Control of Solar Powered Electric Vehicle Using Closed Loop Boost Converter

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With the steep rise in new technologies in the field of digital communications and sensors, Mechatronics have availed us in coming up with new innovative designs for more sustainable physical systems. The forefront of all is the development of the electric vehicles to stop the carbon emissions from IC engines used in these days. In this proposed paper, we have designed a vehicle system using Incremental Conductance Algorithm and a Closed Loop Boost Converter and supported by a backup battery system.

Keywords: Solar Powered Electric Vehicle, Incremental Conductance, Closed Loop Boost Converter, BLDC Motor, Backup Battery System

I. INTRODUCTION

Due to increasing levels of greenhouse gases in the atmosphere, partially as a result of human industrial activity, progressively more heat is being trapped, resulting in a phenomenon commonly referred to as global warming. To stop the carbon emission, the use of green and clean energy such as solar, wind, hydro, and etc are enforced. Their use has opened a new alley in utilizing the green energy to provide power to the grid as well as, to the rural area in the form of decentralized grids. The other major contributor to air pollution is the emission from petrol and diesel cars. To stop these emissions, the use of electric vehicles has surged these few years. With every major automobile companies researching on the development of a better system, a new concept of solar cars have also been taken into consideration. Using solar energy directly to drive a vehicle has been heavily researched. The proposed study puts forward a system design that utilizes solar energy to directly drive the motor of the car and to charge a battery system which will provide backup system in absence of sunlight and during night time. Major techniques have been used are, for MPPT we have used Incremental Conductance Method, as well as, we have used closed Loop Controlled Boost Converter and BLDC motor drive using the commutation logic to drive the rotor. This study puts forward a unique system that utilizes solar energy and battery system together for a better performance.

II. PROPOSED SYSTEM DESIGN

The proposed design of the system is shown in Fig. 1

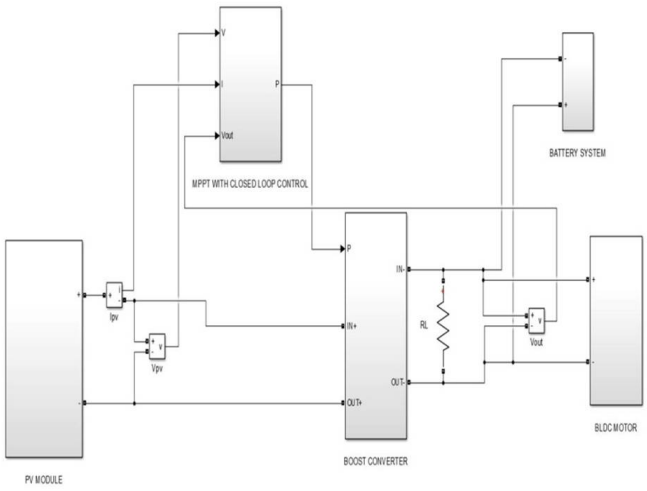

FIG. 1: The proposed design of the system.

III. INCREMENTAL CONDUCTANCE

For our proposed system design, we have used incremental conductance algorithm where it provides numerous advantages among all types of MPPT algorithms. MPPT is referred to Maximum Power Point Tracking which is an electronic system that provides mechanical tracking or extraction of maximum power from a PV module under certain conditions like solar radiation, ambient temperature and solar cell temperature. This technique is used to improve the efficiency of the solar panel.

This algorithm have been used because of its improved efficiency, improved tracking system, sustained system with no frequent collapse of PV power, increased running time and also played a major role in popularizing solar power.

This method uses two voltage and current sensors so that to sense the output voltage and current of the PV module. Here, at MPP the slope of the PV curve is zero.[1]

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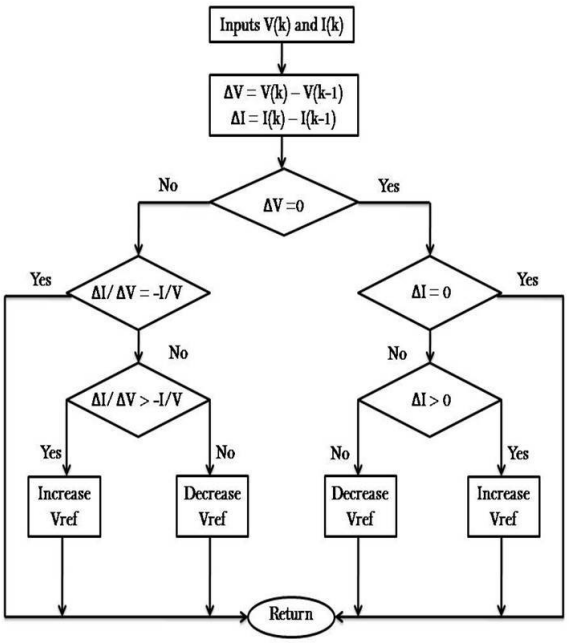


FIG. 2: INC Flowchart.

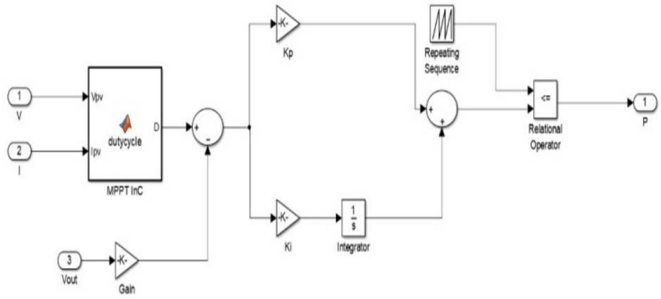


FIG. 3: Boost Converter.

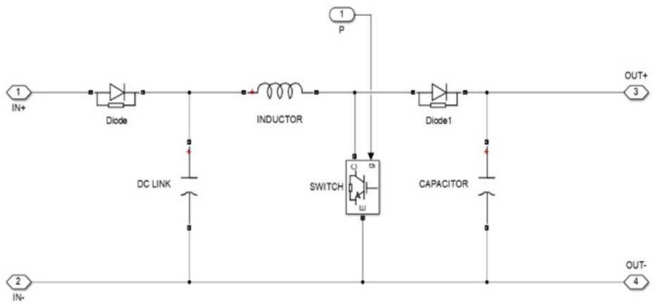


FIG. 4: Closed loop controller for boost converter.

IV. DC-DC CONVERTER

For our proposed system design, we have used closed loop boost converter. A boost converter is a power electronic device which generally increases the DC input voltage at its output side. A closed loop system is implemented so that the output voltage is maintained constantly by obtaining the feedback of the loop. So, a closed loop boost converter is used to obtain a constant DC output voltage which is also determined by duty cycle and switching frequency of the IGBT used in our model. In this process, the output voltage is compared with a set of voltages from where the error value is obtained by the help of a PI controller which is being connected in series with the boost converter. The basic operation is if the error value is positive then the duty cycle is reduced and when the error value is negative the duty cycle is increased so that the output voltage is made to constant. After manipulation, the error value is reduced by controlling the switching pulse i.e. tuning is being done in the PI controller by the use of Zeigler-Nicholas method.

So, the output voltage varies within in the range of +10% to -10% in the system. Hence, the use of closed loop boost converter helps to minimize the variations of the value for better voltage output as well as overall performance.

A DC capacitor link is connected parallel with the MPPT controller unit to provide a low impedance path for high frequency switching currents which results to provide stable voltage.[2]

V. BLDC MOTOR DRIVE

For our proposed system design, we have used BLDC motor(in-runner type) using commutation logic in which the logic consists of two methods namely hall signal decoding and gate signal for switching pattern. This motor have been chosen also for its various advantages as they are suitable for high power density design approach which includes traction characteristics like high starting torque, high efficiency around 95-98%, etc. They are maintenance free, smaller and lighter, longer life, less noise during operation, greater dynamic response, internal air flow mechanics is constructed within the motor and can also be accelerated or decelerated easily. This is the reason why BLDC motors is being widely used and the most preferred motors used in electric vehicle applications due to its high traction characteristics.

So to drive the BLDC motor, commutation logic has been implemented. This logic is a control algorithm that makes the use of hall sensors for its control of three phases a, b and c for the rotation of the rotor. This logic results to produce the gate pulses for the three arms of a inverter accordingly to the phases a, b and c and helps them to energize. The stator winding is divided into six sectors based on the angles of the stator winding. Hall sensors are placed on the stator windings and with the position of the rotor it senses the according sector and sends signal for the switching.[3]

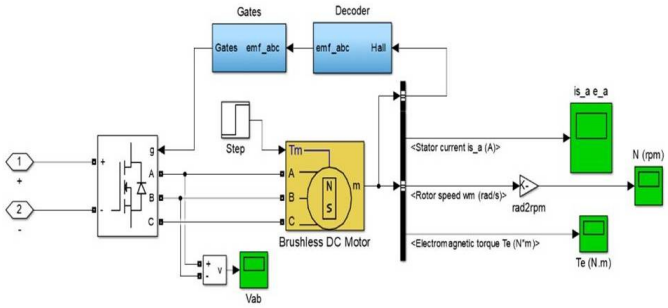


FIG. 5: BLDC motor drive system using commutation logic.

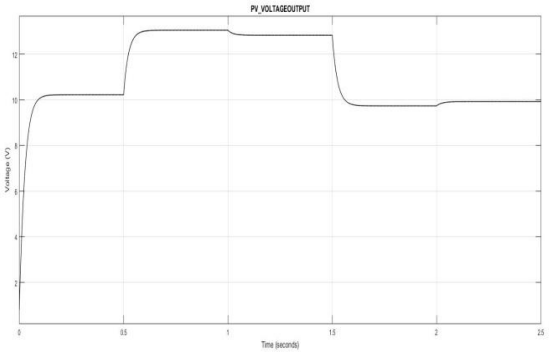
VI. BATTERY SYSTEM

Battery system used here is to overcome one of the main problems that is powering the vehicle during the absence of solar energy. We had to use a bi-directional converter in conjunction to battery and boost converter to keep track of the moment of solar energy not in use. We have selected the battery type Lithium-Ion type which have increasingly being popularized in the field of energy storage system for electric vehicles.

VII. SIMULINK RESULTS

The simulink results are shown in the output voltages of the solar pannel, output voltages of the boost coverter and motor speed curve.

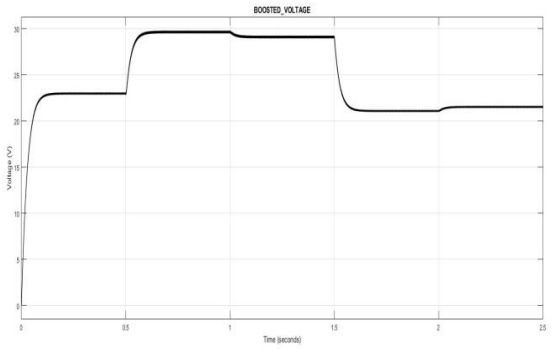
OUTPUT VOLTAGE OF THE SOLAR PANEL



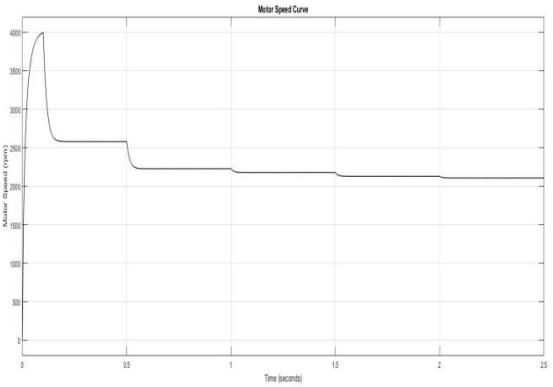
VIII. CONCLUSION

This project is devoted to pursuing system solutions to the current race in developing an efficient and usable system for solar cars. It has been proved that a BLDC motor can be driven with a constant speed if control algorithms and feedback loops are implemented. The research shows all the characteristics of every part of the

BOOST CONVERTER OUTPUT VOLTAGE



MOTOR SPEED CURVE



design separately to show the exact working of the system. The output of the motor show high efficiency and the systems works accurately.

The mean output voltage of solar panel came out to be 11.06V and the mean output voltage of boot converter came out to be 24.63V. The speed curve shows a slight hike in rpm during starting of the motor and then it became constant.

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