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# A DC-DC CONVERTER FOR HYBRID ELECTRICAL VEHICLE

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***ABSTRACT—***

***Now a days battery fed electrical vehicle are commonly being used because of their advantages over conventional IC engine vehicles. This work aims at comparison of various methodologies for hybrid electrical vehicle. In most application a bidirectional dc-dc converter fed permanent magnet dc (PMDC) motor traction drive system for battery fed electrical vehicle (BFEVs) is being used. There is increase in efficiency with the use of the half bridge non-isolated bidirectional dc-dc converter by maintaining battery voltage level to the motor rated voltage and also a controller which works in both the modes i.e. motoring and regeneration has been suggested for the speed control.***

***Keywords: Battery fed electrical vehicle (BFEV), Bidirectional dc-dc converter, battery.***

## I. INTRODUCTION

Our human activity is polluting our atmosphere with carbon dioxide and also petroleum resources across the world is degrading at a very high speed due to the large dependency of the transportation sector on petroleum as the primary fuel. As it is very well known that these petroleum resources are finite but our consumption is increasing day by day, this is causing the increase in petroleum prices. It is estimated that current global petroleum resources could be used up within 50 years if they are consumed at present consumption rates. Also due to this large consumption, there is a vast greenhouse gas emission which causes global warming, which traps heat, steadily drive up the planet's temperature. This has motivated a tremendous interest for the design of the vehicles with lesser or no dependency on the petroleum resources.

This has lead to the increased rate of the development of the Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) technologies in past two decades. Hybrid energy sources complement drawbacks of each single device. The first HEV car was introduced during 1900 by Lohner Coach Factory, which was driven by a hub motor powered by the generator run through a gasoline engine with a small battery for reliability. But since then due to the better development in the ICE technologies and the cheaper petroleum prices made the ICE run vehicle a better option than a HEV. Therefore the growth of the HEV technologies remained almost stagnant until recent past two decades when the petroleum prices started rising due to their limited availability and greater consumption as well as because of the degrading atmospheric and environmental conditions because of the emissions due to hydrocarbon combustion.

Nowadays, the usage of light electric vehicles (LEV) is fostered by the public administrations to reduce pollution and traffic congestion in the city areas, therefore An HEV uses combination of both energy storage system (ESS) and ICE technology. Since the vehicle is no longer dependent on only one type of fuel, they have many benefits like increase in the efficiency and drivability and at the same time reducing the emissions. It is very unlike conventional vehicles which solely depend on an ICE engine for the traction power. The integration of the electrical storage system also makes the provision for the regeneration during braking which can further boost up the efficiency of the overall system.

## II. BIDIRECTIONAL DC-DC CONVERTER

Bidirectional DC-DC converters serves the purpose of stepping up or stepping down the voltage level between its input and output along with the capability of power flow in both the directions. Bidirectional DC-DC converters have attracted a great deal of applications in the area of the energy storage systems for Hybrid Vehicles, Renewable energy storage systems, Uninterruptable power supplies and Fuel cell storage systems. Traditionally they were used for the motor drives for the speed control and regenerative braking. Bidirectional DC-DC converters are employed when the DC bus voltage regulation has to be achieved along with the power flow capability in both the direction. One such example is the power generation by wind or solar power systems, where there is a large fluctuation in the generated power because of the large variation and uncertainty of the energy supply to the conversion unit (wind turbines & PV panels) by the primary source. These systems cannot serve as a standalone system for power supply because of these large fluctuations and therefore these systems are always backed up and supported by the auxiliary sources which are rechargeable such as battery units or super capacitors. This sources supplement the main system at the time of energy deficit to provide the power at regulated level and gets recharged through main system at the time of surplus power generation or at their lower threshold level of discharge. Therefore a bidirectional DC-DC converter is needed to be able to allow power flow in both the directions at the regulated level. Likewise in HEVs, bidirectional DC-DC converters are employed to link up the high voltage DC bus to the hybrid electrical storage system (usually a combination of the battery or a fuel cell with the super capacitor). Here they are needed to regulate the power supply to the motor drive to assist the ICE according to the traction power demanded. The need for a bidirectional DC-DC converter in the HEV



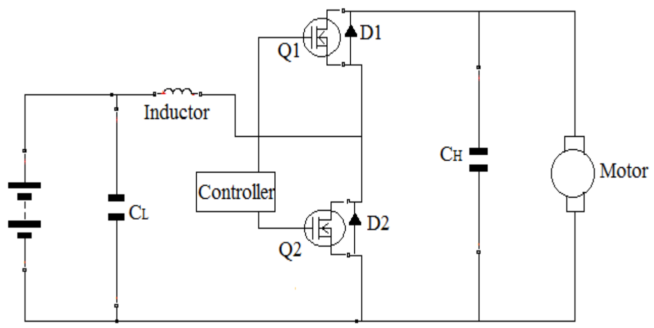


Fig.1: Bi-directional DC-DC Converter with battery and dc motor

## III. OPERATION

**Mode 1 (Boost Mode)**: In this mode switch Q2 and diode D1 enters into conduction depending on the duty cycle whereas the switch Q1 and diode D2 are off all the time. This mode can further be divided into two interval depending on the conduction on the switch Q1 and diode D2 .

**Interval 1** (Q2-on, D2-off; Q1-off, D2-Off): In this mode Q2 is on and hence can be considered to be short circuited, therefore the lower voltage battery charges the inductor and the inductor current goes on increasing till not the gate pulse is removed from the Q2 . Also since the diode D1 is reversed biased in this mode and the switch Q1 is off, no current flows through the switch Q1.

**Interval 2** (Q1-off, D1-off; Q2-off, D2-on): In this mode Q2 and Q1 both are off and hence can be considered to be opened circuited. Now since the current flowing through the inductor cannot change instantaneously, the polarity of the voltage across it reverses and hence it starts acting in series with the input voltage. Therefore the diode D1 is forward biased and hence the inductor current charges the output capacitor C2 to a higher voltage. Therefore the output voltage boosts up.

**Mode 2 (Buck Mode)**: In this mode switch Q1 and diode D2 enters into conduction depending on the duty cycle whereas the switch Q2 and diode D1are off all the time. This mode can further be divided into two interval depending on the conduction on the switch Q2 and diode D1.

**Interval 1** (Q2-on, D2-off; Q1-off, D2-off): In this mode Q1 is on and Q2 is off and hence the equivalent circuit is as shown in the Fig below. The higher voltage battery will charge the inductor and the output capacitor will get charged by it.

**Interval 2** (Q1-off, D1-off; Q2-off, D2-on): In this mode Q2 and Q1 both are off again since the inductor current cannot change instantaneously, it gets discharged through the freewheeling diode D2.

The voltage across the load is stepped down as compared to the input voltage.

## IV. SIMULATION DESIGN:

Closed loop Simulation of the Bidirectional Converter fed PMDC Motor with the designed values was done in the MATLAB Simulink. The inductor parasitic resistance and MOSFET turn-on resistance are not considered in this case.

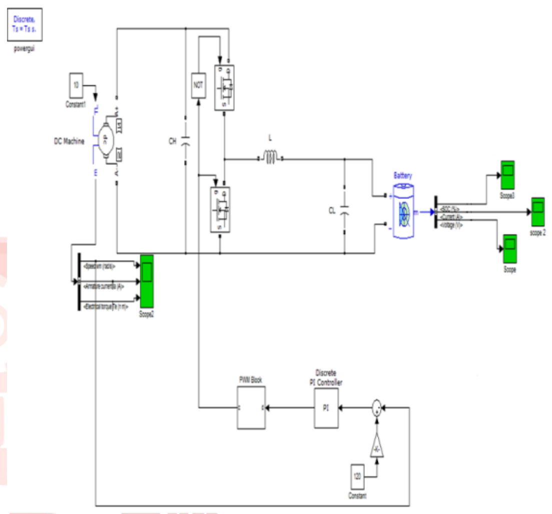

Fig.2: simulation model for Bi-directional DC-DC Converter with battery and dc motor.The simulation is carried out for

**a. motor speed,**
**b. torque,**
**c. battery power and motor power**

## V. RESULTS

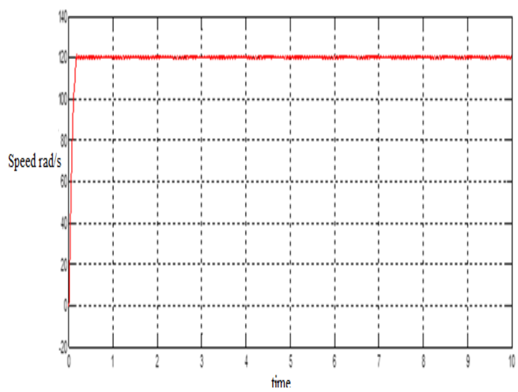


Fig.3: Motor speed at steady state

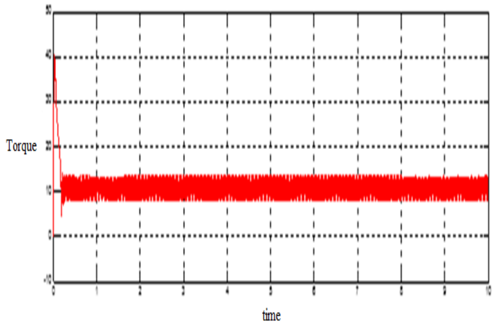


Fig. 4 : Motor Torque at steady state

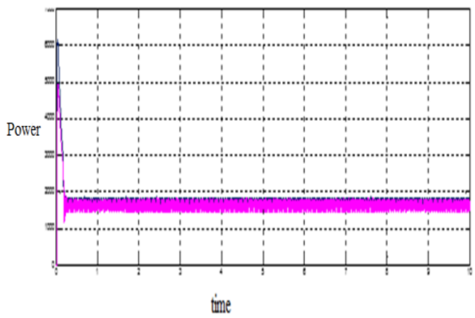


Fig.5: Motor and battery power at steady state

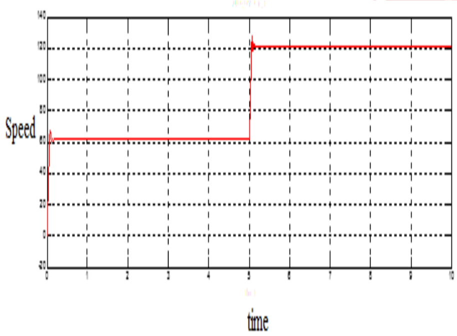


Fig.6 : Motor speed at transient state

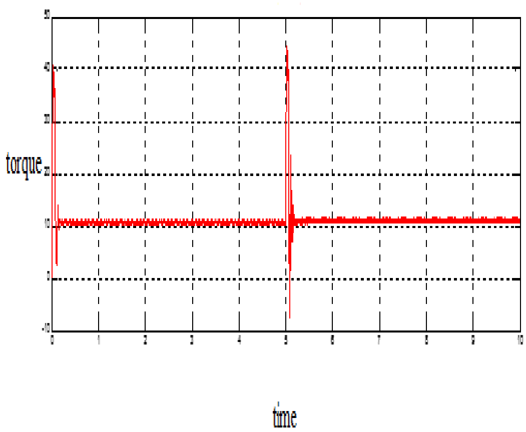


Fig.7 : Motor Torque at steady state

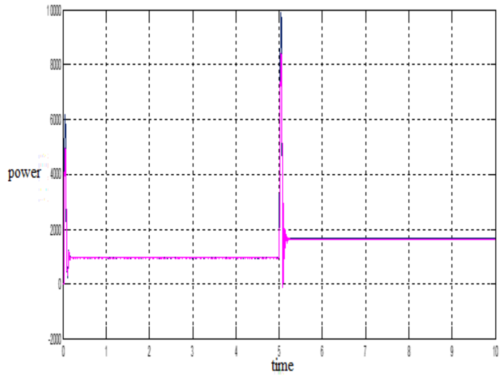


Fig.8 : Motor and battery power at transient state

## VI. CONCLUSION

This work demonstrates the performance of a battery operated hybrid electric vehicle system and it shows satisfactory performance at different driving condition. This control technique with PI controller find suitable for this electric drive. The performance of the BFEV is verified under forward motoring mode, regenerative mode and when there is step change is speed command. It is found that hybrid electrical vehicle by using PMDC motor drive has better results in case of voltage, current and torque. The overall cost and volume of the battery operated electric vehicle is less with the least number of components used in the system

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