1 \right] - \frac{V + I R_s}{R_p}$$

Where,

- $I_{ph}$  is the Insulation current,
- $I$  is the Cell current,
- $I_0$  is the Reverse saturation current,
- $V$  is the Cell voltage,
- $R_s$  is the Series resistance,
- $R_p$  is the Parallel resistance,
- $V_T$  is the Thermal voltage,
- $K$  is the Boltzman constant,
- $T$  is the Temperature in Kelvin,
- $q$  is the Charge of an electron.

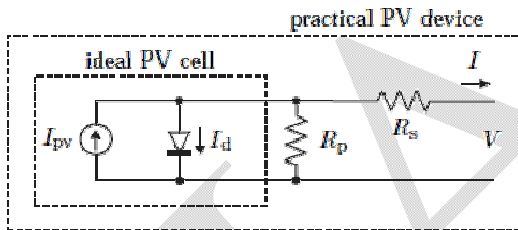


Fig 1 Circuit diagram of photovoltaic cell module

Group of PV cells together arranged in series and parallel manner formed the PV array. This array is used for extract the power. Depending upon the activated PV cells in the array, output voltage or current produced by the PV module is varied. This is happened because of the variations present in the solar radiation.

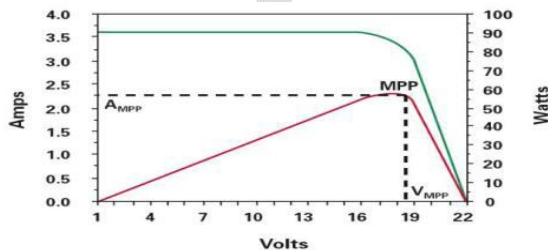


Fig 2 : VI characteristics of PV module

The characteristic of solar array is non linear which makes difficult to determine the maximum power point. The figure 2 shows the voltage and current characteristics of the solar panel. Therefore to get maximum efficiency many MPPT algorithms are developed.

**III. MPPT (MAXIMUM POWER POINT TRACKING)**

Maximum Power Point Tracking is frequently referred to as MPPT. It is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is an electronic system that varies the electrical operating point of the modules so that it is able to deliver maximum available power.

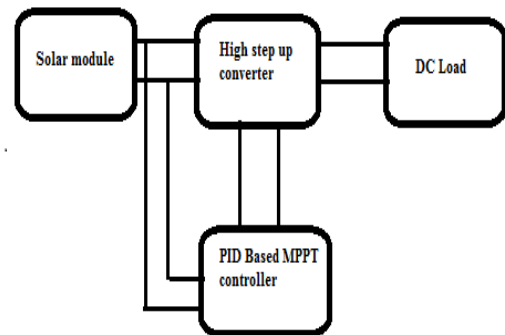


Fig 3 : PV System with MPPT

The efficiency of a solar cell is low. So to increase the efficiency, few methods are undertaken to match the source and load properly. One of the methods is the Maximum Power Point Tracking (MPPT). This technique is used to obtain the maximum possible power from a varying source. In photovoltaic systems the I-V curve is non-linear, therefore by utilizing a boost converter whose duty cycle is varied by using a MPPT algorithm. A boost converter is used on the load side and a solar panel is used to power this controller [2]. PV system with PID based MPPT controller is shown in figure 3.

**IV. MPPT ALGORITHMS**

Many different algorithms have been used for tracking maximum power point. Commonly used algorithm for tracking is perturb and obserb (P&O) algorithm. The P&O MPPT algorithm is used maximum due to its ease of implementation. Figure 4 shows the flow chart of P&O method. After every operation the current power is calculated and it is compared with previous value to determine the variation of power  $\Delta P$ . If  $\Delta P > 0$ , the operation continues in the same direction of perturbation. Or else the operation reverses

the perturbation direction [3]. The perturbation is done until it reaches the maximum power point.

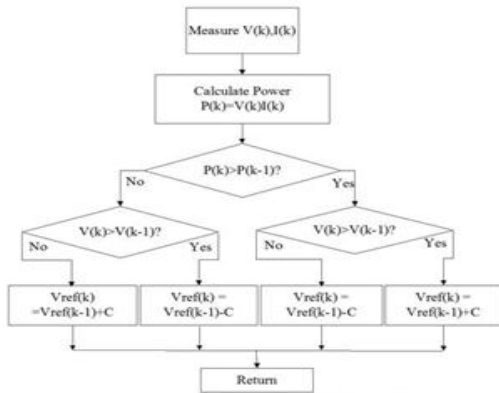


Fig 4 : flow chart of P&O algorithm

V. FUNCTION HIGH STEP UP CONVERTER

The high step up converter output voltage (VO) will be more than input voltage (VIN). To be used in high power applications the converter should have maximum of two power switches. The power switch having low RDS (on) and low power is selected, for achieving high efficiency high efficiency. The circuit of high step up converter used in this work is shown in figure below. The coupled inductance is used to achieve the step up the voltage. The turn's ratio of coupled inductance is same. To reduce voltage ripple the filter made of capacitor is used. The non-stable voltage output is stabled by changing duty cycle of switching pulse technique. By using the pulse width modulation technique on high step up converter, a stable output is obtained.

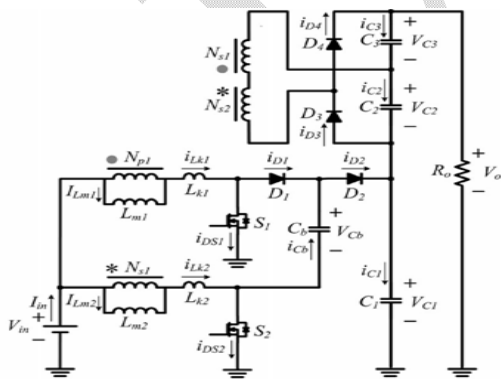


Fig 5: Circuit of high step up converter

The advantages of the high step up converter are, the converter is characterized by a low input current ripple and low conduction losses, making it suitable for high-power applications; the converter achieves the high step-up voltage gain that renewable energy systems require; leakage energy is

recycled and sent to the output terminal, and alleviates large voltage spikes on the main switch; the main switch voltage stress of the converter is substantially lower than that of the output voltage; low cost and high efficiency are achieved by the low voltage rating of the power switch.

VI. SIMULATION AND RESULTS

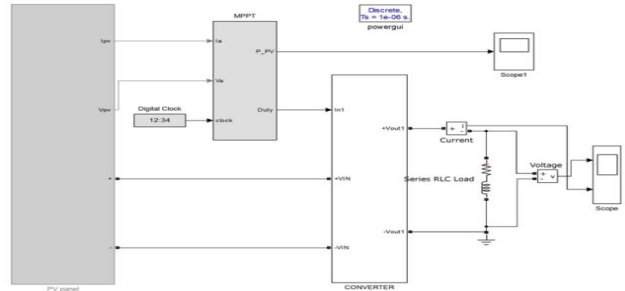


Fig 6 : Simulink model of the proposed system with PID controller

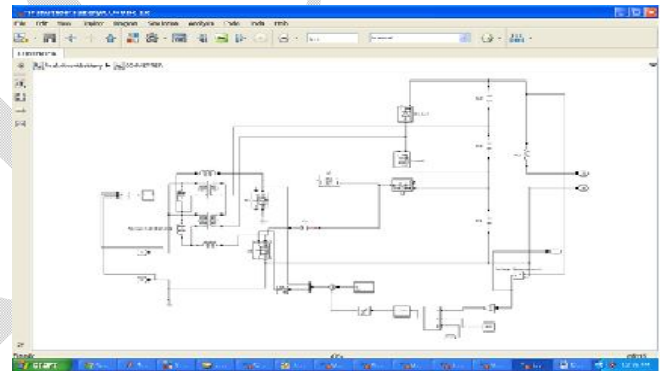


Fig 7 : Simulink model of the high step up converter with PID controller

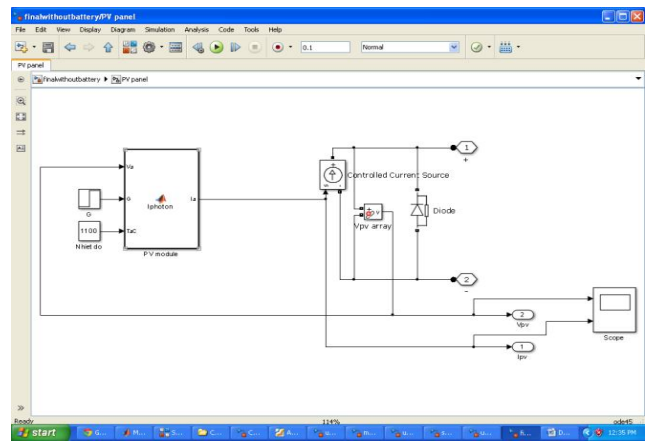


Fig 8 : Simulink model of PV panel

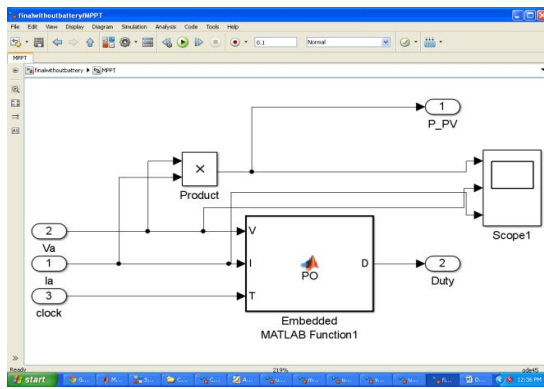


Fig 9 : Simulink model of MPPT controller

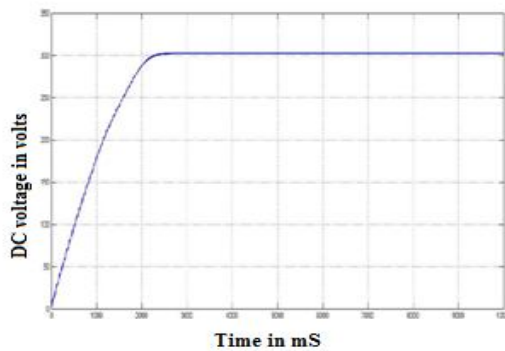


Fig 10 : DC Voltage output

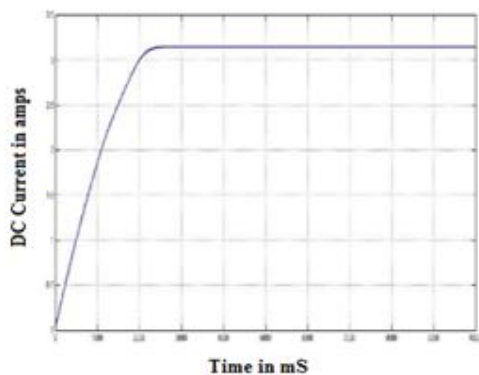


Fig 11 : DC Current output

Table 1 Comparison of high step up converter without and with controllers

High step upconverter	DC voltage in volts	Settling time in seconds
Without controller	280	0.999
With PI controller	300	0.999
With PID controller	317	0.644

## VII.CONCLUSION

A photovoltaic fed high step up converter with PID based maximum power point tracking has been modeled and simulated in MATLAB software. The algorithm used in MPPT controller is based on PID controller. The entire system is simulated and from the results it is clear that the system with such controller is more efficient. This technique of using PID controller is able to reach the MPP quickly and oscillation is minimum. The maximum power point tracker tracks the MPP and the high step up converter; boost the voltage panel voltage to maximum voltage. This system settling time is low when compared to system with PI controller and it is shown in table 1. Thus the proposed system is efficient and it is recommended for high voltage DC applications.

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