Analysis & Simulation of Buck-Boost Converter Controlled by MPPT along with Inverter and PWM Techniques in Photovoltaic System

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Abstract-It is essential to convert the energy obtained with photovoltaic panel from low efficiency to maximum possible efficiency. So the concept of maximum power point Tracking (MPPT) based P&O(perturb & observe) technique is introduced as it ensures energy conversion with highest efficiency in the Buck-Boost converter and inverter topologies. In this study, Buck -Boost converter fed by solar panels and controlled by PI-controlled MPPT along with inverter and PWM techniques are examined and their performance analysis by Matlab Simulink @ in order to determine the ripple free output voltage waveforms of photovoltaic panels. In the simulation after modelling the designed at given temperature and irridation, the output voltages of each topologies is compared.

I. INTRODUCTION

With global population explosion and Rapid industrialization the demand for energy has increased drastically and it cannot be made by present power generation system which mainly depends on fossil fuels which are becoming depleted. Moreover, the environmental impact of intensive industrialization and inefficient energy consumption has been boosted the energy demand. This situation necessitated that the management of energy production , transmission and distribution processes with more efficient and environmentally friendly studies.

In Recent days solar energy based power generation has become most popular for off-grid power generation. PV system installation requires higher initial cost with nil running cost. Moreover the return on investment(ROI) will be approximately five to ten years period depending upon the energy policy. within the renewable resources, electricity generation with solar and wind energy is the foreground. The setup costs of these resources are higher than those of conventional ones. However low maintenance and operation costs have increased the interest in renewable resources photovoltaic(PV) cells are used to convert solar energy into electrical energy.

Solar PV cells have a major Drawback that it shows nonlinear power voltage (P-V) characteristics even at constant environmental conditions. This nonlinear characteristics has maximum power at a certain operating condition. Thus it becomes very essential to use MPPT to track maximum power point(MPP) in PV based systems. Considering the environmental conditions, MPPT based Algorithm-P & O(perturb & observe) technique decide the operating voltage and current level for the array to extract available maximum power in PV array.

PV system faces a lot of problems due to variation in temperature and spectral characteristics of sunlight. It is desirable to operate the PV cell to extract maximum power. The maximum power occurs only at certain output voltage and output current from the solar panel. The optimum operating point for generating maximum power is obtained through maximum power point Tracking (MPPT). The primary objective is to facilitate increasing penetration levels of PV system by analyzing and quantifying the impacts of grid connected PV energy productivity and ensure high conversion efficiency, a Buck-Boost converter along with inverter and PWM techniques is used.

P & O based MPPT method was used because of its simplicity and effectiveness. In this method the power of PV system before and after perturbation is compared ,based on that the controller will decide the next perturbation size. The conventional P &O method cause oscillations around MPP. As the perturbation step size increases oscillations , while smaller perturbation step reduces the MPPT performance there should be an optimum step size with tradeoff.

Buck- Boost converter are used to interface the PV Panel condition and used to maintain constant output voltage as it depends upon the duty cycle which was generated from the MPPT according to PV panel condition and output was connected to inverter input terminal to get AC output voltage which passes through PWM to get AC output voltage which passes through PWM to get ripple free output voltage.

II. PV PANEL MODELING

Solar cell is made up of semiconductor material which can able to absorb the irradiance and temperature of the solar energy and converts it into the dc current . The cells are connected in series and /or parallel to achieve the corresponding voltage and current if the cells are connected in series and/ or parallel to achieve the corresponding voltage and current if the cells are connected in series then it obtains the large output voltage whereas if the connection is in parallel. it produces large output current . The modeling of the solar cell is defined by voltage-current relationship of PV system.

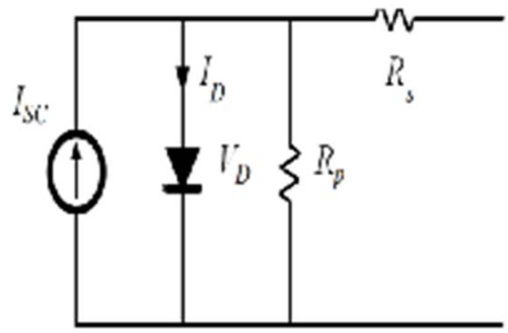

Fig.1. Equivalent circuit of solar cell.

The output power of the solar panel depends on the parameters, solar irradiance and temperature. The relation between the voltage and power of the PV panel is shown in Fig.2. From these characteristics, it is clear that a MPPT algorithm is required to track the maximum power and to generate the appropriate duty cycle for firing the converter.

Io=Irs*(T/Tn)^3*exp[(q*Ego*(1/Tn-1/T)/(n*K)]

Irs=Isc/[exp(q*Voc/n*Ns*K*T)]

Ish=(V+I*Rs)/Rsh

Iph=[Isc+{ki*(T-298)}*G/1000]

I= Iph-I0*[exp{(V+I*Rs)*q/(n*K*T*Ns)}-1]-Ish

Where:

Iph: PV current (A)
Io : saturation current
Irs : Reverse saturation current
Ish : shunt current
n : diode ideality factor
k : Boltzmann constant
q : Electron charge
T : operating temperature(K)
Ego: Band gap energy of semiconductor
Rs : series resistance
Rsh : shunt resistance

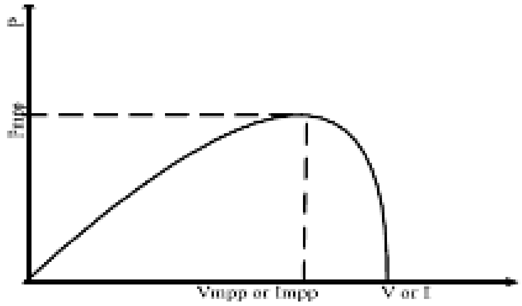

Fig. 2. Characteristics PV array power curve.

III. P&O BASED MODELING (MPPT CONTROLLER)

The output power of the photovoltaic panel is continuously monitored by the P & O MPPT method. In this method, only the current and voltages values of the panel need to be read instantaneously. It is decided to increase or decrease the reference value by establishing a correlation between the change of the output power of the panel and the change of the control variable. This allows the MPPT controller to adjust the pulse width ratio to keep the power at the maximum point. It is among the preferred algorithm in the literature because of the low transaction volume and ease of control.

The operating point of the PV system is tracked using P & O based MPPT algorithm. This methodology is shown using the flow chart using in Fig3. The duty cycle of the P& O method is described by the voltage and power relations as given in equation (2)

dP(n)/dVpn = P(n)-P(n-1)/Vpv(n)-Vpv(n-1)

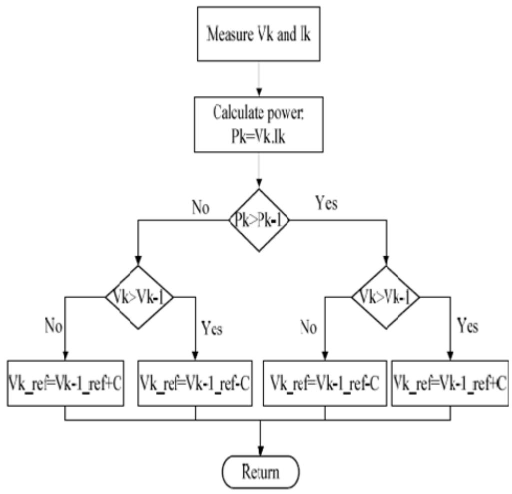

Fig.3 P&O algorithm Flowchart.

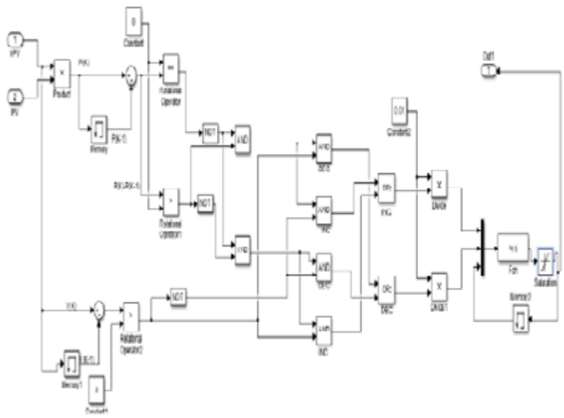

Fig. 4. Simulink model of P & O MPPT.

IV. MODELLING OF BULK-BOOST CONVERTER

The Buck-Boost converter is operated under step up principle. The output voltage is larger than the input voltage. It consists of an inductor, capacitor, a switch and a diode as shown in Fig-5. When the switch is closed (turn On), the diode gets reverse Biased and hence the current increases linearly as the current flows through inductor and switch. when the switch is opened (turned off) the diode becomes forward biased and stored energy is released from inductor and current flows through inductor and capacitor.

The Duty cycle design using input and output voltages values.

[Vo=Vm/1-D]

Where :

Vo: output voltage

Vin: Input voltage

D: duty cycle

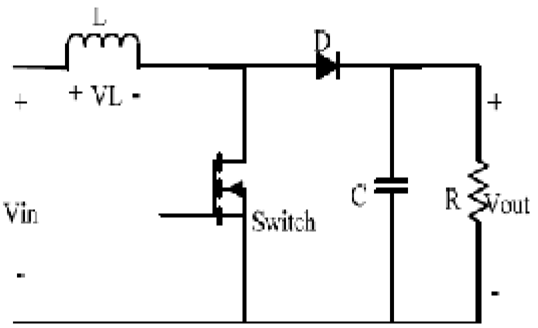

Fig. 5 Circuit diagram of a boost converter.

V. MODELLING OF INVERTER

An inverter is a static converter used to convert the DC voltage and current into AC voltage and current with variable Amplitude and frequency. Each leg of the variable amplitude and frequency. Each leg of the inverter consists of two power devices :typically IGBT , and the respective free-wheeling diodes connected in parallel.

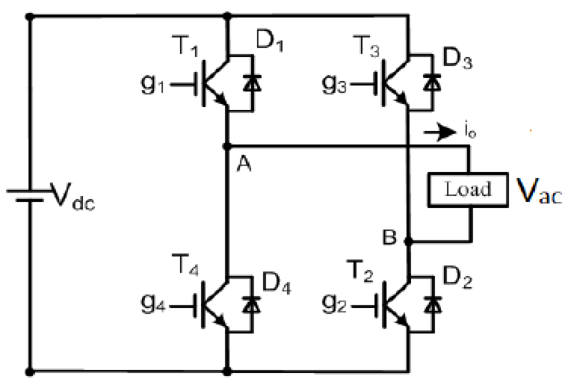

Fig. 6 Block diagram of inverter.

VI. MODELLING OF PWM

In order to generate currents and voltage variables in amplitude and frequency; a modulation strategy has to be applied. There are several modulation strategy which differ for generation of devices driving signals for the value of harmonic components in voltage and current and for the use of dc bus.

The modulation strategy used in this work is sinusoidal pulse width modulation (SPWM).The leg A and B of the inverter are controlled separately by comparing a repetitive triangular signals Vtriag with two control signals Vcont and -Vcont. The control signals are used to modulate the switch duty ratio and have a frequency equal to to desired fundamental frequency of the inverter output voltage. The frequency of the triangular signals establishes the frequency with which the inverter switches are closed. The comparisons between Vcont and Vtriag results in the following logic signals to control the device of leg A;

if Vcont>VTRIAG-S1on and S2 off-Vac=Vdc

if Vcont< Vtriag-S1 off and S2 on-Van=0

Comparing -Vcont and Vtria can be found the logical signals to control the switches of leg B;

if -Vcon>Vtria-S3 on and S4 off-Vbn=Vdc

if -Vcont<Vtriag-S3 off and S4 on-Vbn=0

VII. PROPOSED METHODOLOGY

The output power of the photovoltaic panel is continuously monitored by P& o MPPT method. In this method; only the current and voltage values of the panel need to be read instantaneously. It is decided to increase or decrease the reference value by establishing a correlation between change of output power of the panel and the change of control variables. This allows the MPPT controller to adjust the pulse width ratio to keep the power at maximum point.

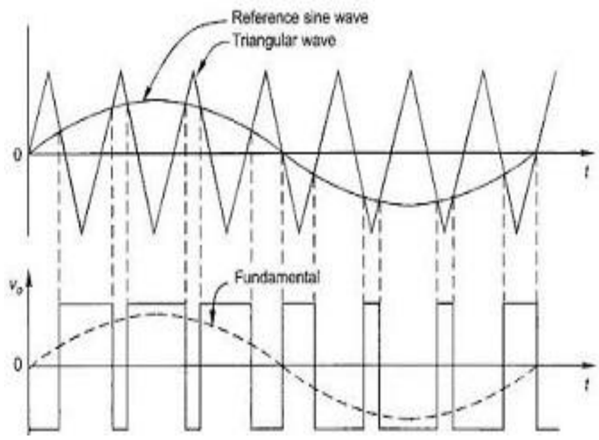

Fig. 7 Pulse width modulation technique.

From this study, the design of MPPT working with the PI-controlled P& O method is performed. The current and voltage value taken from the converter output are applied to MPPT. The MPPT generates switching angles to the converter and Buck-Boost converter output are applied to inverters which removes ripple and harmonic content from the output by the use of PWM (pulse width modulation).

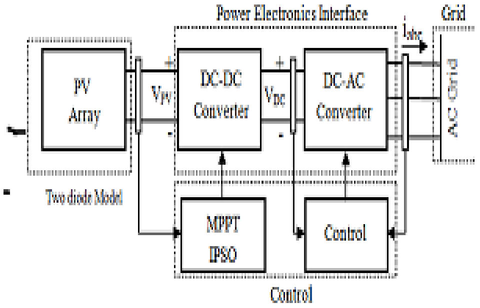

Fig-8. Proposed methodology block diagram.

VIII. SIMULATION RESULTS

Output voltage of Buck Boost Converter is 27.94 volt DC output voltage of inverter is 27.94 with ripple. Ouput voltage through PWM is 27.94 without harmonic (ripple free).

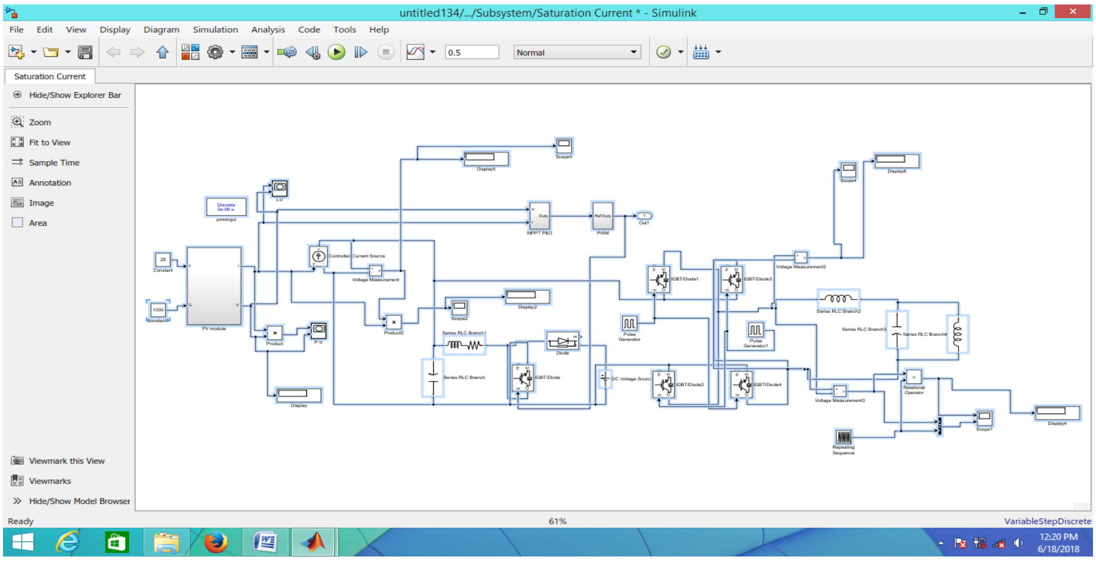

Fig-9- PV based MPPT controlled Buck-Boost Simulink model.

Parameters	PV Panel	Bulk-boost	Inverter with PWM
V_{in}(v)	-	21.3	27.94
V_{out} (v)	21.3	27.94(DC)	27.94 (Without Ripple)
I_{in} (A)	3.11	0.99	0.987
I_{out} (A)	0.99	0.987	0.99

Table-Numerical Value of Simulation results

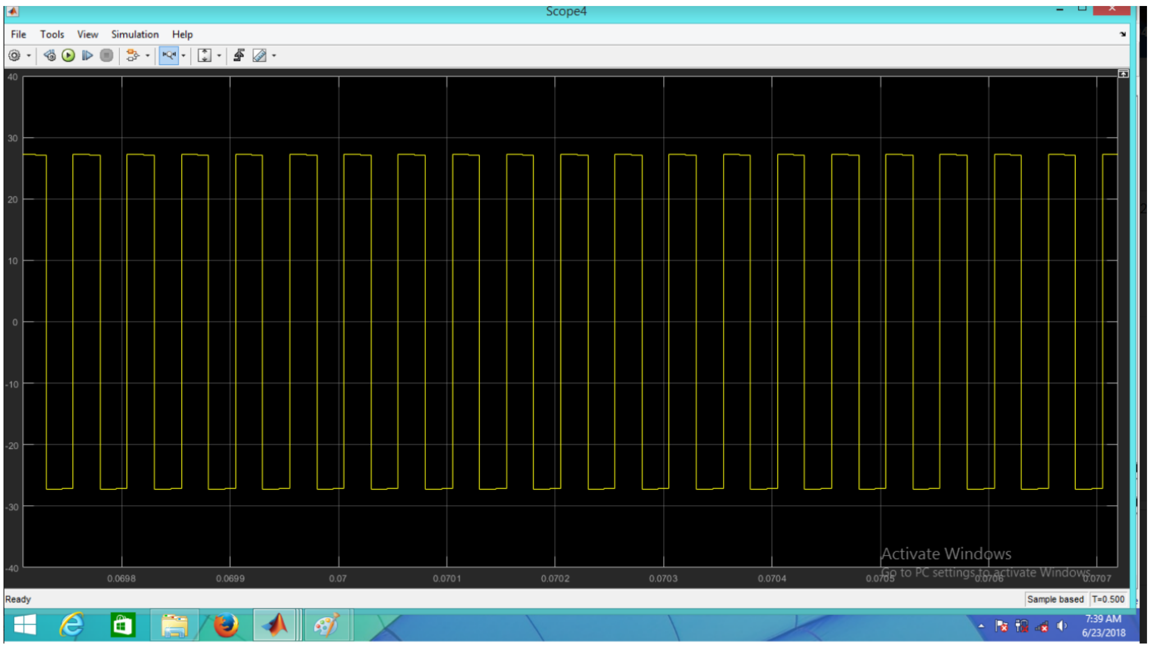

Fig-10. Simulink Results of Inverter (voltage-time) Output characteristics.

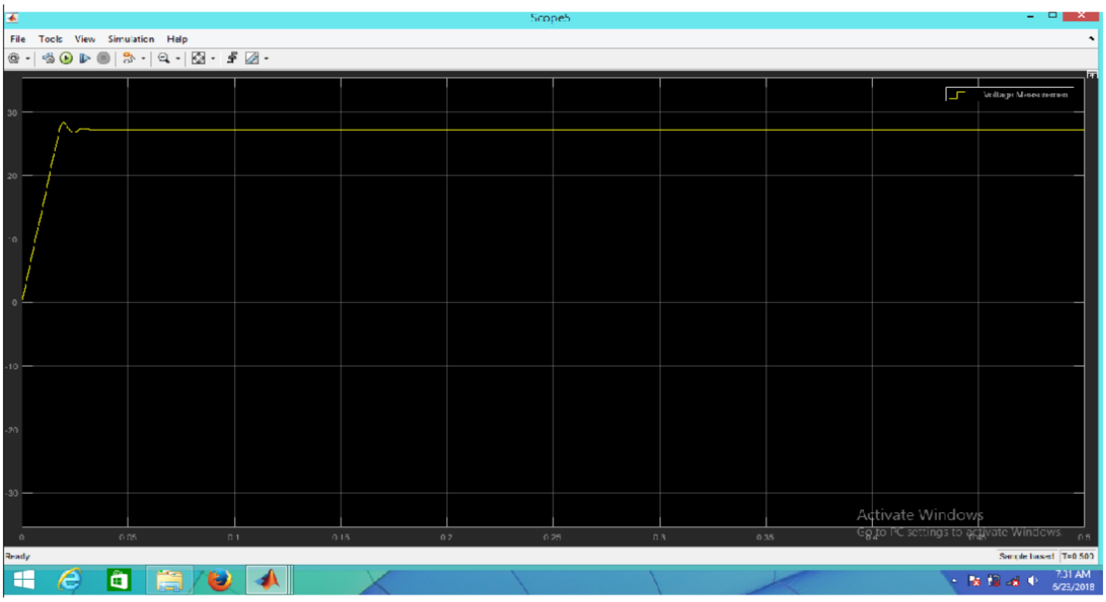

Fig-11. Simulink Results of Buck Boost Converter (voltage-time) Output characteristics.

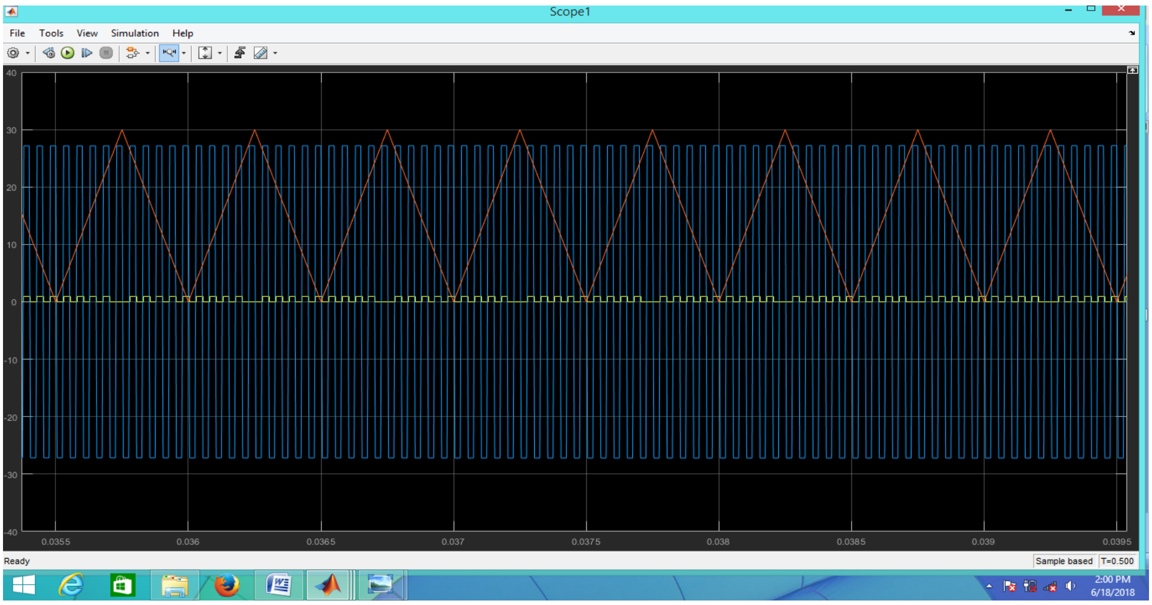

Fig-12. Simulink Results (voltage-time) characteristics.

IX. CONCLUSION AND FUTURE SCOPE

In this study, design and performance analysis of Buck-Boost converters controlled by PI-controlled MPPT along with inverter and PWM Technology have been performed in Matlab Simulink program. The converter are supplied with dc voltage obtained from the designed with the help of switching device (Duty cycle) in order to maximize the power and increase the efficiency . The PI controlled MPPT ensures that the output voltage is fixed at desired reference value by changing the switching ratio of converters. Then converters output contains ripple are applied to inverter and in turn to PWM which remove the harmonic and ripple content for the output voltage. The MPPT system design according to the obtain results quickly catches the reference value given.

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