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A DC Converter With Battery Energy Storage for Hybrid Electric Vehicle

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Abstract –Now a day's electric vehicles are becoming alternatives for sustainable and cleaner energy emissions in transportation. This project deals with the modeling and simulation of a basic dc converter is designed and the energy storage system. The electrical vehicles have become more important in the future. The proposed converter will be operating in an exceedingly buck mode and boost mode with two directional power flow control. Moreover the whole work is designed and simulated by using MATLAB/SIMULINK.

Key Words – Bidirectional dc/dc converter (BDC), dual battery storage, hybrid electric vehicle (HEV).

1. INTRODUCTION

The World progress technology, an increasing amount of energy is consumed. Increasing the efficiency of primary energy consumers provides a potential offset to the increasing in energy consumption. In the future the hybrid electric vehicles are the most important. In the conventional internal combustion as the source of energy for the driving purpose. Moreover, conventional IC engine vehicles emit carbon dioxide and various green house gases by making it harder to satisfy the environmental. EV does not emit pollutant like particulates, ozone, volatile organic compounds, carbon monoxide, hydrocarbons, lead and oxides of nitrogen which plays a vital role in air pollution and green house gas Moreover fossil fuel issue it can be minimized.

If the operating properties of the vehicle including HEV, FCV, and more electric vehicles. The hybrid electric vehicles are the most important and they are future for us.

The Energy consumption is growing every day as shown in the fig.1 if the energy is growing day to day then the efficiency is also increases. As per the diagram the energy is increased in Non-organized economic development corporation's countries but still the energy is improved in organized economic corporation's development countries. By using of the hybrid vehicle in the future we are increasing the energy and to increase the consumer products then automatically increase the efficiency.

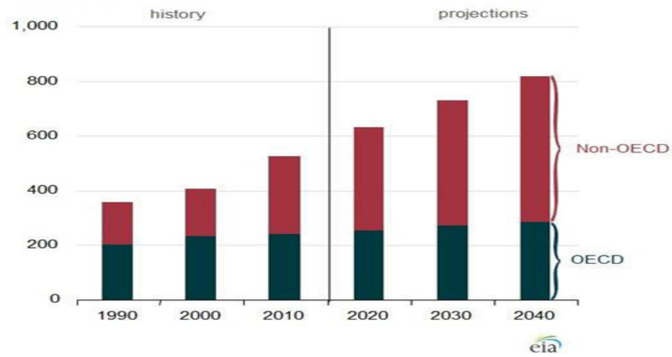

Fig1. World Energy Consumption

Each sector shows that how much energy we are consumed. If the energy is used in many purposes, most of the energy is used in transportation purposes. Some of the energy is used in petroleum, and natural gases are comes from conventional energy resources. Most of the energy is comes from the non-conventional energy resources which would decrease the petroleum consumption and fuel economy of the electric vehicles. By using the hybrid electric vehicle reduce the pollutants like co2 and toxic emissions and some of the dangerous gases. We have to increase the energy and overall efficiency is increased.

The diagram for a fuel cell/hybrid vehicle is as shown in fig. 2. We have to use two energy sources they are main energy sources and auxiliary energy sources. The fuel cell and super capacitor is connected to dc-dc converter, and it is connected in to the driving inverter to the motor. The fuel cell is used as the main energy source. The fuel cell is given to the dc converter and it is converted in to the sufficient dc voltage this will be given to the dc-bus to the driving inverter and this is converted into the required dc-voltage. This voltage is given to the motor this will run the vehicles. This will be managing the energy levels of the electric vehicles and hybrid electric vehicles. We have to reduce the pollution by using of the hybrid vehicle . In the future hybrid electric vehicle comes every one is use for the vehicle and we have to reduce the cost.

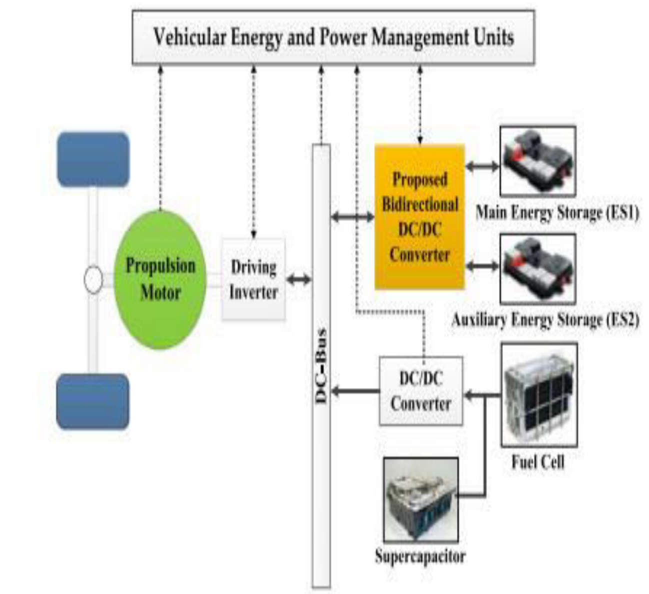

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Fig.1. Diagram of a fuel cell/ hybrid electric vehicle system

The main energy storage (ES1) is used as a high peak voltage and Auxiliary energy storage (ES2) is used as a low-voltage to achieve the vehicular range extender. The fuel cell and hybrid electric vehicle is connected to the energy storage system and this will run the inverter.

The fuel cell and battery storage have a different voltage levels. Bidirectional converters have developed to have a various voltage and the control power flow between the different sources and thus minimizing the overall cost, volume, and power reduction.. The bidirectional converters are of two types and they are isolated converters and Non-isolated converters.

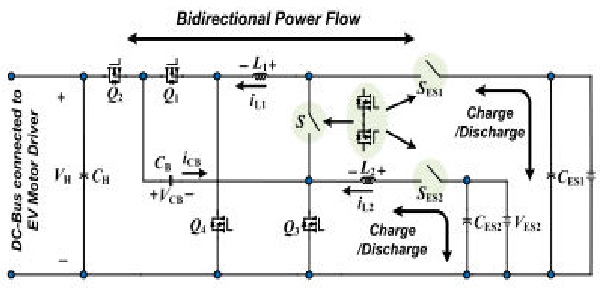


Fig. 2 Bidirectional dc converter topology with dual battery energy storage.

It consists of a interleaves double-voltage and high voltage and low voltage circuit is as shown in fig. 2 Where

c_B = Charge-pump capacitor voltage

V_H= high-voltage dc voltage

V_{ES1}=Main energy storage

V_{ES2} = Auxiliary energy storage

L_1, L_2 = phase inductors

Q_1, Q_2, Q_3, Q_4 = Active switches

S_{ES1}, S_{ES2} ,S = Bidirectional power switches.

A new bidirectional topology for a fuel cell and hybrid vehicle consists of an interleaved double voltage and high -voltage and low-voltage circuit. The voltage is applied to the high side to low side then it operate as a buck circuit and the power flows between the two converters, we can observe the voltage across the inductors and current across the inductors waveforms are observed. The voltage is applied to the low side to high side then it operate as a boost circuit and the power flows between the converters, we can observe the voltage across the inductors and capacitor voltage wave forms are observed. The operation and operating modes of the simulation results were observed. The converter can operate over a wide range of voltage levels. The characteristics of the dc converter are as follows: 1) it interfaces more than two dc sources for various voltages, 2) it controls the power flow between two dc converters, 3) it reduces the voltage gain and stress between the converters, 4) it process a cycle voltage and different voltage levels between the two converters.

The converter modes and operating principle are discussed. 1) The study state characteristics of the converter and operating principle are analyzed. 2) Voltage gain and converter control scheme, 3) The simulated and experimental results are observed. And finally we can study the conclusion of the study.

2. TOPOLOGY AND OPERATING MODES

Where V_H, V_{ES1}, and V_{ES2} represents the high-voltage dc-bus voltage, the main energy storage (ES1), and the auxiliary energy storage (ES2) of the system, respectively. A charge-pump capacitor (C_B) is integrated as a voltage divider with four active switches ($Q_1, Q_{2,}, Q_3, Q_4$) and two-phase inductors (L_1, L_2) to improve the static voltage gain between the two low-voltage dual sources (V_{ES1}, V_{ES2}) and the high-voltage dc bus (V_H) in the proposed converter. Furthermore, the additional C_B reduces the switch voltage stress of active switches to eliminate the duty ratio.

The proposed converters, all the conduction status of the power devices are involved and operation and operating modes are explained.

2.1 Low-Voltage Dual-Source Powering Mode

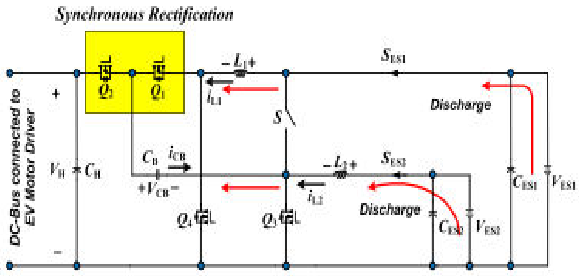
Fig .2(a) circuit and waveforms for the converter is as shown in the fig. In the low-voltage dual source powering mode the switches are in off positions and the switches (S_{ES1}, S_{ES2}) are on positions and the two low voltage dual sources (V_{ES1}, V_{ES2}) and are supplying the energy to the dc-bus. In the mode two switches are operating as a active switches and other two are acting as a passive switches.

Based on the modes of operation of the bidirectional dc converter in low-voltage dual source powering mode, the operating modes can be explained briefly.

a) State 1 [$t_0 < t < t_1$]: During this state, the switches Q_2, Q_4 are switches are in on position, and switches Q_2, Q_4 are switched off. In addition, inductor L_2 is charge by the second energy source and the inductors are linearly increasing manner, and it can be denoted as

$$L_1 \frac{di_{L1}}{dt} = V_{ES2} - V_{CB} \quad (1)$$

$$L_1 \frac{di_{L1}}{dt} = V_{ES2} - V_{CB} \quad (2)$$



(a)

b) State 2 [$t_1 < t < t_2$]: During this state, switches Q_3, and Q_4 are turned on; and switches Q_1, and Q_2, are switched off. The voltages are located between the two inductors so they are linearly increasing the energy, and it can be denoted as

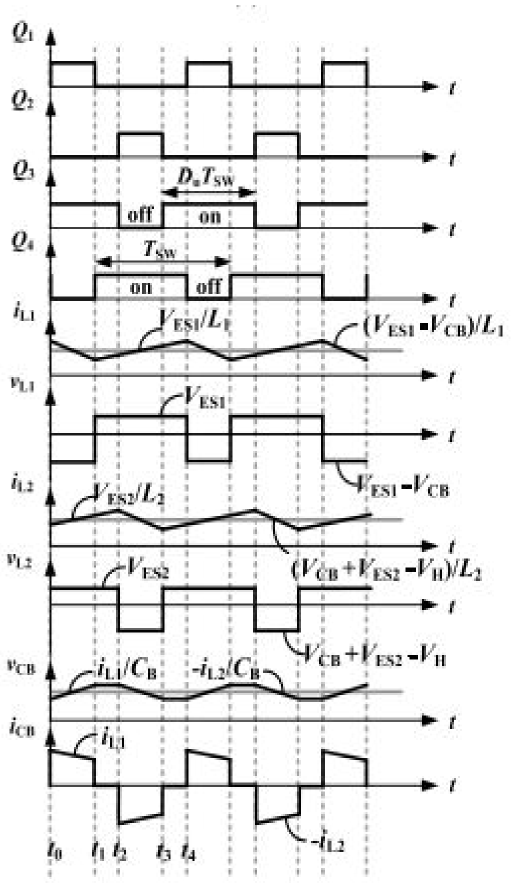
$$L_1 \frac{di_{L1}}{dt} = V_{ES1} \quad (3)$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} \quad (4)$$

c) state 3[$t_2 < t < t_3$]: During this state, the switches Q_3, and Q_4 are switched on; and switches Q_1, and Q_2, are switched off position. If the inductor voltages are denoted as

$$L_1 \frac{di_{L1}}{dt} = V_{ES1} \quad (5)$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} + V_{CB} - V_H \quad (6)$$



(b)

Fig. 2.1 Low-voltage dual-source –powering mode of the proposed BDC: (a) circuit schematic and (b) steady state waveform

c) state 4[$t_3 < t < t_4$]: During this state, the switches Q_3, and Q_4 are switched on; and switches Q_1, and Q_2, are switched off position. The inductor voltages are denoted as

$$L_1 \frac{di_{L1}}{dt} = V_{ES1} \quad (7)$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} \quad (8)$$

2.2 high-Voltages Dual-Source Powering Mode

Fig .33(a) circuit and waveforms for the converter is as shown in the fig. In the high-voltage dual source powering mode the two switches are in off position. The switches (S_{ES1}, S_{ES2}) are switches are in on position, and the two voltages are applied to the energy to the dc bus. In the mode two switches are operating as a active switches and other two are acting as a passive switches.

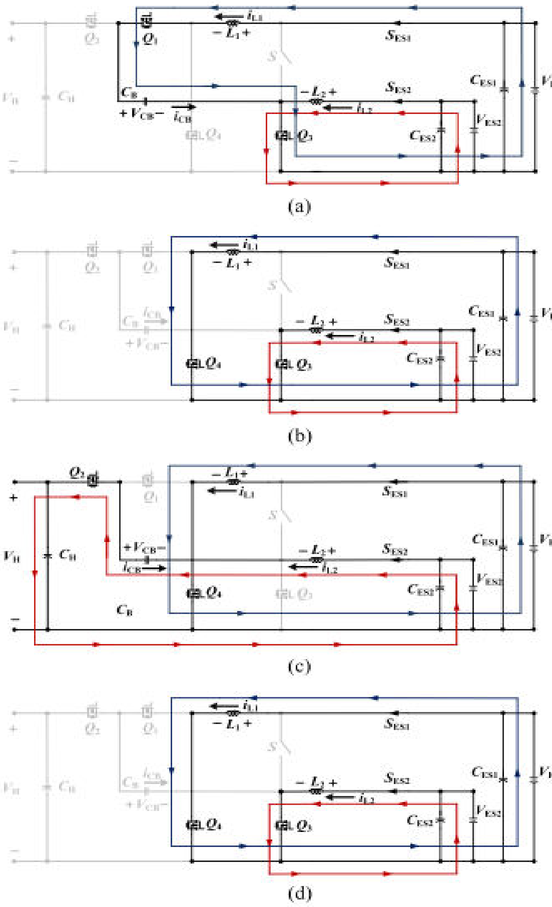


Fig. 2.2 Circuit states of the proposed BDC for the low-voltage dual source-powering mode (a) state 1 (b) state 2 (c) state 3 (4) state 4

2.2 high-Voltages Dual-Source Powering Mode

Based on the modes and operation of the bidirectional dc converter in low-voltage dual source powering mode, the modes are to be explained briefly. Fig 2.3(a) circuit and waveforms for the converter is as shown in the fig. In the low-voltage dual source powering mode the switches are in off position and the switches (S_{ES1}, S_{ES2}) are switched on, and the two low voltage dual sources (V_{ES1}, V_{ES2}) are supplying the energy to the dc-bus. In the mode two switches are operating as a active switches and other two are acting as a passive switches.

a) State 1 [$t_0 < t < t_1$]: During this state, the switches Q_1, Q_3 are turned on, and switches Q_2 , Q_4 are off. The inductors are located between two voltage sources and it can be denoted as

$$L_1 \frac{di_{L1}}{dt} = V_{ES1} - V_{CB} \quad (9)$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} \quad (10)$$

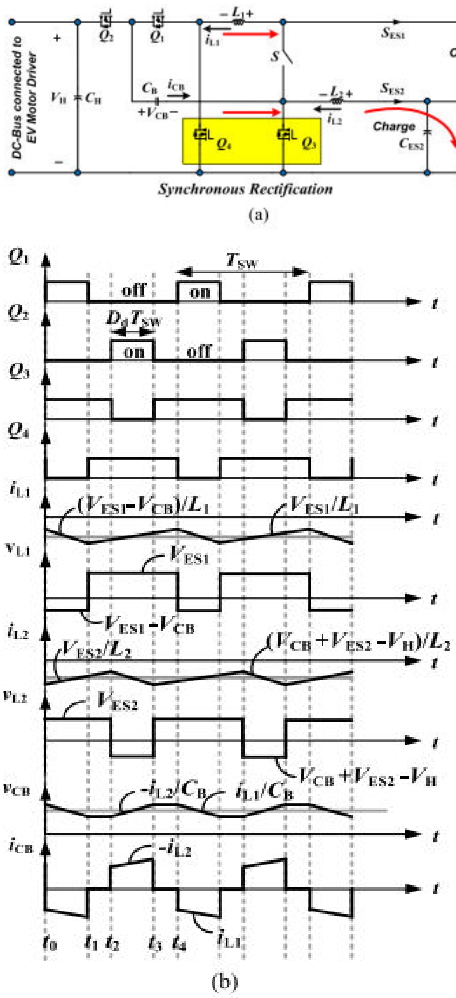


Fig.2.3 High-voltage dc-bus energy regenerating mode of the proposed BDC:

(a) circuit schematic and (b) steady-state waveforms

b) State 2 [$t_1 < t < t_2$]: During this state, switches Q_3, and Q_4 are on; and switches Q_1, and Q_2, off. The voltages are located between the two inductors and it can be written as

$$L_1 \frac{di_{L1}}{dt} = V_{ES1} \quad (11)$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} \quad (12)$$

c) State 3 [$t_2 < t < t_3$]: During this state, the switches Q_3, and Q_4 are on; and switches Q_1, and Q_2, are off. The voltage across the inductors between the two voltages and it can be denoted as

(9)

$$L_1 \frac{di_{L1}}{dt} = V_{ES1} \quad (13)$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} + V_{CB} - V_H \quad (14)$$

d) State 4 [$t_3 < t < t_4$]: During this state, switches Q_3 and Q_4 are on, and switches Q_1 and Q_2 are off. The voltages in between the inductors and it can be denoted as

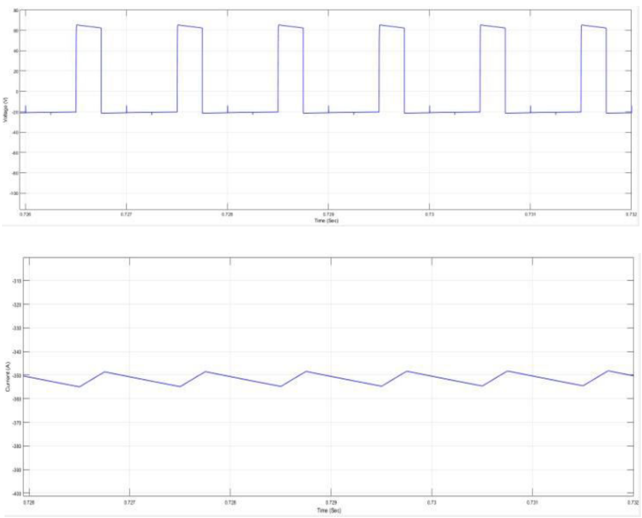
$$L_1 \frac{di_{L1}}{dt} = V_{ES1} \tag{15}$$

$$L_2 \frac{di_{L2}}{dt} = V_{ES2} \tag{16}$$

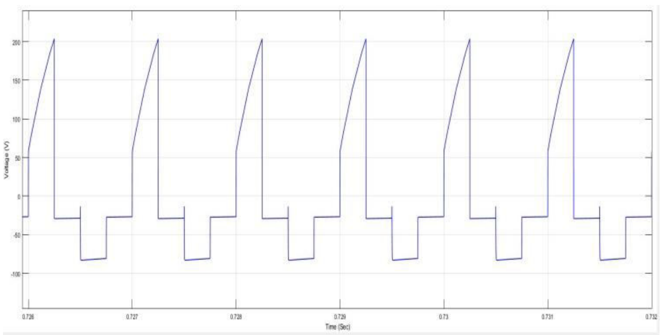
III Results

The energy flows in bidirectional power flow, when the energy flows in high voltage side V_H to low voltage side V_L then it operate as a charging mode operation and it is also called as buck mode operation. The output voltages of the voltage across the inductor and capacitor voltages in the fig and the status of the battery voltages and currents are observed.

Fig:4(a).Voltage across the inductor (L2).



The response of source and load current waveforms produced by the above simulink model is shown in below fig.4(b).



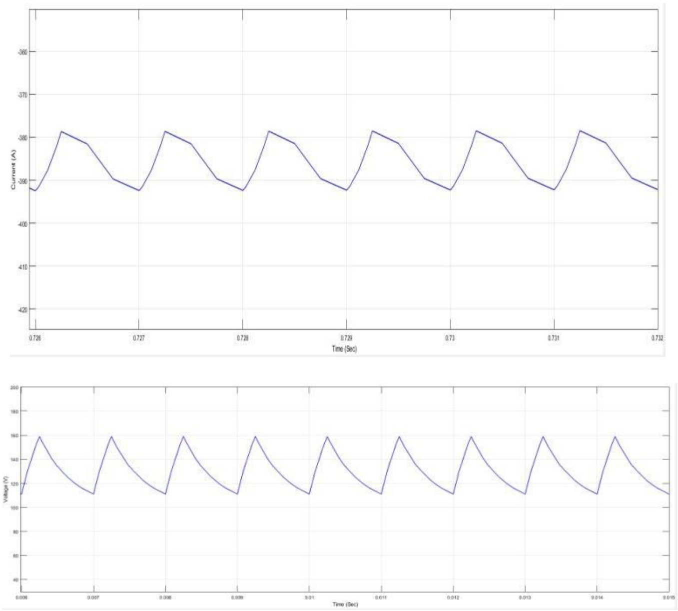


Fig:4(b) voltage across the inductor (L2) and capacitor voltage(V_{CB})

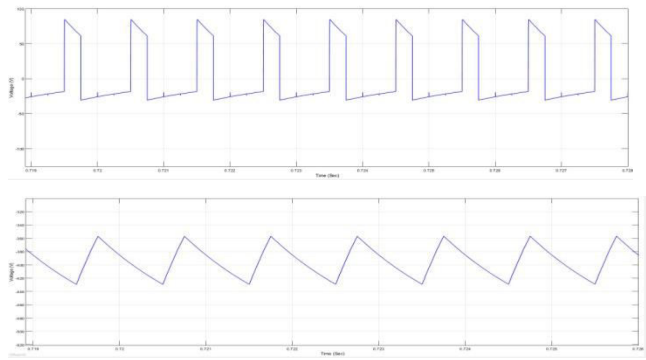
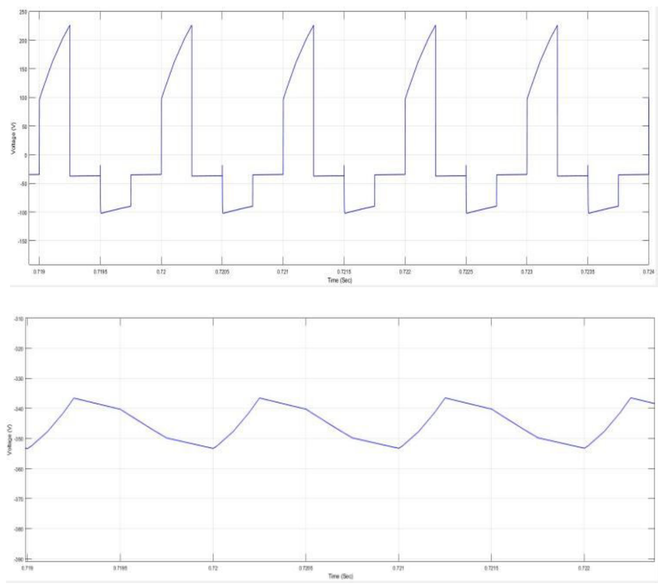


Fig:4(c). Voltage across the inductor (L2)

The above figure shows that the above figures shows that the voltage across the both inductors and capacitor voltage waveforms are shown in the above figure.



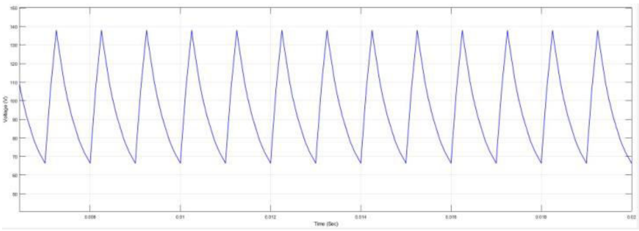
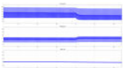
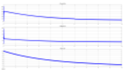


Fig.4 (d). voltage across the inductor (L1 and L2) and capacitor Voltage (V_{CB})





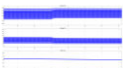
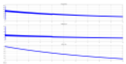


Fig.4.(e) voltage,current and state of charge of the battery(2)



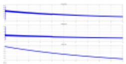


Fig.4(f) voltage,current and state of charge of the battery(1)

5. CONCLUSION

The bidirectional charger is acclimatized to charge the Vehicle battery. Here the charger operates in charging mode only. An Electric vehicle charger is designed for level 1 charging with a 150V input supply. A Bi-directional dc-dc converter is designed. If the DC-DC converter is designed and simulated for the inductor voltages and capacitor voltage. The battery voltage, current and status of the battery waveforms are observed.

The new bidirectional dc-dc converter topology was designed and to interface dual batter energy sources and high-voltage dc bus of various voltage levels. If the converter principle, operation and working principle and analyze the circuit and voltage gains of the bidirectional dc-dc converter and different modes of the converter are discussed.

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