Interfacing Advanced Power Electronics System for Electric Vehicle Application Using Matlab/Simulink

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***Abstract* – In today's world most of the conventional vehicles using fossil fuels for their operation. Using these fossil fuels leads to emission of Green House Gases (GHG) causing a Global warming. Electric Vehicles technology is the alternative way to reduce Global warming and its effect. This paper introduces interface of Advanced Power Electronics System for electric vehicle application using Matlab/Simulink. And also discussed about Bi directional DC/DC converter, Bidirectional DC/AC converter and onboard charging feature.**

Key words: Electric Vehicle, Global Warming, Bidirectional converters.

I. INTRODUCTION

The automotive industry and the large number of automobiles in use around the world have caused and are still causing serious problems for society and Human life. Decay in air quality, global warming, and a decrease in Petroleum resources are becoming the major threats to human beings. The transportation field is one of the crucial to our economy and our personal lives. Major transportation system uses fossil fuels for their operation, due to burning of these fossil fuels emits Green House Gases due to that global warming is occur. Electric vehicle technology is helps to reduce global warming issue and its effects. The electric vehicle technology is more attractive technology due to advances in battery technologies, advanced power electronics systems, control strategies and significant improvements in electrical motor efficiency.

Power electronics converter plays a very important role in electric vehicles application. These converters control the power flow and converts AC/DC, DC/AC, AC/AC and DC/DC. For bidirectional operation the system uses bidirectional switches. There are a number of research is going on developing the Power Electronics System that can be used in Electric vehicle applications. These studies are focused on improving the efficiency, reliability, cost, and size of the Power Electronics Systems.

II CO_2 EMISSION BY DIFFERENT SECTORS AND TRANSPORTATION SECTOR

Global warming is a result of the Green House Effect induced by the presence of carbon dioxide and other gases, such as methane, in the atmosphere. These gases trap the Sun's infrared radiation reflected by the ground, thus retaining the energy in the atmosphere and increasing the temperature. An increased earth temperature results in major ecological damages to its ecosystems and in many natural disasters that affect human populations.

Transportation sector represents nearly 30 percent of our global warming pollution and 70 percent of our oil addiction. Transportation energy use and emissions are also growing rapidly. Transport Sector plays a major role in emission of the carbon dioxide, since approximately 28% of the world's total CO_2 emissions from energy sources are generated. The following Fig.1 shows the GHG Emission by different Sectors in this transportation and Electricity generation sectors produces maximum GHG and GHG Emission by different Transportation sectors respectively. Fig.2 shows GHG emission in different transportation sectors.

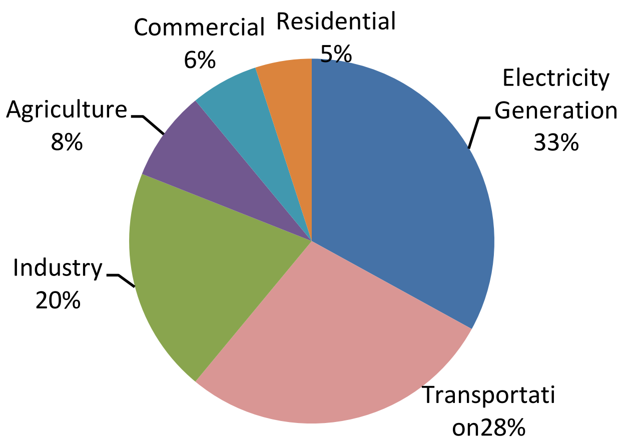

Fig.1 GHG Emission by different sectors.

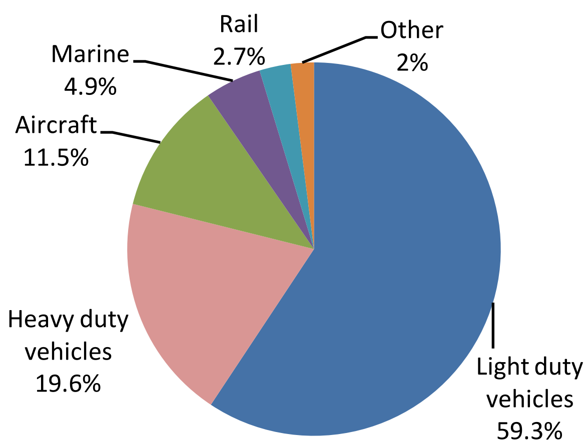

Fig. 2 GHG Emission by different Transportation sectors.

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III. PROPOSED ADVANCED POWER ELECTRONICS SYSTEM BLOCK DIAGRAM

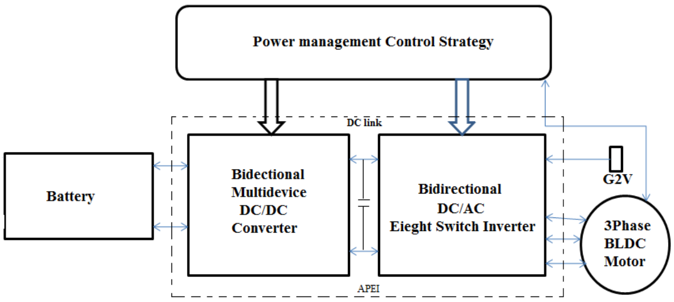

Fig.3 Block diagram of Advanced Power Electronics System.

The above fig shows the block diagram of proposed advanced power electronics system it consist of Bidirectional Multidevice DC/DC Converter, Bidirectional DC/AC Eight Switch Inverter, Battery, 3 phase BLDC Motor and Power management Control Strategy blocks.

A. Bidirectional Multidevice DC/DC Converter

The bidirectional DC/DC Converter operates in buck and boost mode. In buck mode converts higher DC link voltage to lower voltage when charging and regenerative braking occurs then feed to battery. In boost mode converts lower battery voltage to higher voltage for motoring operation. The Converter has the ability to reduce the size of the passive components (such as inductors and capacitor), and to reduce input/ output EMI filters by means of increasing the frequency of inductor current ripple and the output voltage ripple without increasing the switching frequency. To achieve the control strategy of the BMDIC, a phase-shift interleaved control between phases and parallel devices is used to generate the switching patterns. This sequence can contribute to a higher system bandwidth compared to bidirectional-interleaved converter (BIC) with four switches (IGBTs) and four diodes.

B. Bidirectional DC/AC Eight Switch Inverter

The bidirectional DC/AC Eight Switch inverter interfaces between DC link and BLDC motor in motoring operation and transfers energy from BLDC motor to DC link in regenerative braking. And in charging mode it acts as a rectifier.

C. Battery

Electrochemical batteries, more commonly referred to as batteries. These are electrochemical devices that convert electrical energy into potential chemical energy during charging, and convert chemical energy into electric energy during discharging. A battery is composed of several cells stacked together. A cell is an independent and complete unit that possesses all the electrochemical properties. Battery manufacturers usually specify the battery with amp-hours, which is defined as the number of amp-hours gained when discharging the battery from a fully charged state until the terminal voltage drops to its cut-off voltage. Battery manufacturers usually specify a battery with a number of amp-hours along with a current rate.
Ex: Lead-Acid Batteries, Nickel-based Batteries, Lithium-Based Batteries

D. BLDC Motor and Power management

Brushless DC motors are inverter fed motors which perfectly suited for EVs due to their various characteristics such as high efficiency, wide speed ranges and good power densities. BLDC motor is one of the types of synchronous motor. Hence BLDC motors don’t have slip i.e. the magnetic field produced by stator and rotor have same frequency. To sustain the rotation the position of rotor is sensed with the help of Hall sensors which is mounted on the stator. The voltage vector of BLDC motor is divided into six, which is in correspondence with the Hall Effect sensors signal, the corresponding hall signals are given to the controller which generates gate signals. These PWM signals are given to the switches in the inverter which supplies the stator winding thus with the help of Hall sensors the motor is controlled using any micro controller. Three phase motors use six switches, two in with this each arm of the inverter. MOSFET or IGBTs are most widely used. Due to its low output impedance IGBTs are commonly used in high power applications.

The Power management block generates gating pulses. And also controls the power flow from grid to battery, battery to motor and auxiliary unit and reflow from motor to battery in regenerative braking.

IV. SIMULATION RESULTS

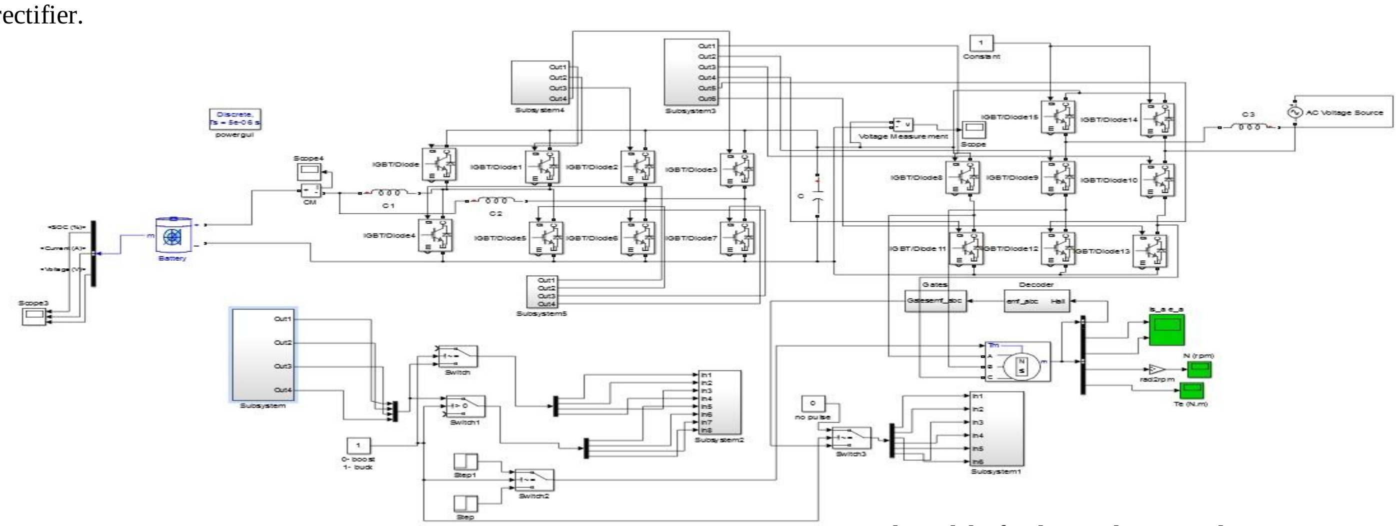

Fig.4 Proposed Model of Advanced Power Electronics System.

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In the proposed simulation model we are using 16 bidirectional power IGBT/DIODE. The Bidirectional Multidevice interleaved DC/DC converter (BMDIC) uses 8 switches i.e. 4 switches for Boost operation and other 4 switches for Buck operation. The DC/AC Eight Switch Inverter (ESI) uses remaining 8 switches for their operation. The proposed Advanced Power Electronics Systems combines the merits of the Bidirectional Multidevice interleaved DC/DC Converter and DC/AC Eight Switch Inverter, which can improve the electric vehicles efficiency and reliability as well as minimizing the size of the passive components (such as inductors, capacitors, and filters). In the structure of the BMDIC, the power switching devices are operated by using an interleaved technique, which leads to share the current between these power-switching devices. As a result, the current ratings of these switches can be reduced. It means that the proposed topology can decrease the current stress on the switches and EMI especially at transients. In addition, this structure can also provide a high reliability compared to other topologies, thanks to multichannel and multidevice topology. The proposed system can be mainly operated in four operating modes. These operating are given as follows:

1) *In Mode 1*, the ESI will operate as a dc/ac inverter to transfer the power from dc-link to the IM, while the BMDIC operates in boost mode to set-up the LV battery to the high-voltage dc-Link.

2) *In Mode 2*, the ESI operates as a three-phase PWM ac/dc rectifier to transfer the power from motor to dc-link, whereas the BMDIC works in buck mode to transfer the energy from the high-voltage dc-Link to the battery pack.

3) *In Mode 3*, the ESI works as a single-phase PWM ac/dc converter to charge the battery from the ac grid, while the BMDIC operates in buck mode to transfer the energy from the dc-link to the battery pack.

4) *In Mode 4*, the ESI operates as a single-phase dc/ac inverter to deliver the power from the dc-link to the ac grid during peak load, whereas the BMDIC works in boost mode.

The BMDIC operates as Boost converter, the lower four switches will be turned on and boosting 48V DC supply stored in battery to nearly 185V DC supply across the DC link. This supply feed to ESI it converts DC supply into AC supply then feed to 3 phase BLDC motor. Boosting Voltage, BLDC motor rotor speed, Electromagnetic Torque and battery parameters are show in Fig.5, Fig.6, Fig.7 and Fig.8 respectively.

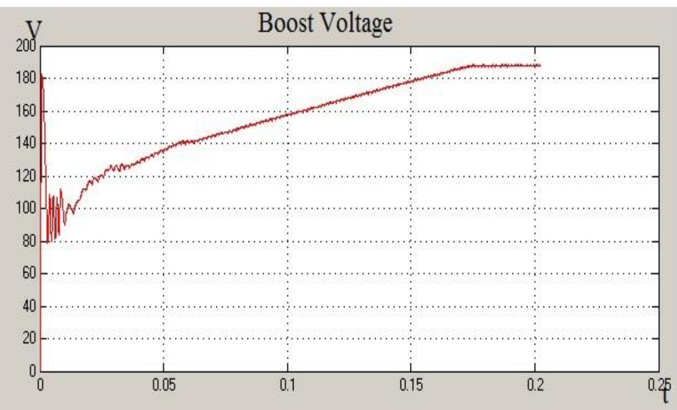

Fig.5 Voltage in Boost mode.

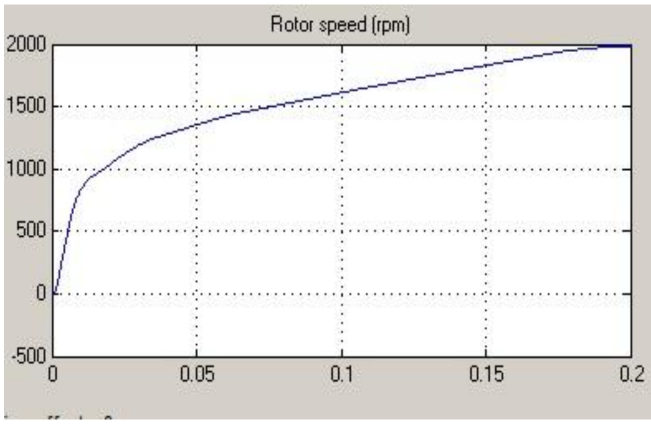

Fig.6 BLDC motor speed.

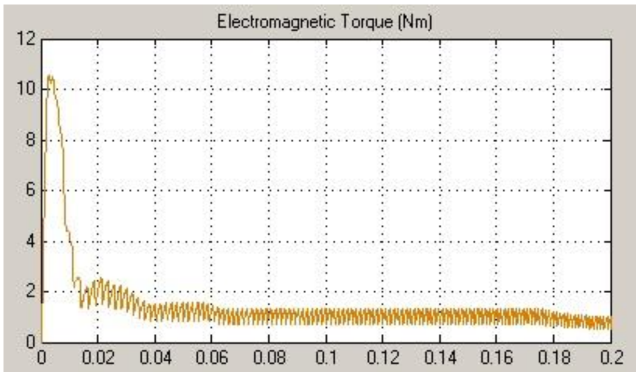

Fig.7 Torque.

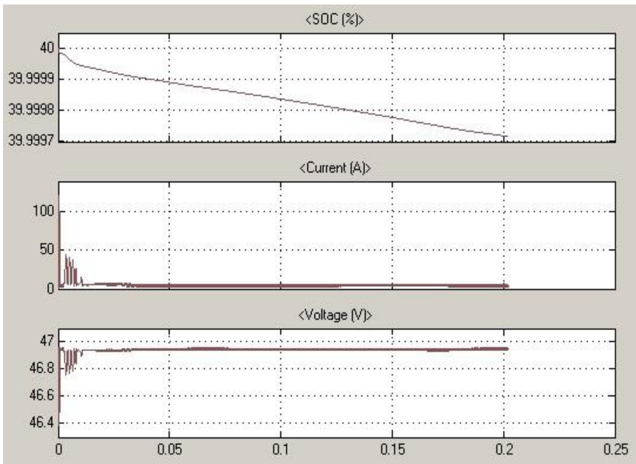

Fig.8 Parameters of battery.

Charging Battery from AC grid and in regenerative braking system in this condition ESI converts AC to DC (Rectifier) and feed to DC link. The BMDIC converts Higher DC link Voltage to lower Voltage and feed to Battery unit. In regenerating braking system BLDC motor acts as a generator. At that time mechanical energy is converted into electrical energy and feed to battery through ESI and BMDIC. The buck

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voltage and rotor speed is shown in Fig.9 and Fig.10 respectively

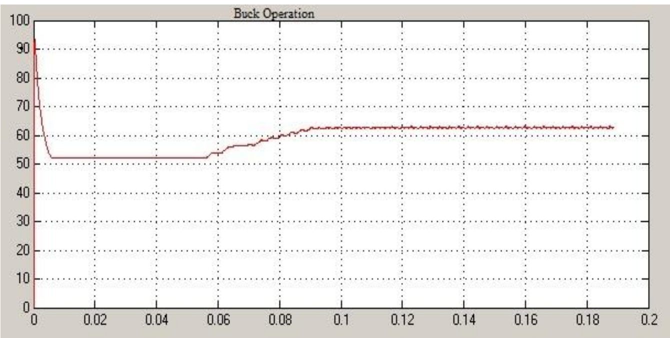

Fig.9 Voltage level in Buck mode.

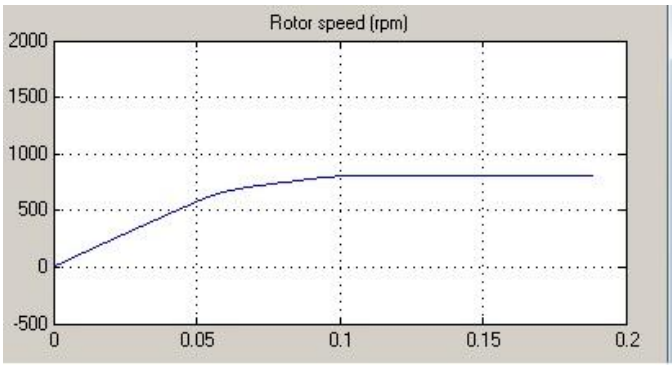

Fig.10 BLDC Motor speed in regenerative braking.

IV. CONCLUSION

In this paper, the proposed Advanced Power Electronics System design helps to achieve higher performance and reliability. In this system we are using Bidirectional Multidevice Interleaved DC/DC converter with the help of this minimizing the passive components size compare to other topology and it uses interleaved technique, which leads to share the current between power switching devices as a result current rating of power switches can be reduces. The on board charging feature also carried out using Eight Switch Inverter topology. Energy is feed back to battery in regenerative braking mode.

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