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Solar PV Array Fed Four Switch Buck-Boost Converter for LHB Coach

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Abstract : This paper deals with application of Four switch Buck-Boost converter in solar system. Photovoltaic energy is one form of renewable energy which can be produced with solar panels from the sun. The high efficiency on the solar panels is needed in order to make the system more efficient. Also due to variation of power Production continuously we need constant adaptation. To achieve the high efficiency we need Maximum power point tracking techniques for converters, the MPPT present good results on the Photovoltaic system. In this paper, we are using the Four switch Buck-Boost converter the FSBB Converter presents some advantages compared to other Power Converters. The Mat lab/ simulink model of Solar panel with Four switch Buck-Boost converter with controller has developed in order to exploit the capabilities of new converter. The controller can choose working of the converter either Buck or Boost depends on the output of the solar panel at maximum power point condition. The solar pv array fed Four Switch Buck-Boost converter is designed and verified through simulated results using MATLAB/ simulink . Finally these system can be arranged on the LHB coaches for the coach applications.

Keywords : Solar PV, FSBB (Four Switch Buck-Boost Converter), MPPT(Maximum Power Point Tracking) Controller.

1. INTRODUCTION

Now a days researchers and industries utilizing the solar energy in large extent due to reduction of power electronic equipment and the solar panels cost the government also encouraging the researchers to work on the solar pv system. The maximum efficiency of the solar PV array can be achieved through a maximum power point tracking (MPPT) technique [1-3] using the DC-DC power converters. Various DC-DC power converters are like Buck converter [3], Boost converter[4], Buck-Boost converter [5], Cuk converter[6], SEPIC converter[7] have been used to find best one with Maximum power point tracking technique in different solar PV array based converter applications. The DC-DC power converters are compared [8] with each other to find a converter which shows best result with MPPT. It has been concluded that the buck-boost DC-DC converter is best selection among these DC-DC converters in the solar PV system.

FSBB power converter is cascaded combination of Buck converter followed by a Boost converter the converter is different from the other DC-DC converters why, because it has four switches to be controlled, that is, two gate pulses we need. This means for the same working point with different values both gate pulses can be used. Further more, due to its simple and cascaded combination of Buck-Boost structure, it

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presents high adaptability and high performance to system voltage changes. All these advantages makes the FSBB DC-DC Converter suitable for the Photovoltaic applications or power supply applications [9]. To fully determine the modes of operation of this new power converter structure, a theoretical study has been carried out and compared with simulation results.

2. THE CONFIGURATION OF PROPOSED SYSTEM

The proposed configuration of the system in this paper under study is shown in Fig.1 It consists of the Solar PV array fed to FSBB Converter which feeds the Load. MPPT algorithm generates switching pulse for the switches of FSBBC. The model design and controller of the configuration shown in Fig. 1 are detailed in below sections

3. THE PROPOSED SYSTEM DESIGN

The proposed system comprises of solar PV array, a FSBBC, Load. The solar PV array and the FSBBC are designed as per the design of the proposed system. Power rating of the Load is selected as 1.5 kW respectively. On the basis of these selected ratings, each stage of the configuration shown in Fig. 1 is designed and explained in the following section.

A. Design of Solar PV Array

The maximum power rating of Solar PV array is designed for Pmpp = 1.5 kW peak power capacity. A PV module of 60 cells connected in series is designed to produce an open circuit voltage of Voc = 13.6V and short circuit current of Isc = 3.35 A. It is reported that the peak power generally occurs between 71% and 78% of open circuit voltage and between 78% and 90% of short circuit current [10].

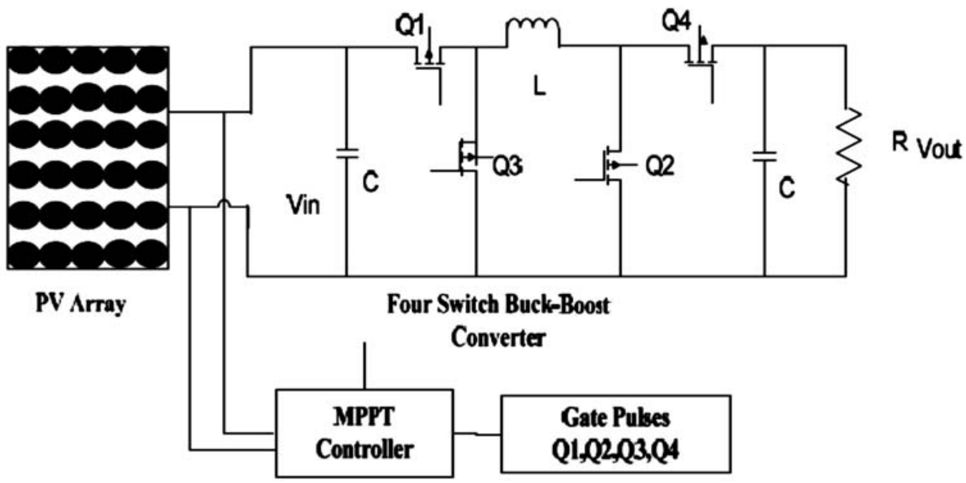


Fig. 1. Configuration of proposed Solar PV array fed FSBB Converter.

Hence, the voltage of a module at MPP, Vm = 0.78*13.6 = 10.47 V and the current of a module at MPP, Im = 0.9*3.35 = 3A.Voltage of the Solar PV array at MPP is considered as, Vmpp = 83.33 V. The current of the Solar PV array at MPP, Impp = Pmpp/ Vmpp = 1500/83.33 = 18 A. Numbers of solar pv modules required to connect in series are, Ns = 8 Numbers of solar pv modules required to connect in parallel are, Np = 6.

B. Design of Four Switch Buck-Boost Converter

Based on these estimated parameters, the solar PV array of required size is developed. The Four switch Buck-Boost converter as shown in Fig.2 it is a combination of Buck converter followed by Boost converter, a four switch buck-boost converter can operate in buck mode or boost mode rather than conventional buck-boost converter. As such, its efficiency can be improved by synchronous rectification the power stage consist of four switches (Q1, Q2, Q3, Q4), single inductor(L), input and output Capacitors. Here the MOSFETs Q3,Q4 share the gate control signal, Which is complementary to the gate control signal of MOSFETs Q1 and Q2, In the buck-boost mode the MOSFETs Q1 and Q2 share gate control signals and turn on and off simultaneously. When the MOSFETs Q1 and Q2 are turned on, the input voltage Vin is applied, the inductor L stores the energy, output capacitor supplies the load current entirely. When Q1 and Q2 are turned off , MOSFETs Q3,Q4 are turned on in these stage the energy is transferred from the inductor to output load and capacitor. Here we are using a synchronous rectification scheme these means we are using MOSFETs instead of diodes to reduce the switching and power losses and to improve efficiency.

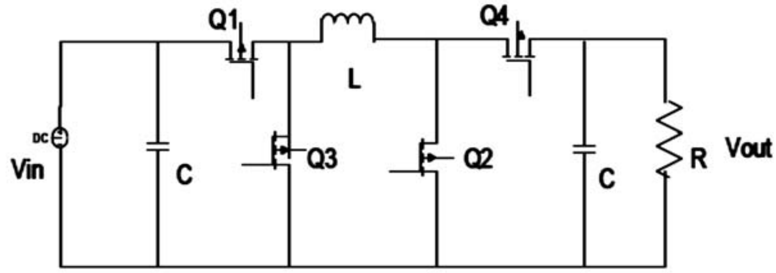


Fig. 2. Four-switch buck-boost converter.

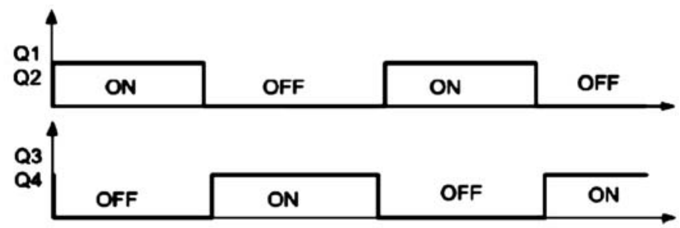
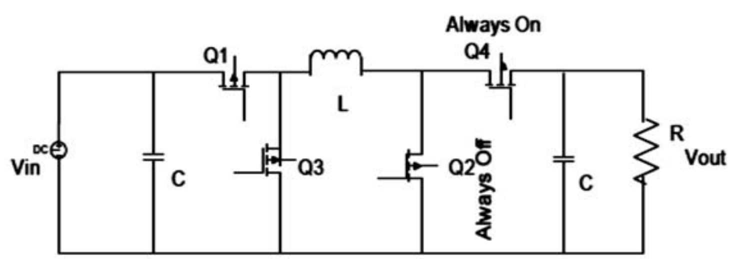


Fig. 3. Gate control signals in Buck-Boost mode.

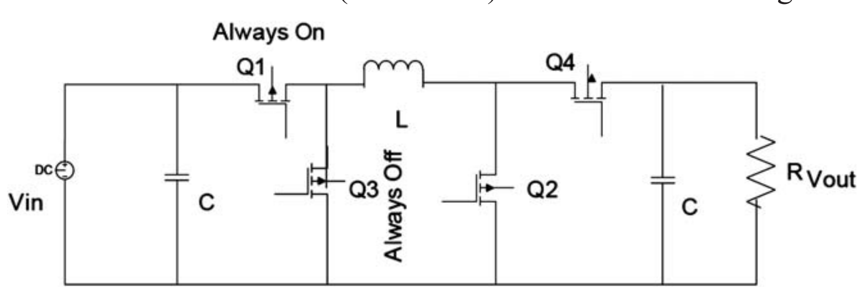
The Fig.4 shows the equivalent circuit of the converter in buck and boost mode. When Vin is higher than Vout, The MOSFET Q2 is always OFF, Q4 is always ON, Q1 and Q3 ON and OFF simultaneously thus it works like a buck converter(Vin > Vout) as shown in below figure.



Buck Mode (Vin >Vout)

Fig. 4.

When Vin is lower than Vout, Q1 is always ON And Q3 is always OFF, Q2 and Q4 ON and OFF simultaneously it works as a boost converter (Vin < Vout) as shown in below fig



Boost Mode (Vin < Vout)

Fig. 5. Equivalent circuit in Buck/Boost mode.

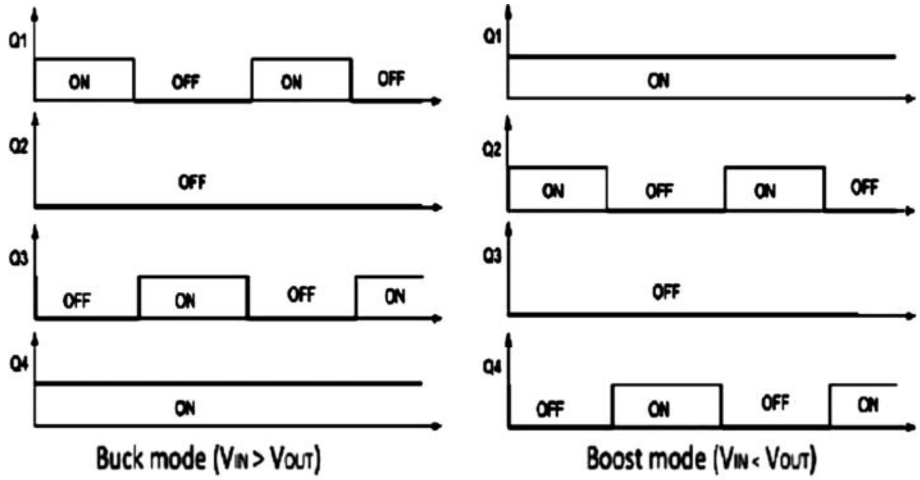


Fig. 6. Gate control signals in Buck/Boost mode.

C. Maximum Power Point Tracking (MPPT)

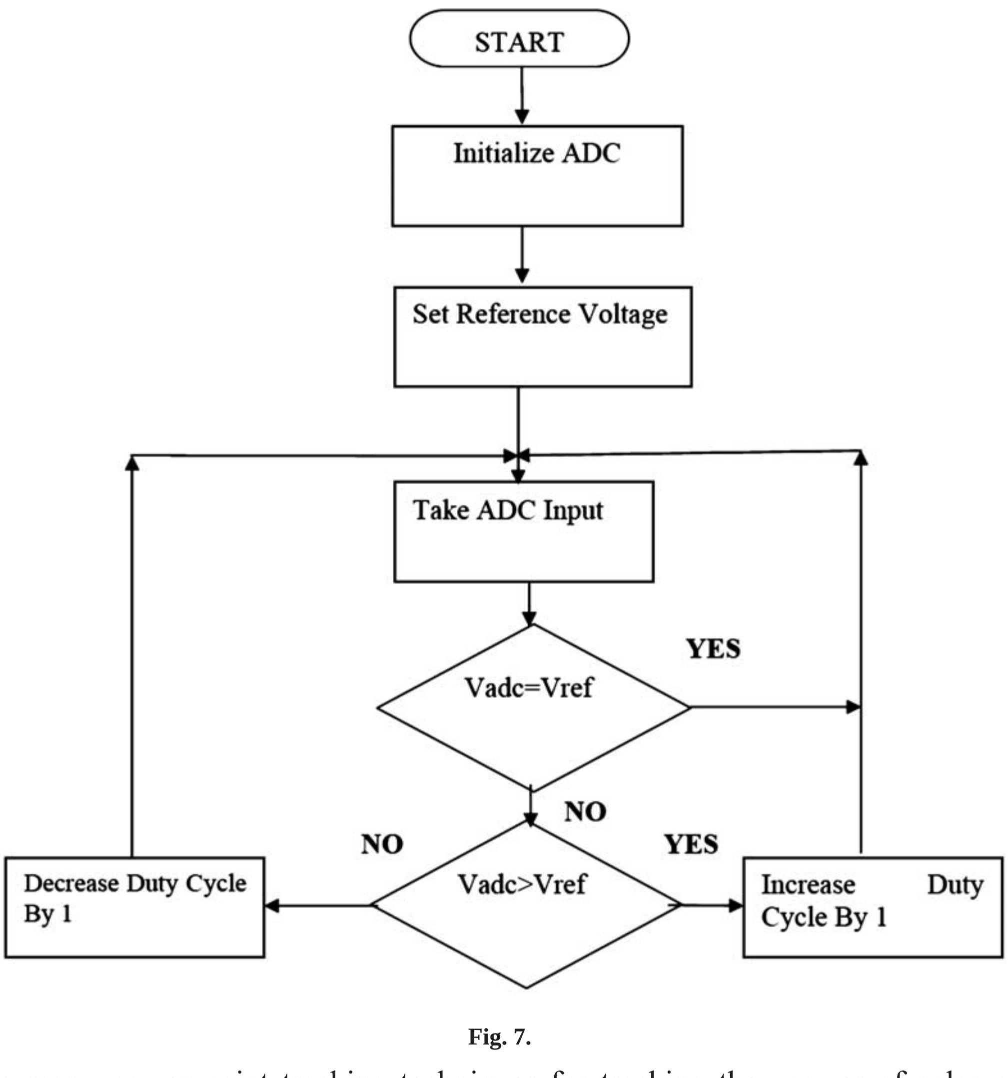


Fig. 7.

There are many power point tracking techniques for tracking the power of solar pv array, The techniques are Incremental conductance Algorithm, P&O algorithm, Artificial neural network, Particle swarm optimization, Adaptive Neuro fuzzy inference system fuzzy based MPPT, Genetic Algorithm, Open circuit voltage method , Short circuit current method, Type2 based MPPT, Type2 fuzzy based MPPT, Type2 neuro fuzzy based MPPT among these MPPT techniques we are chosen Open circuit voltage method for MPPT tracking because this method has less complexity and easy implementation. The open circuit voltage method operation is based on the Vmpp, it has linear relationship with open circuit voltage Voc for different temperature and irradiation values. These method estimate the voltage Vmpp by measuring the Output of Open circuit voltage of solar PV panel/Array

4. EXPERIMENTAL RESULTS

The proposed configuration of solar PV array fed Four Switch Buck-Boost Converter shown in Fig.1are designed and developed, simulated using MATLAB/Simulink. The behaviors of the proposed system studied through simulated results. As shown in Fig. 8-11 the proposed system exhibits a very good performance under the various possible working conditions as described. The Open circuit voltage maximum power point tracking system can generate the switching pulses by comparing the reference voltage with PV panel output and it can increase /decrease the duty ratio of switching pulses.

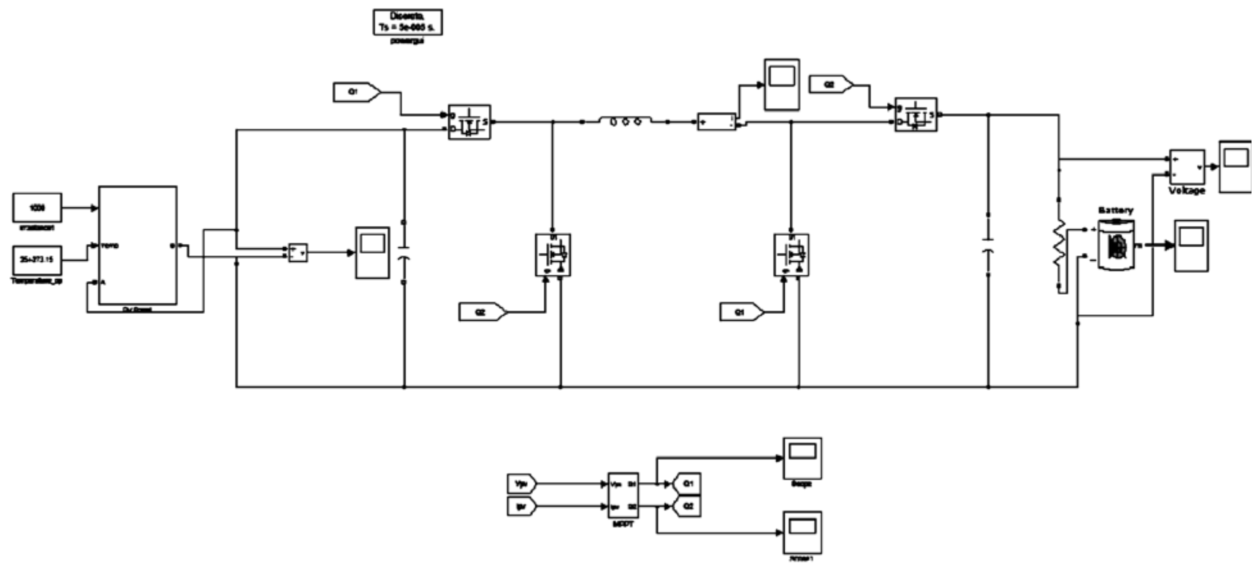


Fig. 8. Mat lab model of Solar PV array fed Four Switch Buck-Boost Converter

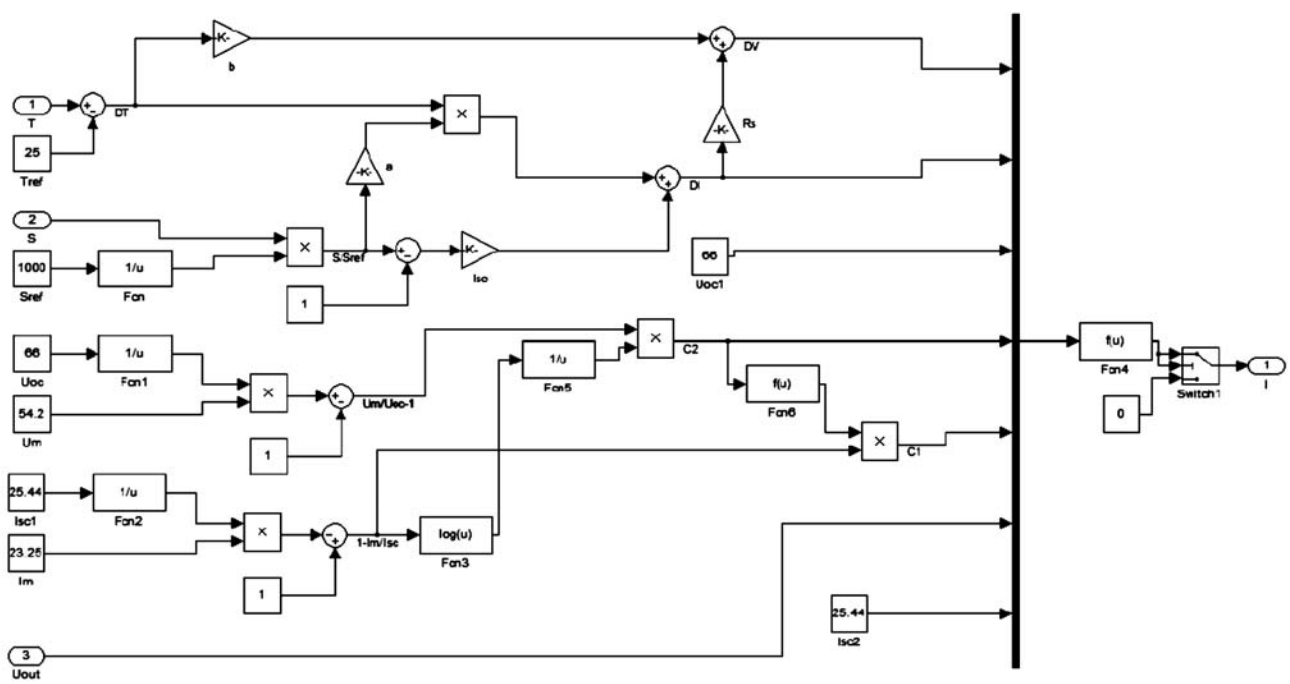


Fig. 9. Solar PV model

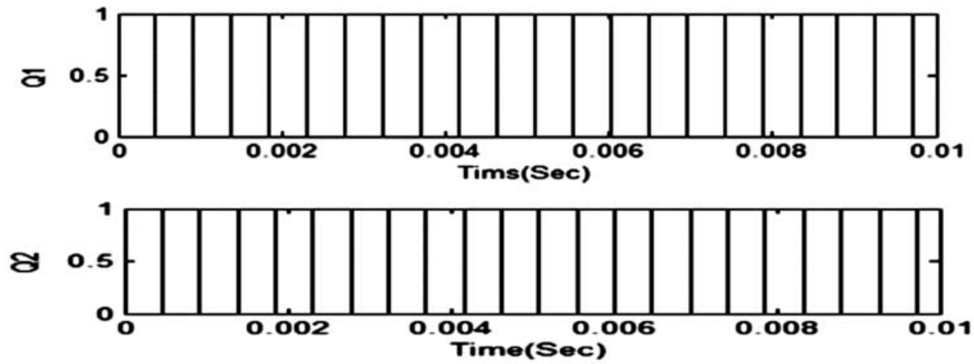


Fig. 10. Gate Pulses.

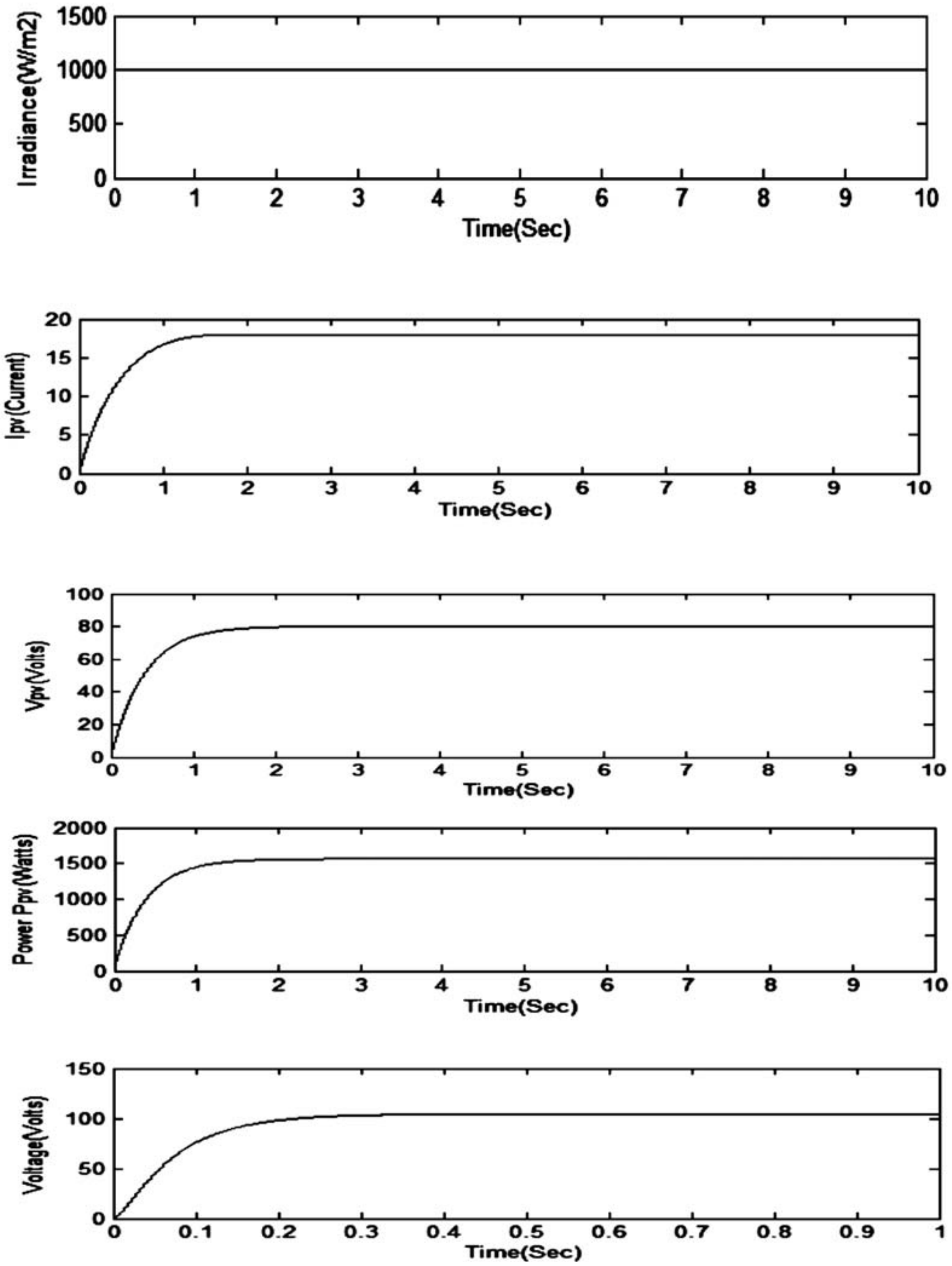


Fig. 11. Performance of Solar PV array fed Four switch Buck-Boost converter at 1000 W/m2, Solar PV array , FSBB Converter Variable.

5. APPENDIX

A. Parameters of proposed Solar PV Array

Open circuit voltage of panel, Voc = 109v; Short circuit current of panel, Isc = 20A; Maximum Power of PV, Pmpp = 1.5KW; Voltage at Maximum power point Vmpp = 83.33V; Current at Maximum power point, Impp = 18; Number of cells connected in series, Nss = 60; Number of modules connected in series, Ns = 8; Number of modules connected in parallel, Np = 6.

B. Parameters of Four switch Buck-Boost Converter

Input voltage, Vdc = 85-320V; Output voltage, Vout = 110V; Switching frequency, Fsw = 5KHZ; Input Capacitor, C = 0.5μF; Output Capacitor, C= 500μF; Inductor, L = 50mh

6. CONCLUSION

The performance of the proposed solar PV array – fed Four Switch Buck-Boost Converter has validated. The Maximum power available from the solar PV array has been fully utilized by using Open circuit voltage Maximum power point tracking to acquire an efficient operation of the Converter. The characteristics of Four switch Buck-Boost converter made it suitable for solar applications. Among the all working conditions the converter fixed at single working point to found the best efficiency which can be obtained when the converter working like pure Buck Converter or pure Boost Converter. The Open circuit voltage Maximum power point tracking system is generated the pulse required for the converter for its operation , The proposed system seems to be useful for generating solar power to the LHB Coach applications like Tube lights, Fans, Mobile Charging Sockets, Emergency Lamps.

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