

Article Info

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Step Up Boost Converter for a Photo Voltaic System Using MPPT

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ABSTRACT

This paper presents the performance of a converter topology for PV array. The system containing solar cell, DC-DC boost converter and ac load. This paper presents the simulation of a photovoltaic system using MATLAB. The photovoltaic array is designed for 80V. The proposed PV model was prepared on MATLAB and input parameters are solar irradiation and temperature. The output current and power characteristics of PV model are simulated for varying effects of temperature and solar irradiation. A DC-DC boost converter is used for boosting of DC voltage obtained from Photovoltaic system. A DC DC converter is designed for 550 V.

Keywords: Photovoltaic Module; DC/DC Boost Converter; MPPT Technique.

1.0 Introduction

Solar energy is the largest renewable resource among the other renewable energy options. Conversion of solar energy to electrical energy by using device called the photovoltaic cell. A set of connected cells form a panel. Photovoltaic systems have become increasingly popular and are ideally suited for distributed systems. Many governments have provided the much needed incentives to promote the utilization of renewable energies. Recent studies show an exponential increase in the worldwide installed Photo voltaic power capacity. There is ongoing aimed to research at reducing the cost and achieving higher efficiency.

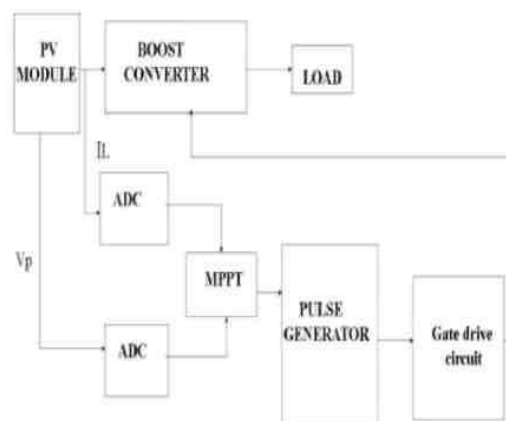
Photovoltaic (PV) is a technology in which radiant energy from the sun is converted to direct current (DC) electricity. Unfortunately solar cells are still far to produce a significant fraction of the world's energy needs because of the initial investment cost. PV cells produce direct current (DC) energy. Because most residential and commercial electrical equipment is AC (alternating current), this DC energy needs to be converted. The AC power produced can also be provided to a utility. The voltage and current available at the terminals of a PV device may directly feed small loads such as lighting systems.

More applications require electronic converters to process the electricity from the PV device. These converters may be used to regulate the

voltage and current at the load. The power from photovoltaic cell is given to the DC-DC boost converter where the input voltage is boosted up to the required DC voltage, then given to the DC-AC converter.

The generated power in PV cells can be used for our output source. In the output power of the PV system can also be stored in batteries. However, the battery systems are expensive, bulky and high maintenance. Where utility power is also available, another solution is to feed the power into the grid, which requires a grid connected inverter. The paper discusses the PV system topologies with MATLAB and the proposed converter.

Fig 1: Block Diagram of Photovoltaic System Using Boost Converter with MPPT

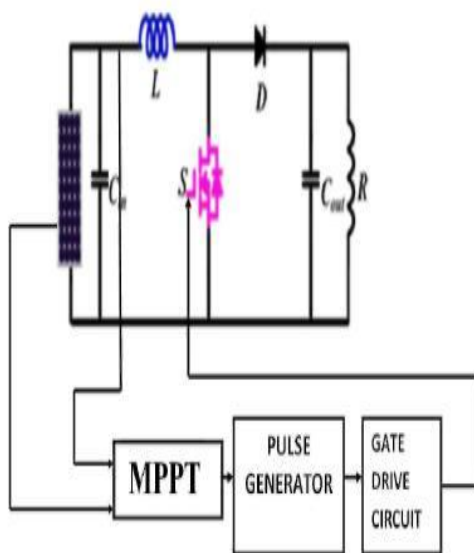


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In the system, PV panel produced the light energy into electrical energy by using the PV module and PV array. In this PV system is connected to the boost converter or step-up boost converter. The boost converter, the average output voltage is greater than input voltage. The output voltage is connected to the load. The peak voltage and load current is produced in the PV panel and its connected to the MPPT and connected to the pulse generator. The pulse generator is passed to the gate drive circuit and its connected to the boost converter

2.0 Circuit Diagram of Proposer System

Fig 2: Circuit Diagram of Photovoltaic System Using Boost Converter with MPPT



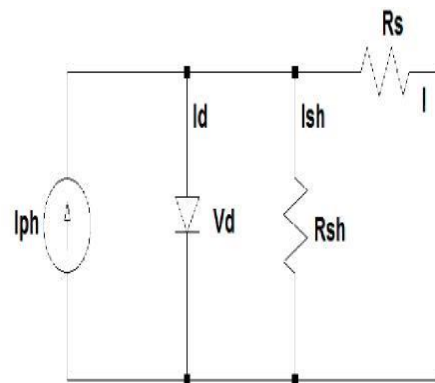
For implementing the MPPT, there is a need to include the dc-dc converter into the system. The dc-dc converter can be either buck or boost converter. The boost converters are step-up power converters. They are popular because of their high efficiency and compact size.

In this paper, the boost converter is chosen where the duty cycle of the boost dc-dc converter is controlled by PWM signal from controller implementing Incremental Conductance and integral regulator algorithm. Therefore, whatever the weather (irradiation and temperature) and the load conditions, the control system of the converter will ensure the operating point is optimized for maximum power transfer.

3.0 Pv Cell System

Photovoltaic (PV) is the field of technology and research related to the application of solar cells for energy by converting sunlight directly into electricity. Photovoltaic are generally known as a method for generating solar power by using solar cells packaged in photovoltaic modules, often electrically connected in multiples as solar photovoltaic arrays to convert energy from the sun into electricity.

Fig 3: Basic Equivalent Circuit of Solar Cell



4.0 Boost Converter

DC-DC converters can be used as switching mode regulators to convert an unregulated dc voltage to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching device is generally BJT, MOSFET or IGBT. The minimum oscillator frequency should be about 100 times longer than the transistor switching time to maximize efficiency.

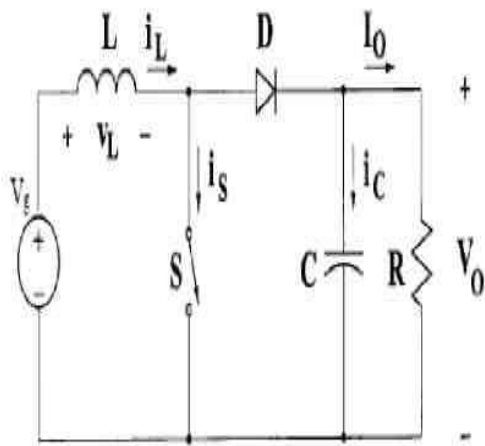
This limitation is due to the switching loss in the transistor. The transistor switching loss increases with the switching frequency and thereby, the efficiency decreases. The core loss of the inductors limits the high frequency operation. Control voltage V_c is obtained by comparing the output voltage with its desired value. Then the output voltage can be compared with its desired value to obtain the control voltage V_{cr} .

4.1 Operation of boost converter

The step up boost converter consists of a dc input voltage source V_g , boost inductor L , controlled

switch S, diode D, filter capacitor C, and the load resistance R. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at that time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the output RC circuit.

Fig 4: Circuit Diagram of Boost Converter

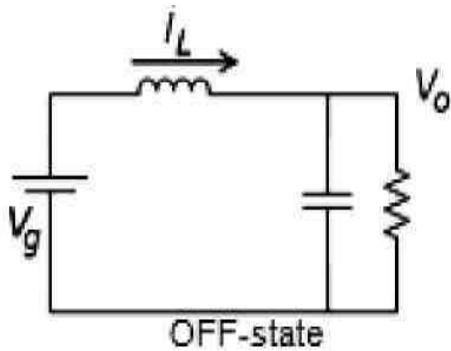


4.2 Steady state analysis of the boost converter

(a) Off State

In the OFF state, the circuit becomes as shown in the Figure.

Fig 5: The OFF State Diagram of the Boost Converter

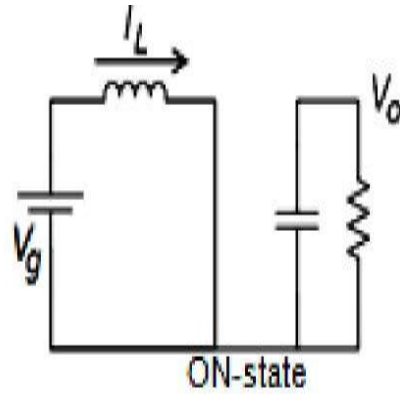


When the switch is off, the sum total of inductor voltage and input voltage appear as the load voltage,

(b) On State

In the ON state, the circuit diagram is as shown below in Figure,

Fig 6: The ON State Diagram of the Boost Converter



When the switch is ON, the inductor is charged from the input voltage source V_g and the capacitor discharges across the load. The duty cycle, $D = T_{on}/T$ where $T = 1/f$

Fig 7: Inductor Current Waveform

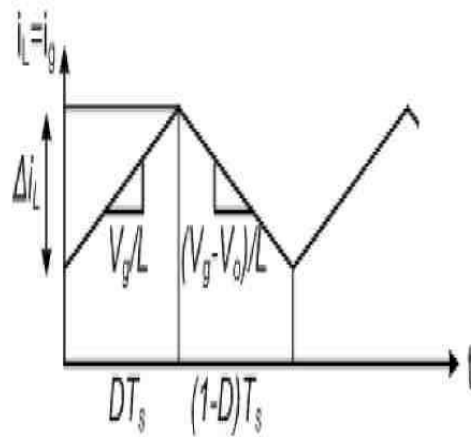
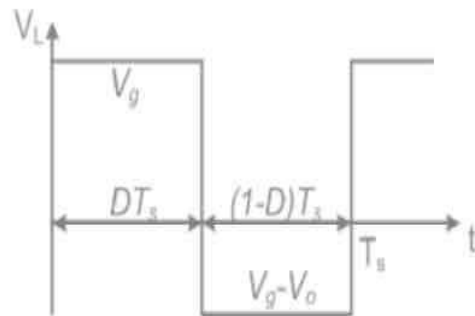


Fig 8: Inductor Voltage Waveform



From the inductor voltage balance equation, we have:-

$$V_g(DT_s) + (V_s - V_o)(1-D)T_s = 0$$

$$V_o = V_g / (1-D)$$

$$\text{Conversion ratio, } M = V_o / V_g = 1 / (1-D)$$

From inductor current ripple analysis, change in inductor current,

$$\Delta I_L = (I_{max} - I_{min})$$

- ◆ $\Delta I_L = (V_g / L) * (DT_s)$

- ◆ $\Delta I_L = (V_g D) / (f_s L)$

- ◆ $L = V_g D / (f_s \Delta I_L)$

The boost converter operates in CCM (continuous conducting mode) for $L > L_b$ where

$$L_b = (1-D)^2 D R / 2f$$

$$C_{min} = D V_o / V_o R f$$

4.3 Simulation parameters

PARAMETER	DESCRIPTION
$V_o = 550V$	OUTPUT VOLTAGE
$I_o = 1.15A$	OUTPUT CURRENT
$V_i = 80V$	INPUT VOLTAGE
$I_i = 1.13A$	INPUT CURRENT
$P = 0.8W$	MAXIMUM POWER

5.0 Maximum Power Point Tracking

The efficiency of a solar cell is very low. In order to increase the efficiency, methods are to be undertaken to match the source and load properly. One such method is the Maximum Power Point Tracking (MPPT).

This is a technique used to obtain the maximum possible power from a varying source..

A boost converter is used on the load side and a solar panel is used to power this converter.

6.0 Simulation Output

Fig 9: Stepup Boost Converter for PV System

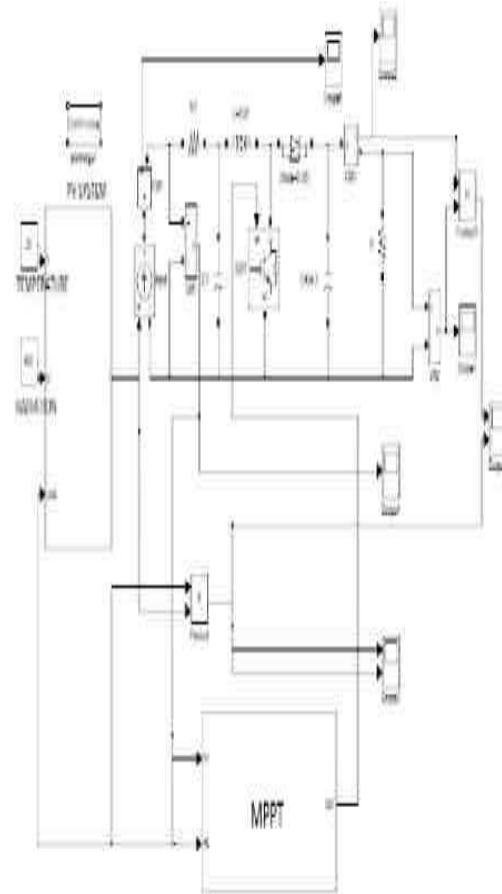


Fig 10: Output Voltage Waveform

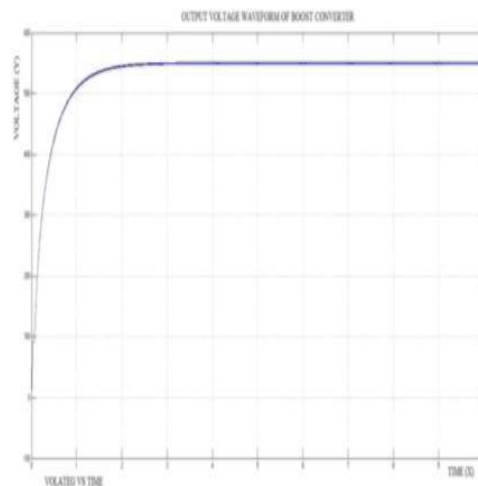


Fig 11: Output Current Waveform

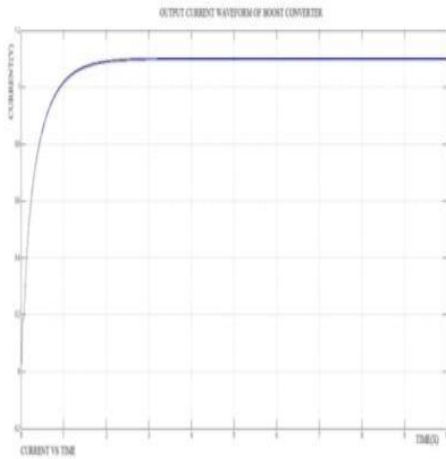


Fig 12: Gate Drive Signal Waveform

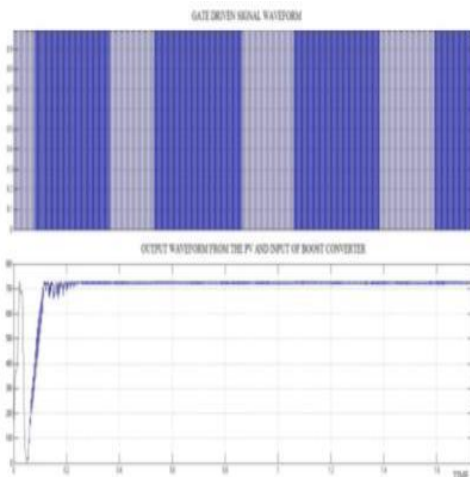
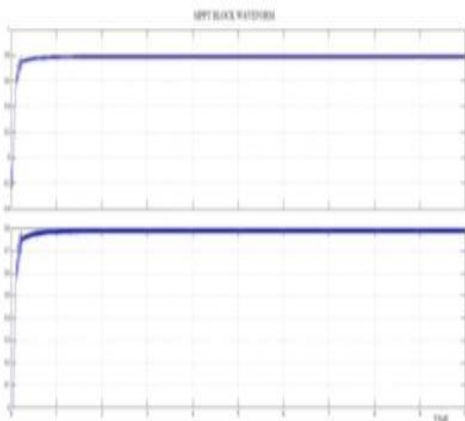


Fig 13: MPPT Block Waveform



7.0 Conclusion

The open circuit P-V, P-I, I-V curves we obtained from the simulation of the PV array designed in MATLAB environment explains in detail its dependence on the irradiation levels and temperatures. The entire energy conversion system has been designed in MATLAB-SIMULINK environment. The various values of the voltage and current obtained have been plotted in the open circuit I-V curves of the PV array at insolation levels. The voltage and current values lie on the curve showing that the coupling of the PV array with the boost converter is proper. However the performance of the photovoltaic device depends on the spectral distribution of the solar radiation.

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