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DESIGN AND IMPLEMENTATION OF DC-DC BOOST CONVERTER FOR BLDC MOTOR DRIVEN HYBRID VEHICLE

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Abstract:

A 'fuel-electric hybrid car 'or' hybrid electric vehicle' is a vehicle which depends on not only on batteries but also on an internal ignition engine which drives a generator to provide the electricity and may also drive a wheel. It has great benefits over the previously used petrol engine that drives the power from gasoline only. It also is a major foundation of air pollution. The objective is to design and formulate a three-wheeled hybrid electric vehicle powered by both battery and gasoline. The grouping of both the power makes the vehicle energetic in nature. It provides its dealer with advantages in fuel budget and ecological impact over conventional automobiles. A hybrid electric vehicle combines a solar panel, charge controller, battery and electric motor with an internal combustion engine to achieve better fuel economy and reduce poisonous releases. The battery alone provides power for low-speed driving circumstances where internal combustion engines are least efficient, in Hybrid Electric Vehicle. In rushing, long highways, or hill climbing the fuel engine can be used. Besides it also uses the concept of regenerative braking for improved utilization of energy. Energy degenerate during braking in Hybrid Electric Vehicle is used for charging the battery. Thus the vehicle is best suitable for the growing urban areas with high traffic flow.

Initially, the designing of the vehicle is done, simulations of the converter and other models are done. Equipment and their cost analysis are done. It deals with the fabrication of the vehicle. The next phase consists of implementing the electric power drive and designing the controllers. The last stage would consist of increasing the efficiency of the vehicle in economic ways.

Keywords: Solar panel, BLDC Motor, The boost Converter, Speed controller.

Introduction: This paper describes the usage of solar energy to power up the vehicle. The output of the solar panel is not effective to drive a vehicle. So to maximize the output of the solar panel boost converters and batteries are been used [1]. The electrical charge is combined from the PV panel and directed to the output terminals to produce a low voltage. The charge controllers direct this energy acquired from the solar panel to the batteries [2,3]. According to the state of the battery, the charging is done, so to avoid overcharging and deep discharge. The voltage is then boosted up using the boost converter, ultimately running the BLDC motor which is used as the drive motor for our vehicle application [4]. In the course work, the characteristic features of the components; solar panel, battery, charge, boost converter and BLDC motor, fuel engine were required for the vehicle application [5]. They have been modeled separately using MATLAB/SIMULINK and the complete hardware design of the system is tested to meet up the application's requirement [6].

1. Design of hybrid vehicle:

This is one of the possible ways of the block diagram of the hybrid vehicle.

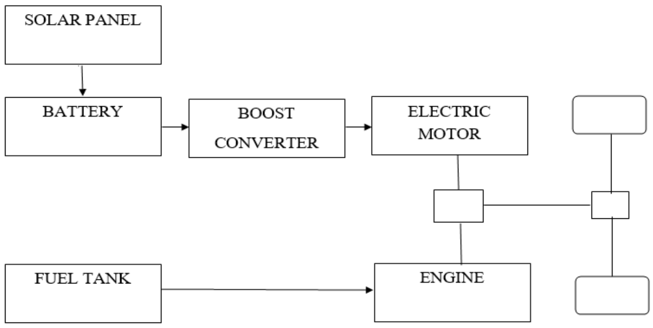


Fig1: Main components of hybrid vehicle.

The hybrid vehicle has characteristics of both the electric vehicle and Engine vehicle. At low-range speed, it runs as an electric vehicle with the battery delivering the drive power. At high-range speeds, the engine and the battery work together to satisfy the drive power demand. The sharing and the distribution of power between these two sources are key determinants of fuel efficiency.

2. Cost analysis:

Comparative cost analysis of EV and Fuel operated the vehicle is done. For this work, a Bajaj three wheeler auto rickshaw is referred as a fuel vehicle for comparison.

a) Fuel vehicle: Bajaj three wheeler Vehicle power: - 800W

b) Passenger capacity: - 4

c) Average:- 24-35KM/lit

Hence from the available data and considering the cost of fuel as 75rs/lit, it charges of Rs 2.54/ KM.

Table 1: shows year wise cost analysis.

ITEM	Fuel Vehicle	Solar EV
Vehicle Cost	Rs 1,50,000/Yr.	Rs 50,000/yr.
Solar Cost	00/-	60,000/-(one-time investment)
Running Cost 90Km/day	2.54 Rs/km, Rs 83439/Yr.	00/-
Maintenance Cost	Rs 10,000/Yr.	Rs 1000/year
Total Rs	2,43,439/Yr.	Rs 1,11,000/ Yr.

3. Acquiring power from the sun:

The first part of this paper deals about how to acquire the power from the sun, and there on to recharge the battery. The second part deals with using the power from the battery in running and controlling the motor.

The rating of the components required for this work is completely based on the motor which is to be used for the application. We are using the 1200Watts (48V) BLDC motor for our application. According to the rating of the motor, the other components are selected. Four batteries of rating 12V/42Ah connected in series to drive the BLDC motor through the batteries. In this work, four Amaron 12V/42Ah batteries are connected in series. After selecting the batteries, the solar controller and the solar panels are to be selected. The complete steps of this work is represented in the schematic diagram in Fig 2.

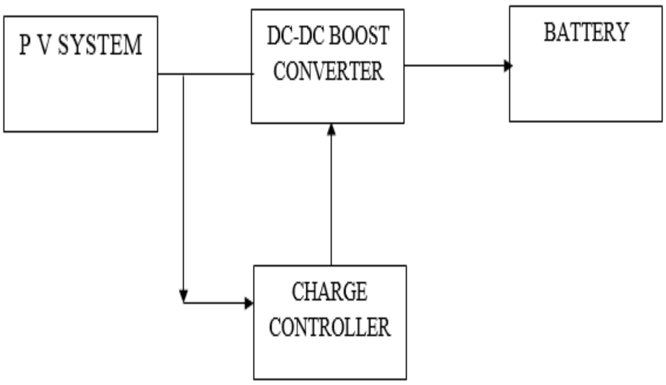


Fig 2: Block diagram of system

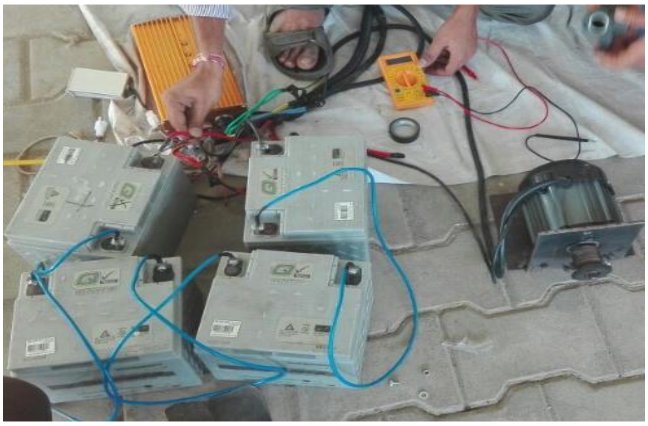


Fig3 Acquiring power from the sun

Charge Controller limits the rate at which electric current is added to or drawn from the electric batteries. The prime purpose of using the Charge Controller is to prevent against overcharging and deep discharging of a battery. For the 12v/42Ah battery, 12v/20A charge controller is the good choice.

4. Power from batteries to motor:

In the next stage of the work is to drive the BLDC motor using batteries. In this phase, the detailed study of the motor is done. The specification of the BLDC motor is given in Table. From the specification, it's well understood that the required voltage to run the motor is 48V, while the rated voltage of a single battery is 12V.Thus to achieve the rated voltage of the motor; we are in need of four batteries which when connected in series can satisfy the requirement. In order to make it cost effective, two batteries were connected serially, giving 24V as the output voltage. This 24V from the serially connected batteries are then boosted to 48V using the boost converter.

Table 2: Specification of BLDC motor:

Power	1200 watts
Rated voltage	48volts
Rated current	20amps
speed	3,500 rpm

Direct Current (DC) converters can be used as switching-mode regulators to convert a DC voltage, normally unregulated, to a regulated DC output voltage. The switching device is normally BJT, MOSFET or IGBT. The electrical circuit of the boost converter is shown in Fig. The input voltage 12V is been given as the input for the boost converter, which is boosted up to 48V. The simulated output (MATLAB/Simulink) of the boost converter is shown in Fig 4.

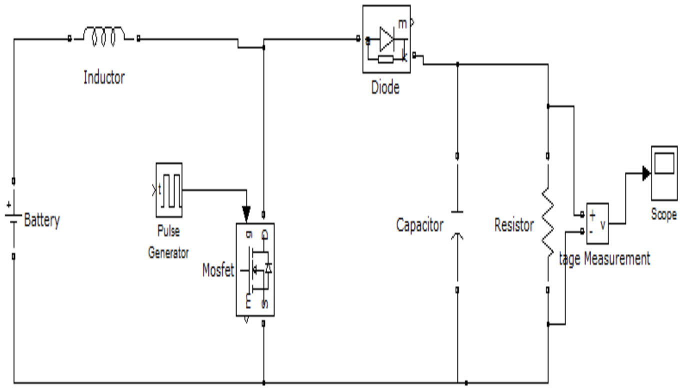


Figure 4: boost converter circuit.

The mathematical modeling for boost converter is shown in fig.5

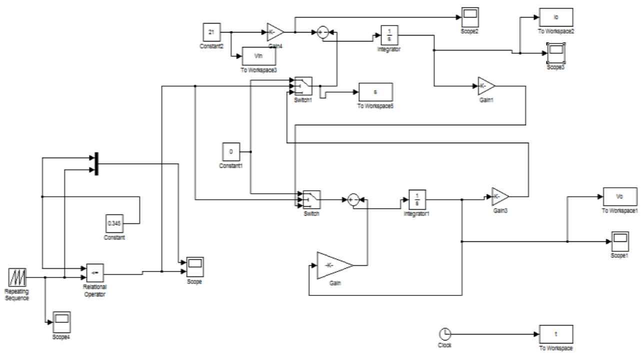


Figure 5: The mathematical modelling of the boost converter

5. Calculations for Mathematical modelling of Boost converter

$V_{in} = 12v$

$I_{in} = 1A$

$D = 0.7$

$P_{in} = 12w$

$Vo = \frac{1}{1 - D} * V_{in}$

$Vo = \frac{1}{0.3} * 12$

$Vo = 40v$

$\eta\% = 95\%$

$Pout = \eta * Pin$

$$\mathbf{Pout}=\frac{95}{100}*12=11.4w$$

Design of L and C:

$$L=\frac{Vin*dt}{di} \quad (dt=D*ts)$$

$$L=\frac{12*0.7*\frac{1}{1*10^{\wedge}3}}{\frac{1}{100}*1}=840mh$$

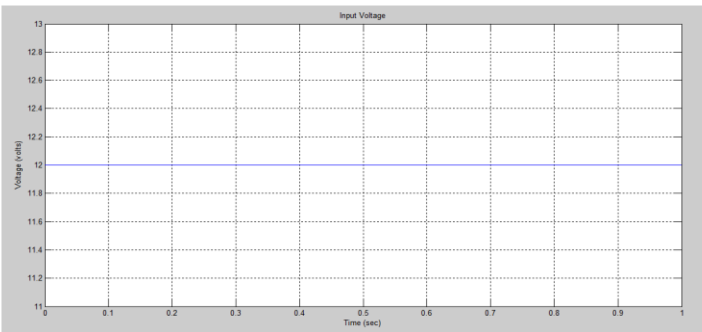
$$C=\frac{ic*dt}{dv}$$

$$C=\frac{0.285*0.0007}{\frac{40}{100}*5}=99.75\mu f$$

The hardware design part of boost converter involves a lot of accuracy in choosing the inductor. The input voltage given to the boost converter varies from 10V to 11.5V, while the output of the converter is fixed 48V.The switching frequency of the boost converter is 20 KHz. The design specification for the boost converter is as follows

Table 3: Boost converter parameters

Input voltage	12
Output voltage	48
Switching frequency	1khz
Duty cycle	0.7



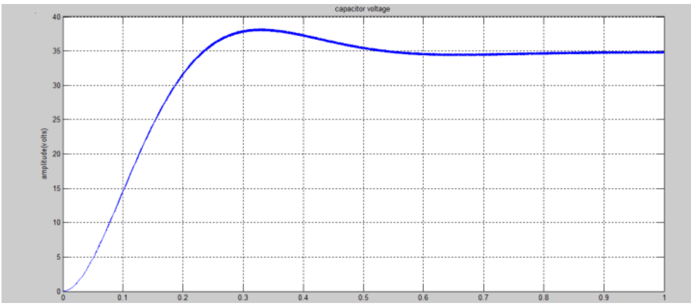


Fig 6: Input and output voltage of boost converter.

The switching diode used in the boost converter have to withstand a reverse voltage equal to the output voltage of the circuit and have to conduct the peak output current. A suitable diode must have a minimum reverse breakdown voltage greater than the output voltage of the circuit. Schottky barrier diodes are often used. The current supplied to the output RC circuit is discontinuous. Then a larger filter capacitor is required to limit the output voltage ripple. The filter capacitor has to provide the DC output current to the load when the diode is in off condition.

In a boost converter, the output voltage is greater than the input voltage. The boost converter required for the Solar Powered BLDC Driven Electric Vehicle needs 12V (from batteries connected in series) to 48V (required rated voltage of BLDC motor).Fig 9 shows the designed boost converter for the vehicle application.

6. Motor operation:

The Brushless DC motor is used as the drive motor for the vehicle. It is a permanent magnet square wave motor. BLDC motor uses feedback of the rotor angular position; the input armature current can be switched among the motor phases in exactly synchronized with the rotor flow of motion. The description of the BLDC motor is given in fig. The reason for choosing the BLDC motor is because of its efficiency and reliable operation, dynamic response and high torque to the weight ratio.

BLDC motor is a closed loop synchronous motor. It has all the characteristics of DC Motor with some added features. It advantages are;

1. It is cheap.

2. It can save 30% to 50% of the power consumed by a normal motor and the efficiency of 80% to 90%.

3. It is small in size. It can have high torque at low speed.

4. Speed range can be customized

5. Replace the AC and frequency equipment, minimizing harmonics introduction to the circuit.

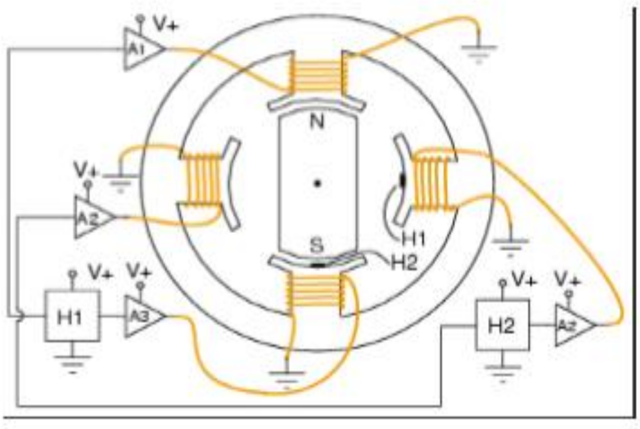


Fig 7: Diagram of BLDC motor

Fig 8: BLDC motor.

7. Combination of system:

The complete integrated setup consists of the solar panel, solar charge controller, batteries, boost converter and finally the BLDC motor. The schematic diagram of the complete setup is shown as in Fig 8.

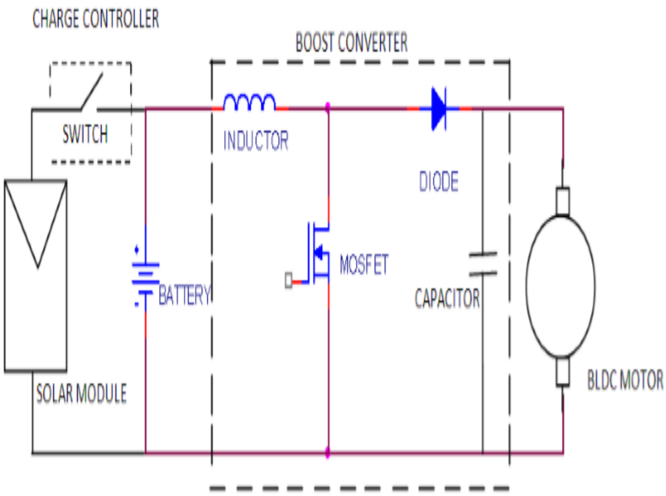


Fig 9: Combination of system.

It is noted that the input voltage of the boost converter from the batteries keeps decreasing since the battery discharges with respect to time, on the other hand, the batteries are also been recharged using the solar modules. The discharge rate depends on upon the load. We can observe the whole flow of the system. It is observed that the solar module charges the batteries, from the batteries connected in series, it is boosted to 48V to meet the required voltage of the BLDC motor. It is noticed that the 0.9A current values are halved to 0.45A when it through the boost converter. And finally, the motor current keeps increasing the speed of the motor is increased.

8. Petrol drive and its components:

Here in this project, we used a 150 CC petrol engine as other option for fuel engine. In accelerating, long highways, or hill climbing this engine can be used, or in case there is no charge in battery this engine can be used.

Table 4: Specifications of fuel engine:

Engine type	Single cylinder four stroke
Power	9hp(6.6kw) 700rpm
Torque	10.35Nm
Clutch	Multiplane
Cooling system	Air
Gear Box	4-speed
Fuel system	Carburettor
Driveline	Roller chain

9. Solar powered vehicle prototype:

Fig : 10 Integration of entire part of system.

The integration of the whole system evolves as the Solar Powered BLDC Motor Driven Electric Vehicle. The prototype of the vehicle as shown in Fig11, was designed with forward and backward movement, which was able to achieve a speed of 42 Kmph.

Fig 11: Prototype of hybrid electric vehicle.

10. Conclusion:

The Hybrid electric vehicle is a vehicle that uses two sources of power- petrol and battery. For low power application, battery drive is used whereas for high power application where power requirement is very high petrol engine is used. Petrol engine drive is most efficient at the high-speed drive. Thus, Hybrid Electric Vehicle's both mode of operation occurs at their maximum efficiency. But in the petrol engine, low speed operation is not suitable and not efficient. Its high-speed mode is only efficient. Therefore, it gives twice the mileage that is given by a normal vehicle. As this hybrid vehicle emits 50% less emission than the normal vehicle, it plays a vital role in reducing the pollution to a certain extent, without compromising with efficiency. It is most efficient and commonly used in urban areas mainly in high traffic. Whereas fuel engines are least efficient as the energy from fuel is being wasted away and creates the pollution**.** Even the input voltage given to the boost converter varies from 10V to 11.5V, while the output of the converter is fixed to 48V. Thus, the boosting of voltage needed for the motor can be achieved through this boost converter.

11. Contribution of project:

Currently, the society mostly uses petroleum as the major source for vehicle propulsion. The electric vehicle is not very efficient for all power conditions, that is it cannot provide maximum power for high-speed conditions. Through this project, a method of hybridization in vehicles is projected which utilizes the efficiency of both the IC engines and motor. This method is implemented in three-wheeled vehicles that are mostly preferred and used by the public. Through a proper manufacturing and cost analysis can make the vehicle a major breakthrough.

References:

1. Muhammad H.Rashid (2004), Power Electronics circuits, devices, and applications, Third edition, 2004, ISBN 81297-0229-0, pp.166-225.

2. Shrivastava, Nishtha, and Anil Brahmin. "Design of 3-Phase BLDC Motor for Electric Vehicle Application by Using Finite Element Simulation." International Journal of Emerging Technology and Advanced Engineering 4.1 (2014).
3. Alphonse, Immanuel, Hosimin Thilagar, and F. Bright Singh. "Design of solar powered BLDC motor driven electric vehicle." International Journal of Renewable Energy Research (IJRER) 2.3 (2012): 456-462.
4. Dakshina M. Bellur and Marian K. Kazimierczuk, “DC-DC Converters for Electric Vehicle Applications”, 2007 IEEE, pp.286-293.
5. Fenton, John, and Ron Hodkinson. Lightweight electric/hybrid vehicle design. Elsevier, 2001.
6. C. C. Chan.”An Overview of Electric Vehicle Technology”, September 1993, Proceedings of the IEEE, VOL. 81, NO.9, pp.1202-1213.
7. Chen, Min, and Gabriel A. Rincon-Mora. "Accurate electrical battery model capable of predicting runtime and IV performance." IEEE transactions on energy conversion 21.2 (2006): 504-511.
8. Pallavi M. Mankar, Atul A. Ghute Solar Powered Battery Operated Electric Vehicle as an Option For Fuel Vehicle, International Journal Of Engineering Sciences & Research Technology, Issn: 2277-9655.