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Design of DC-DC Boost Converter for Solar Powered Electric Vehicle

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ABSTRACT

With ever increasing energy consumption, global warming and consequent climate change concerns, there has been increased attention towards the design and implementation of electric and hybrid electric vehicles. This project discusses the design and implementation of a DC-DC converter for solar powered electric vehicle. P & O MPPT algorithm is employed to extract optimum power under varying atmospheric conditions. The simulation is carried out in MATLAB environment and the results validate the design of the converter for solar powered electric vehicle. The hardware implementation of the prototype has also been carried out and the results are validated.

Keywords: Solar arrays, MPPT, BLDC motor, Boost converter, Inverter, Pulse width modulation

I. INTRODUCTION

Solar energy is a renewable energy which is available abundant in nature. With ever increasing energy consumption,global warming and consequent climate change concerns, both Government as well as Industries globally are heavily pitching for the implementation of electric and hybrid electric vehicles[1-2]. Electric vehicles are preferred because of their cleanliness. Since they operate free of fossil fuels, the environment is free from pollution. The EV also has fewer moving parts, compared to the conventional vehicles, thus making them more efficient and easier to maintain. The cost for charging an EV is also comparatively less.

The main objective of this work is to develop a DC-DC converterfor a solar powered electric vehicle. The project aims towork on a hybrid energy management system which consists of both PV and battery. Lithium-ion battery is used as an auxiliary source. The inputfrom the PV Array is fed to the DC-DC Boost converter. MPPT algorithmis used to track the maximum power from the panel. The output of theconverter is fed to the load which is driven by a BLDC Motor Drive.. Thehardware implementation of the prototype is carried out by connecting thePV Array, Boost Converter, Inverter and the motor load.

II. PROPOSED SYSTEM

The figure1 describes the block diagram of the proposed system. The system consists of two sources PV Array and Li Ion battery as auxiliary source. The PV Array output is connected to the DC-DC Boost Converter through MPPT algorithm in order to obtain maximum power from the panel. By means of a switch, the panel and battery is operated accordingly. The boosted output is given to the inverter, which is connected with the electronically commutated BLDC Motor load.

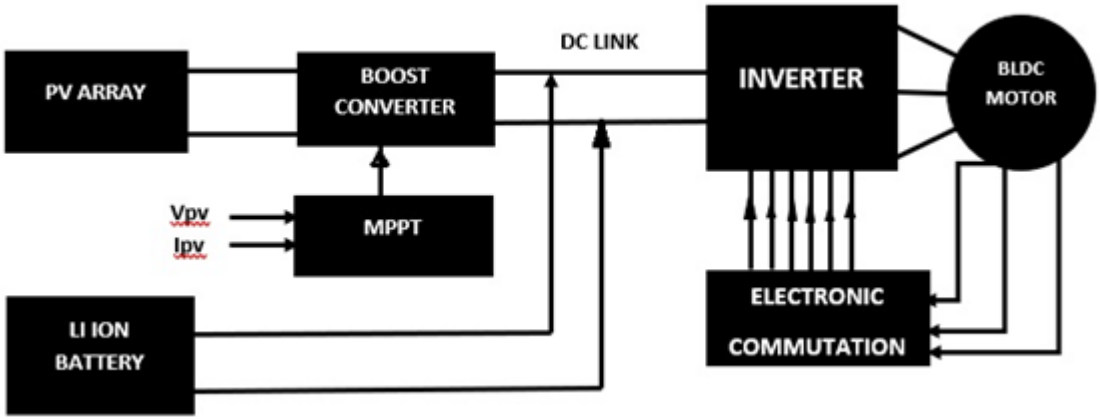

FIGURE 1. Block diagram of the proposed system

2.1 DC- DC Boost Converter

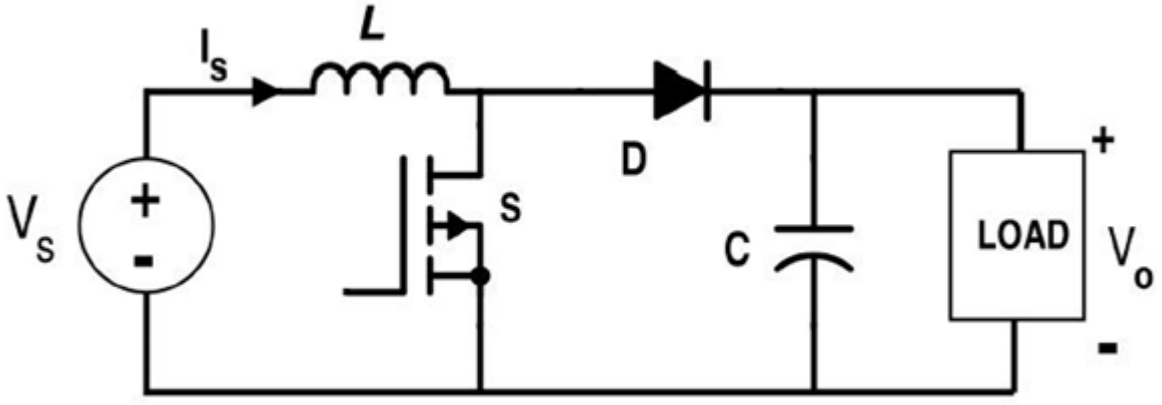

FIGURE 2. Boost Converter Circuit diagram

DC-DC Boost Converter is a power converter circuit that steps up the input voltage. MOSFET is used as a switch as it has very high switching speed and it is capable of handling high currents. The values of inductor and capacitor is obtained using the design equations as discussed below. The value of duty cycle for our application is assumed to be 50%.

- $D = 1 - \frac{Vi}{Vo}$
- $L = \frac{Vi \times D}{\Delta I_l \times f_s}$, where $\Delta I_l = \frac{(0.2 \text{ to } 0.4) I_o V_o}{V_i}$
- $C = \frac{I_o \times D}{f_s \times \Delta V_o}$

Using these formulae, the values are calculated for both best and worst case as the power from the solar is varying. After the calculations, the simulation is done in MATLAB.

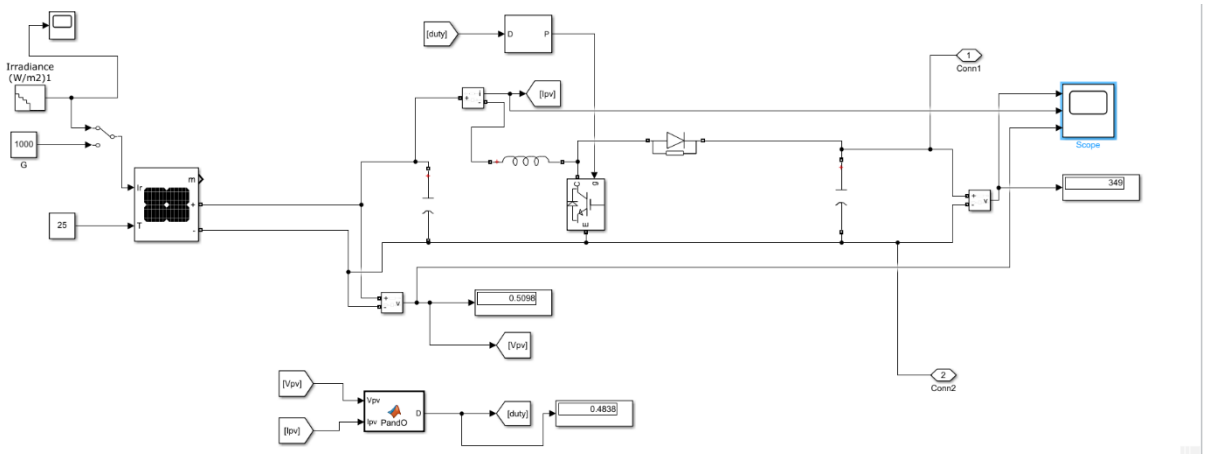

FIGURE 3. Simulation of Boost Converter with variable irradiance and MPPT Control

The boost converter is simulated for the calculated values of inductor and capacitor. Variable irradiance is provided as input and the converter output is improved using the MPPT Algorithm. The below figure 4 describes the simulation results, which is proven to have reduced ripples and hence better power supplied.

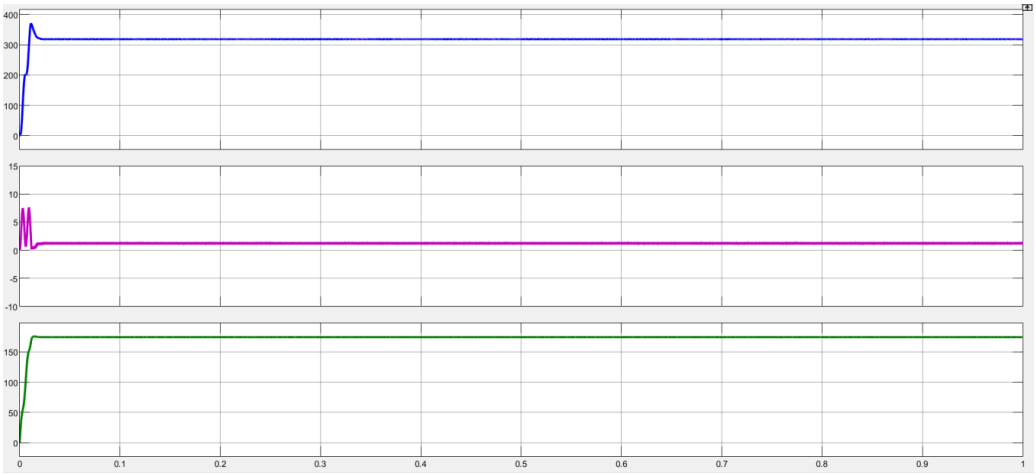

FIGURE 4. Simulation results with MPPT implemented

The plot shows the PV Input Voltage, Current and the Output Voltage after MPPT (P&O) algorithm is implemented.

III. RESULTS AND DISCUSSION

The overall simulation results are obtained by integrating battery source with the solar powered Boost Converter. The hybrid system can offer some definite advantages for electric vehicles, namely the higher fuel economy due to the increase of on-board renewable energy, the better energy security due to the use of multiple resources, and the higher control flexibility.

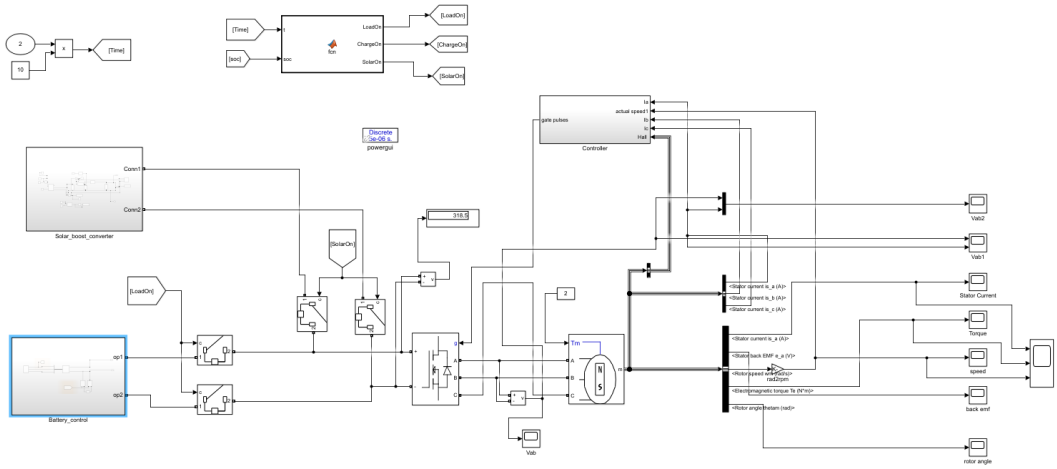

FIGURE 5. Overall Simulation Results

Battery control block is provided with switches to ensure correct usage of battery.

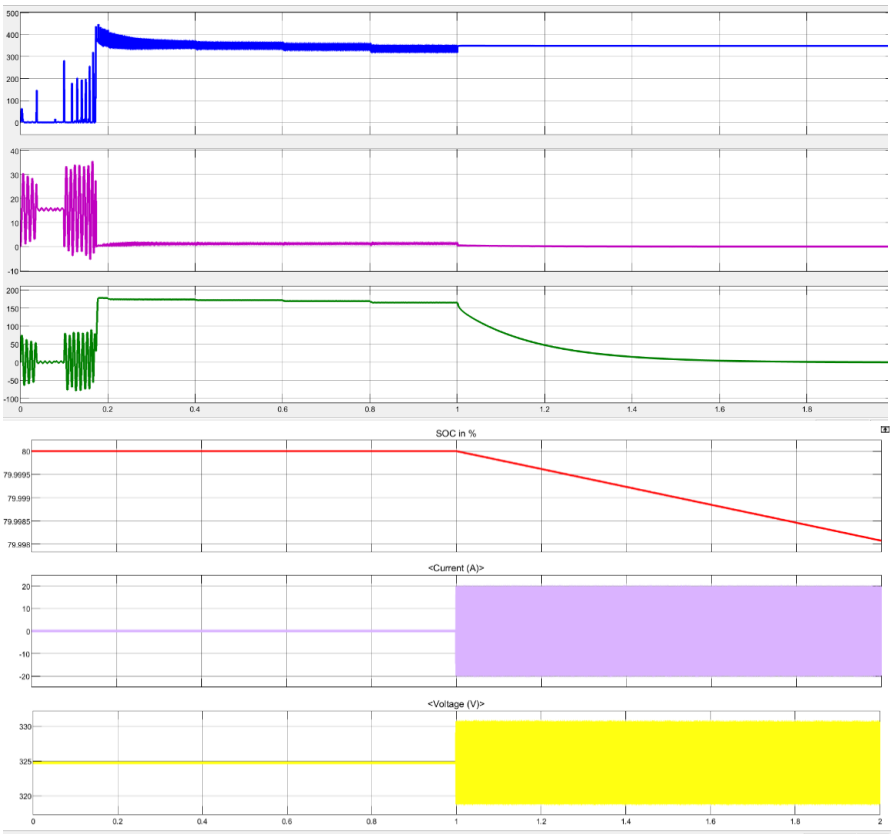

FIGURE 6. Energy Management

The diagram describes two conditions in which the first state is assumed to be day and hence powered by solar energy. The next state is assumed to be night, hence battery supplies energy.

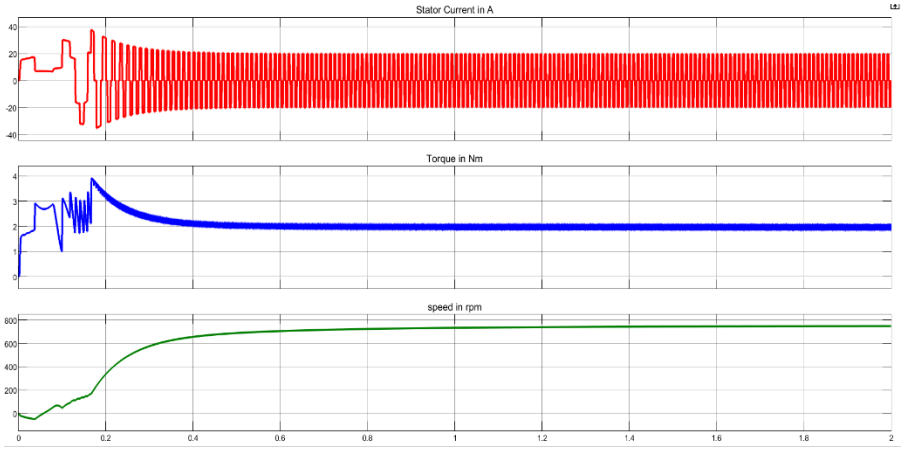

FIGURE 7. Motor Characteristics

After successful simulation, the stator current, torque and speed of the motor is obtained, thus experimentally verifying the simulation.

IV. HARDWARE IMPLEMENTATION

A prototype of the above proposed system is implemented through hardware. The circuit consists of a 20W PV panel which is connected with the boost converter. The output from the converter is given to the inverter fed BLDC Motor, which is an electronically commutated load. The panel supplies 12V and it is boosted to a value of approximately 24V. A multimeter is used at the inverter terminal to verify the output voltage and then the motor is connected.

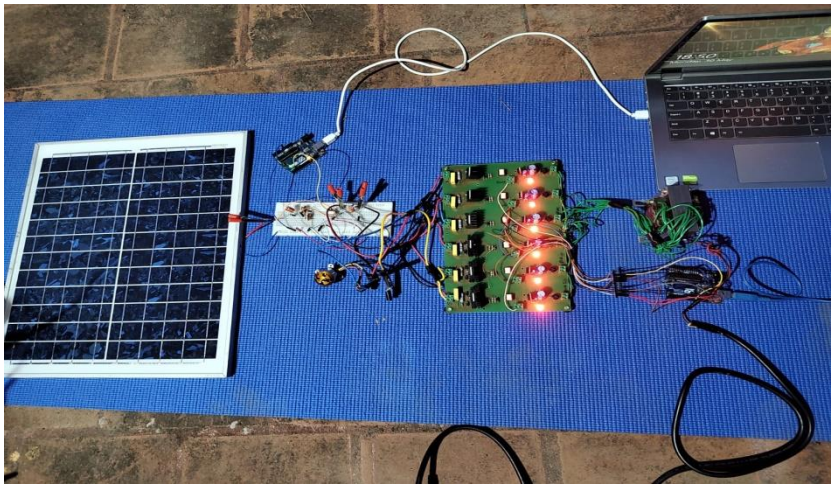

FIGURE 8. Prototype Implementation

The BLDC Motor has a maximum speed of 1000 rpm and it is observed to operate at a high speed, thus experimentally verifying the working of the above prototype model.

V. CONCLUSION

A PV-powered EV with BLDC motor drive for a three-wheel EV is designed and simulated in this work. The inclusion of PV source helps to increase the range that the vehicle can travel. The P&O MPPT algorithm ensures maximum power is extracted from PV array. The DC-DC boost converter acts as a suitable interface to the drive. Simulations were carried out in MATLAB/Simulink environment to verify the effectiveness of the proposed model with modelled system components of three wheeled light electric vehicle. The hardware implementation of the prototype was also carried out and the results were obtained. The results indicate the effectiveness of the proposed design for EV with hybrid energy sources.

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