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Effect of Bidirectional DC-DC Converter on Hybrid Electric Vehicle

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ABSTRACT

The bidirectional DC - DC converter is also called as energy management converter. Conventionally, a hybrid electric vehicle consists of a battery source, an inverter and a motor drive. To improve the performance of power control unit, a DC-DC converter is used. The goal of the work is to match the voltage of the battery and motor drive and to reduce ripple current in the battery during regenerative braking. The operation of the topology is to convert the DC voltage into three phase ac voltage during forward motoring and to rectify during regenerative braking. This can be done using the inverter in 180 degree conduction mode. However the performance is improved without any additional cost by implementing the inverter in 150 degree conduction mode.

KEY WORDS: Hybrid electric vehicle, bidirectional converter, regenerative braking, inverter.

1. INTRODUCTION

A bi-directional DC-DC converter is added in the proposed topology as shown in Fig.2 which enhances the performance of the circuit.

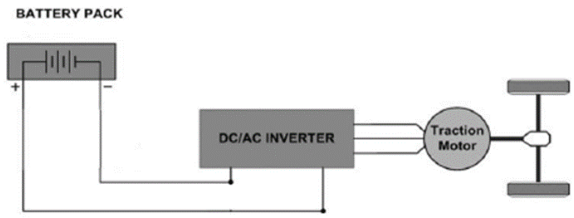

Figure.1. Conventional Topology

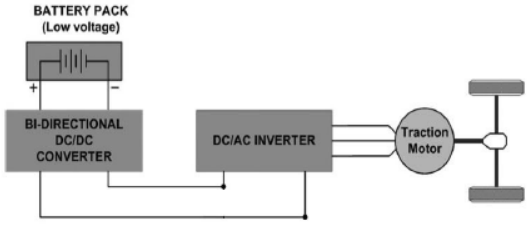

Figure.2. The Proposed Topology

2. METHODS & MATERIALS

Block diagram of the Proposed system: Here the block diagram shown below indicates the direction of power flow during the forward motoring mode and the regenerative braking mode.

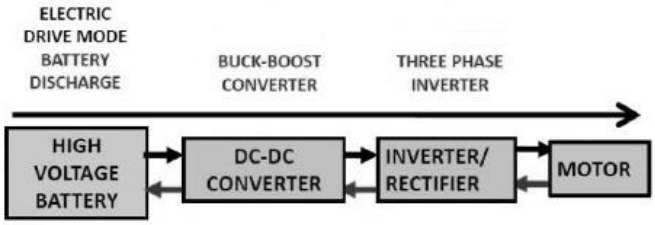

Figure.3. Forward Motoring Mode

During the motoring mode the high voltage battery drives the motor. However the since the motor used is a three phase motor, the dc voltage from the battery is stepped up using the bidirectional converter and the inverter converts the dc into a three phase ac voltage with phase differences between them. Then the three phase voltage source drives the motor.

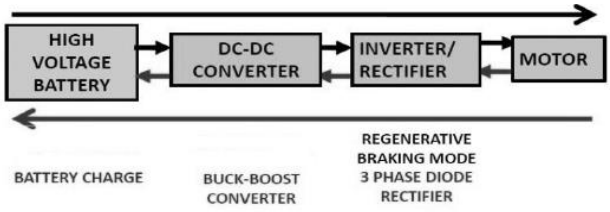

Figure.4. Regenerative Braking Mode

The above diagram shows the power flow during regenerative braking. During braking the motor acts like a generator and produces a three phase voltage source and is then rectified to get the dc voltage. Since converter is a bidirectional dc-dc converter, the same converter steps down the voltage to the rated voltage of the battery and charges the battery.

3. RESULTS

Forward Motoring Mode: During the forward motoring mode the battery drives the electric motor, which then moves the car forward. The voltage of battery and motor system should be matched in this case. High power battery packs are designed at a rated voltage of 300V to 400V and the best operating voltage for a motor and inverter is around 600V. Hence the converter can be used to match the voltages. Here we have used the DC-DC converter and have maintained the voltage across the capacitor (or) the DC bus voltage at around 560V which is the rated voltage of the motor. The rated voltage of the battery is 300V.

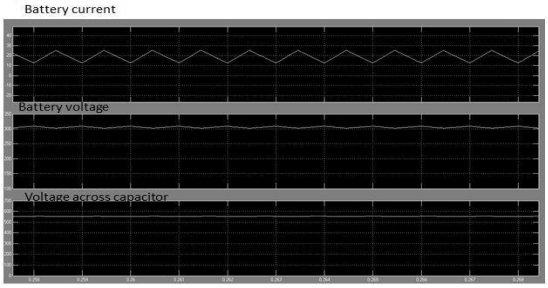

Figure.5. Simulation Results of Forward Motoring Mode

Regenerative Braking without Dc-Dc Converter: When brake is applied, the hybrid vehicle uses the kinetic energy of the car to let the wheels turn the electric motors, which function as regenerators. Energy that is normally lost as friction heat under deceleration is converted into electrical energy, which is recovered in the battery to be reused later. The ripple current is very high as shown in Fig.6.

Figure.6. Current ripple during regenerative braking without DC-DC Converter

Regenerative Braking with Dc-Dc Converter: By using the bidirectional DC-DC converter the ripple current across the battery is maintained as shown in Fig.7 and also the battery voltage is maintained around 300V.

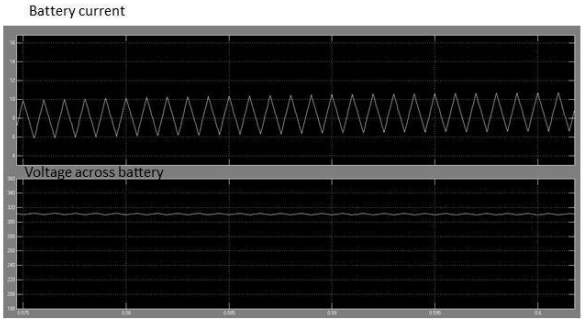

Figure.7. Current ripple during regenerative braking without DC-DC Converter

Impact of Inverter on the Dc Link Voltage: When a 180 degree conduction mode is used, a higher voltage level at the battery pack is obtained as shown in Fig.8 during the regenerative braking process. This reduces the charging time of the battery as the rated voltage is applied for charging. Since regenerative braking is for a small period of time it is essential to give rated voltage for the battery to charge.

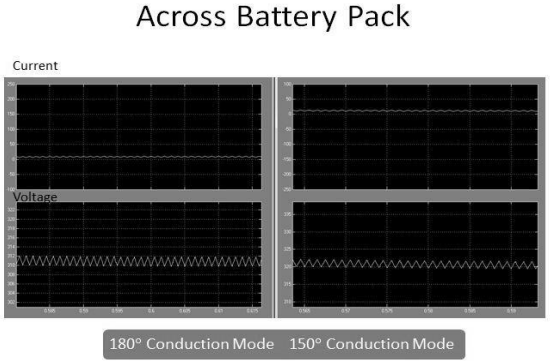

Figure.8. Comparison between 180 degree and 150 degree conduction mode

4. CONCLUSION

In this work, it has been demonstrated that the high power Bidirectional DC-DC converter equipped in HEV between the battery pack and the inverter can help improve the drive capability, reduce current ripple and potentially extend battery life because of the controlled charge and discharge behaviour.

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