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Energy Management System For Hybrid Electric Vehicle Using Bidirectional Dc/Dc Converter Using Pi Controller

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Abstract
This project develops a newly designed, patented, bidirectional dc/dc converter (BDC) that interfaces a main energy storage (ES1), auxiliary energy storage (ES2), and dc-bus of different voltage levels, for application in hybrid electric vehicle systems. The proposed converter can operate in a step-up mode (i.e., low- voltage dual- source-powering mode) and a step-down (i.e., high-voltage dc-link energy-regenerating mode), both with bi directional power flow control. In addition, the model can independently control power flow between any two low- voltage sources (i.e., low-voltage dual-source buck/boost mode). Herein, the circuit configuration, operation, steady-state analysis, and closed-loop control of the proposed BDC are discussed according to its three modes of power transfer. Moreover, the simulation results for a system are provided to validate the proposed converter.

INTRODUCTION

Global climate change and energy supply is declining have stimulated changes in vehicular technology. Advanced technologies are currently being researched for application in future vehicles. Among such applications, fuel-cell hybrid electric vehicles (FCV/HEV) are efficient and promising candidates. In the past, Ehsani et al. studied the vehicles' dynamics to look for an optimal torque-speed profile of the electric propulsion system. Emadi et al. discussed the operating properties of the topologies for different vehicles including HEV, FCV, and more electric vehicles. Emadi et al. also integrated power electronics intensive solutions in advanced vehicular power system to satisfy huge vehicular load. Schaltz et al. sufficiently divide the load power among the fuel cell stack, the battery, and the ultra capacitors based on two proposed energy-management strategies. Thounthong et al. studied the influence of fuel-cell (FC) performance and the advantages of hybridization for control strategies. Chan et al. reviewed electric, hybrid, and fuel-cell vehicles and focused on architectures and modeling for energy management. Khaligh and Li presented energy-storage topologies for HEVs and plug-in HEVs (PHEVs). They also discussed and compared battery, UC, and FC technologies. Furthermore, they also addressed various hybrid ESSs that integrate two or more storage devices. Rajashekara reviewed the current status and the requirements of primary electric propulsion components-the battery, the electric motors, and the power electronics system. Lai et al. implemented a bidirectional dc/dc converter topology with two- phase and interleaved characteristics.

For EV and dc-micro grid systems, the converter has an improved Voltage conversion ratio. Furthermore, Lai also studied a bidirectional dc to dc converter (BDC) topology which has a high voltage conversion ratio for EV batteries connected to a dc-micro grid system. In FCV systems, the main battery storage device is commonly used to start the FC and to supply power to the propulsion motor. The battery storage devices improve the inherently slow response time for the FC stack through supplying peak power during accelerating the vehicle Moreover, it contains a high power- density component such as super capacitors (SCs) eliminates peak power transients during accelerating and regenerative braking. In general, SCs can store regenerative energy during deceleration and release it during acceleration, thereby supplying additional power. The high power density of SCs prolongs the life span of both FC stack and battery storage devices and enhances the overall efficiency of FCV systems.

A functional diagram for a typical (FCV/HEV) power system is illustrated in Fig1.1. The low- voltage FC stack is used as the main power source, and SCs directly connected in parallel with FCs. The dc/dc power converter is used to convert the FC stack voltage into a sufficient dc-bus voltage in the driving inverter for supplying power to the propulsion motor. Furthermore, ES1 with rather higher voltage is used as the main battery storage device for supplying peak power, and ES2 with rather lower voltage could be an auxiliary battery storage device to achieve the vehicle range extender concept. The function of the bidirectional dc/dc converter (BDC) is to interface dual-battery energy storage with the dc-bus of the driving inverter. Generally, the FC stack and battery storage devices have different voltage levels. Several multiport BDCs have been developed to provide specific voltages for loads and control power flow between different sources, thus reducing overall cost, mass, and power consumption. These BDCs can be categorized into isolated and non- isolated types.

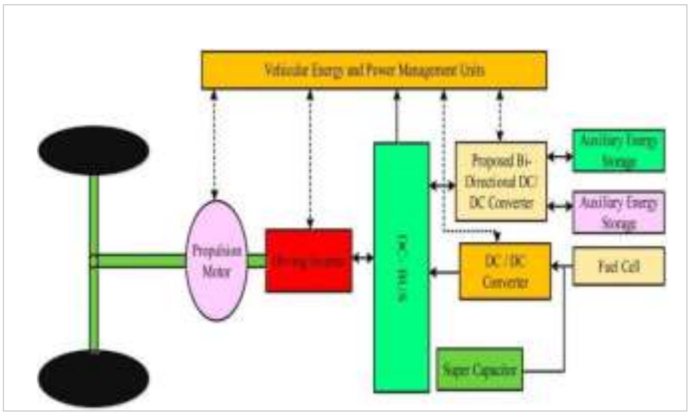


Fig.1.1. Typical functional diagram for a FCV/HEV power system.

LITERATURE SURVEY

M.Ehsani, K.M.Rahman, and H.A.Toliyat, "Propulsion system of electric and hybrid vehicles," proposed There is a growing interest in electric and hybrid- electric vehicles due to environmental concerns. Efforts are directed toward developing an improved propulsion system for electric and hybrid-electric vehicles applications. This paper is aimed at developing the system design philosophies of electric and hybrid vehicle propulsion systems. The vehicles' dynamics are studied in an attempt to find an optimal torque-speed profile for the electric propulsion system. This study reveals that the vehicles' operational constraints, such as initial acceleration and grade, can be met with minimum power rating if the power train can be operated mostly in the constant power region. Several examples are presented to demonstrate the importance of the constant power operation. Operations of several candidate motors in the constant power region are also examined. Their behaviors are compared and conclusions are made.

A. Emadi, K. Rajashekara, S. S. Williamson, and S. M. Lukic, "Topological overview of hybrid electric and fuel cell vehicular power system architectures and configurations," proposed This paper discusses the operational characteristics of the topologies hybrid electric vehicles (HEV), fuel cell vehicles (FCV), and more electric vehicles (MEV). A brief description of series hybrid, parallel hybrid, and fuel cell-based propulsion systems are presented. The paper also presents fuel cell propulsion applications, more specific to light- duty passenger cars as well as heavy- duty buses. Finally, some of the major fundamental issues that currently face these advanced vehicular technologies including the challenges for market penetration are highlighted.

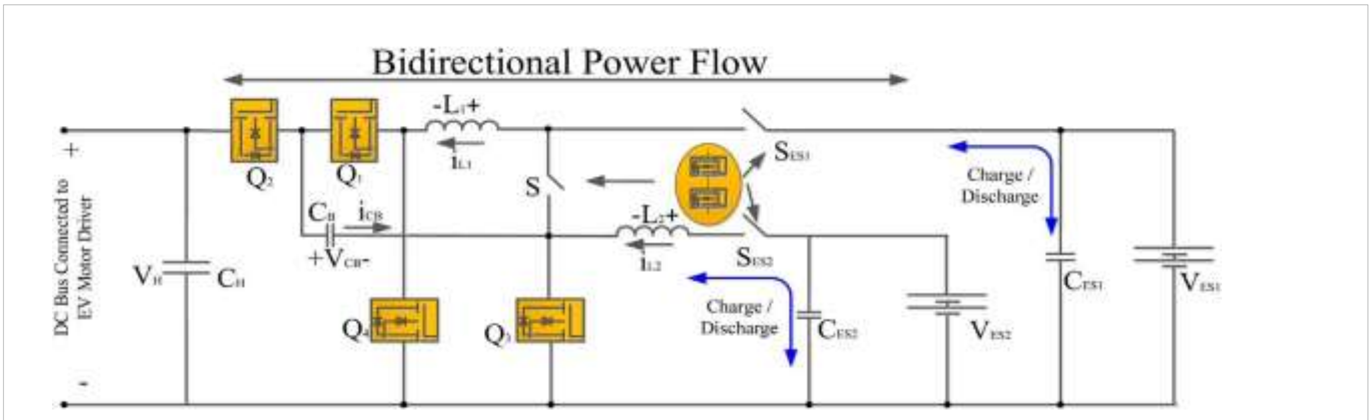


Fig. 3.1. Proposed BDC topology with dual-battery energy storage.

PROPOSED SYSTEM

Operating Modes	ON	OFF	Control Switch	Synchronous Rectifier (SR)
Low-voltage dual-source-powering mode (Accelerating, x_1=1, x_2=1)	S_{ES1}, S_{ES2}	S	Q_3, Q_4	Q_1, Q_2
High-voltage dc-bus energy-regenerating mode (Braking, x_1=1, x_2=1)	S_{ES1}, S_{ES2}	S	Q_1, Q_2	Q_3, Q_4
Low-voltage dual-source buck mode (ES1 to ES2, x_1=0, x_2=0)	S_{ES1}, S_{ES2}	Q_1, Q_2, Q_4	S	Q_3
Low-voltage dual-source boost mode (ES2 to ES1, x_1=0, x_2=0)	S_{ES1}, S_{ES2}	Q_1, Q_2, Q_4	Q_3	S
System shutdown	--	S_{ES1}, S_{ES2} Q_1, Q_2, Q_3, Q_4	--	--

TABLE 3.1 CONDUCTION STATUSES OF DEVICES FOR DIFFERENT OPERATING MODES

The proposed BDC topology with dual-battery energy storage is illustrated in Fig.4.1, where VH, VES1, and VES2 represent the high-voltage dc-bus voltage, the main energy storage (ES1), and the auxiliary energy storage (ES2) of the system, respectively. Two bidirectional power switches (SES1 and SES2) in the converter structure, are used to switch on or switch off the current loops of ES1 and ES2, respectively. A charge- pump capacitor (CB) is integrated as a voltage divider with four active switches (Q1, Q2, Q3, Q4) and two phase inductors (L1, L2) to improve the static voltage gain between the two low-voltage dual sources (VES1, VES2) and the high-voltage dc bus (VH) in the proposed converter. Furthermore, the additional CB reduces the switch voltage stress of active switches and eliminates the need to operate at an extreme duty ratio.
Furthermore, the three bidirectional power switches (S, SES1, SES2) displayed in Fig. 2 exhibit four-quadrant operation and are adopted to control the power flow between two low-voltage dual sources (VES1, VES2) and to block either positive or negative voltage.
This bidirectional power switch is implemented via two metal-oxide- semiconductor field-effect transistors (MOSFETs), pointing in opposite directions, in series connection. To explain the concept for the proposed converter, all the conduction status of the power devices in operating modes are displayed in TABLE 3.1.

SOFTWARE

For the development of a Hybrid Electric Vehicle (HEV) using a Bidirectional DC-DC Converter, MATLAB 2009, along with Simulink and Sim Power Systems, is used for simulation and analysis. MATLAB 2009 provides tools for modeling power electronic circuits, designing control strategies, and analyzing system performance. Simulink enables graphical modeling of the HEV powertrain, including the battery, bidirectional converter, and motor, while Sim Power Systems facilitates the design of MOSFET/IGBT-based switching circuits, inductors, capacitors, and diodes. The PWM Generator and PI Controller regulate the converter's operation, ensuring efficient energy transfer between the battery and motor. By simulating Boost and Buck modes, the model evaluates energy efficiency, battery SOC, and regenerative braking performance, helping to optimize power flow and improve HEV performance.

CONVERTER CONTROL

Fig.5.1(a) depicts the converter control structure, which consists of a vehicular strategic management level and the proposed BDC controller. The corresponding realized DSP flowchart for selecting operating modes of the proposed BDC is also shown in Fig.5.1(b) for reference. The strategic management level involves electrical power demand estimation and contains a vehicular power and voltage management unit. The global results of the management must maximize the use of the source that best suits the powertrain power demand, fulfilling the driver and route requirements. In FCV/HEV power systems (Fig. 1.1), the dc-bus voltage of the driving inverter is regulated and powered by the FC stack through a dc-dc converter. Hence, instead of controlling the converter output voltage of each operation mode, the inductor current iL1 or iL2 is detected and compared with the reference current to control the power flow as shown in Fig.5.1(a). In the converter control structure, the vehicular energy and power and voltage management unit selects the BDC mode according to the operating conditions of the vehicle, such as power demand of different driving state (Pdem) and the dual-source voltages (VES1, VES2). It then selects the appropriate current references iL1,ref or iL2,ref that can control the active switches (S, Q1~Q4) with proportional integral (PI) or more advanced methods. Notably, in spite of it is not easy to choose the optimal parameter of PI controller, the advantages of zero steady-state error and capability of noise filtering, making PI control the most widely used industry algorithm. Furthermore, referring to Table I, two switch selector (x1, x2) of BDC controller can be defined for various operating modes. The pulsed-width- modulation (PWM) switching scheme converts the duty cycle determined by different switch selector statuses into gate control signals for the power switches.

As Fig.5.1 displays, the current reference iL1,ref is used to control the bidirectional power flow between the low- voltage dual-source and the high-voltage dc-bus (i.e., 2 LV to HV or HV to 2 LV). In either case, the average inductor current iL2 is equal to the controlled average inductor current iL1 because of the inherent uniform average current sharing in the proposed BDC topology. By contrast, the current reference iL2,ref is used to control the power flow between the main energy storage and the auxiliary energy storage (i.e., ES1 to ES2 or ES2 to ES1). The procedure of mode switching is shown in Fig.5.1(b) and it is depicted below. First of all, when vehicle is in driving state (Pdem>0), the controller is iL1 control loop (x1=1), and the controlled switches as shown in Table I (vehicle is accelerating (iL1,ref >0, HV to 2 LV) or braking (iL1,ref 0, VES2 to VES1).if neither of the two situations, it will execute reselect mode to process the

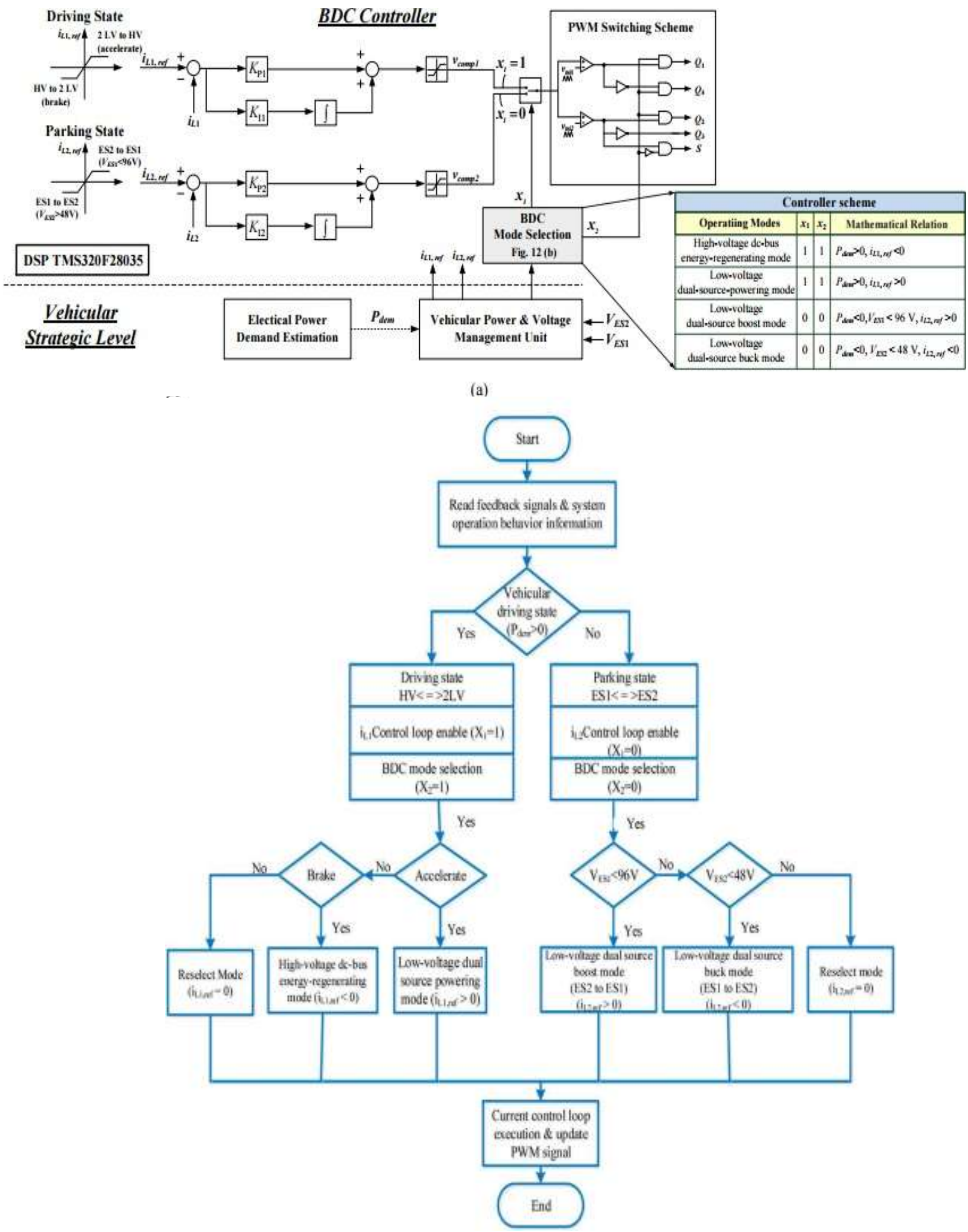
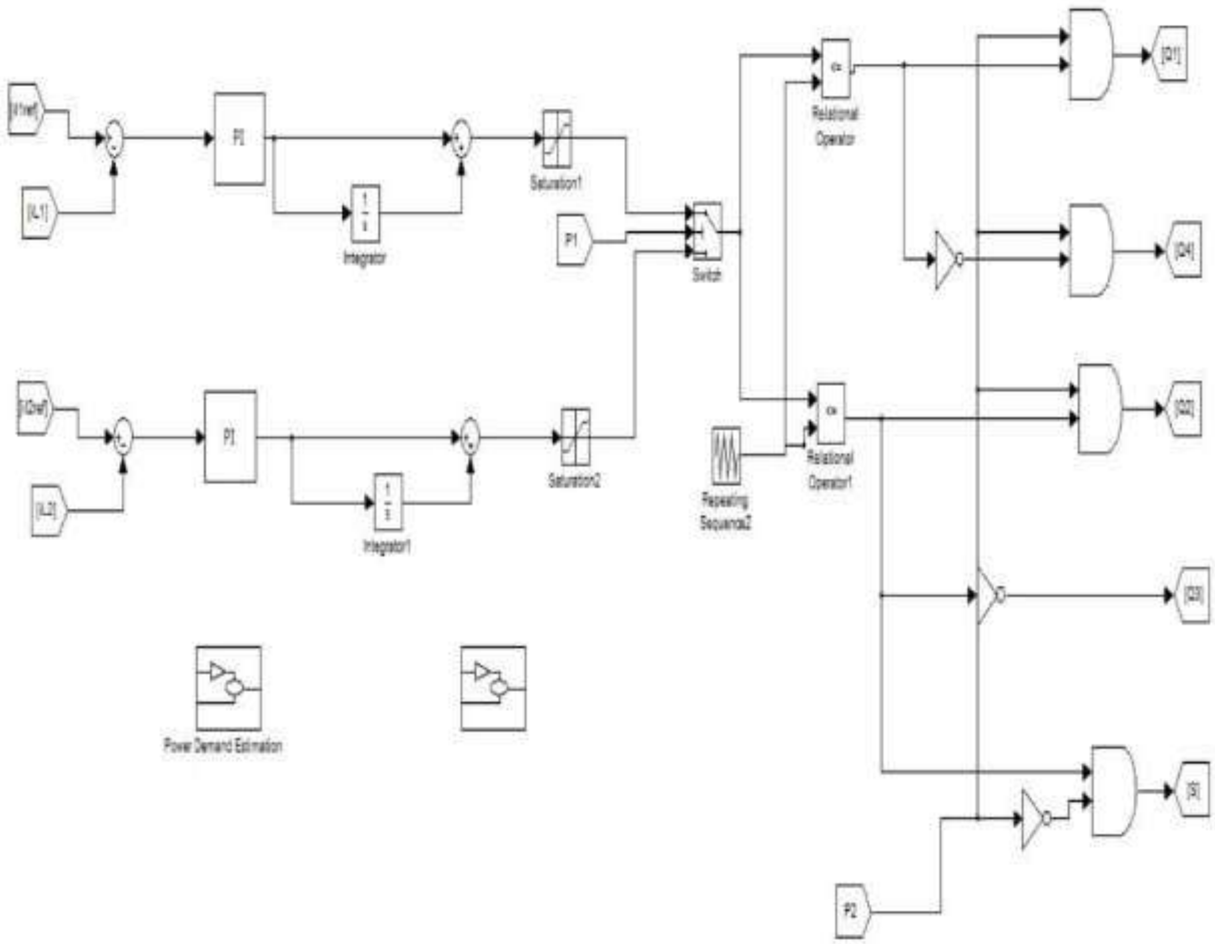


Fig.5.1. (a) Block diagram of the closed-loop control scheme; (b) realized DSP flowchart for various operating modes of the proposed BDC

next judgement of mode switching .Additionally, when vehicle is in parking state (pdem<0), the controller is Il2 control loop (x1=0),and the controlled switches as shown in table1.1.In this state, the judgement of mode switching depends on the voltage of VES1(96V) and VES2(48V).if VES1<96V, the mode is low-voltage dual source boost mode(iL2,ref>0,VES1 toVES2).when VES2<48V,the mode low voltage dual source buck mode(iL2,ref<0,VES1 to VES2).

SIMULINK MODEL RESULTS



In the above proposed converter there are three bidirectional switches and four MOSFETs for changing the mode of operation of the circuit .the modes are changed with respect to the state of the charge of the battery and the DC machine operation.

The above is the controller in mode a for switching Q1,Q2,Q3&Q4.The duty ratio is generated by PI controller with comparison of reference value with measured value

WAVEFORMS

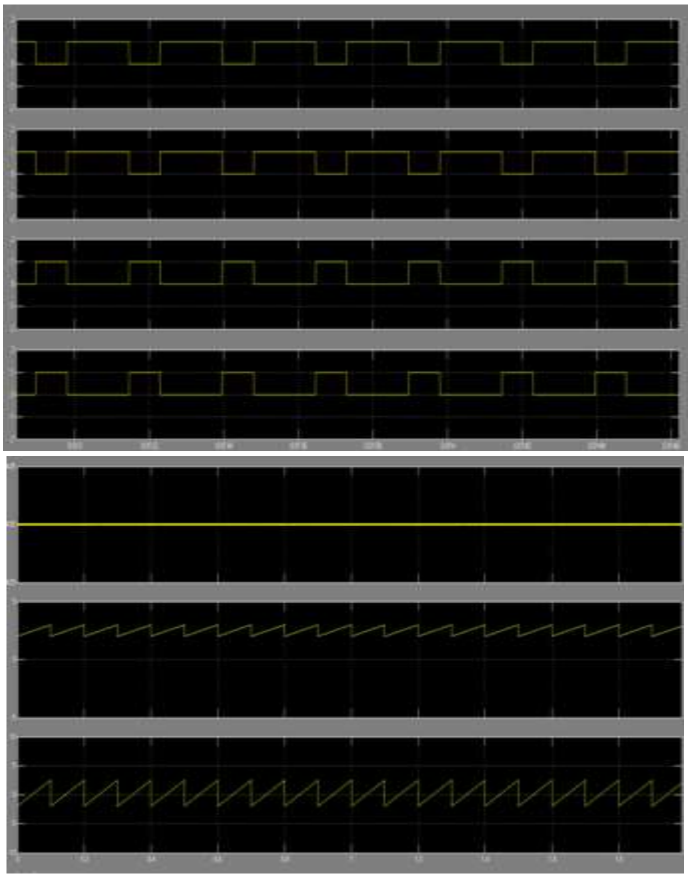


Fig 7.1Measured waveforms for low-voltage dual-source- powering mode: (a) gate signals (b) output voltage and inductor currents.

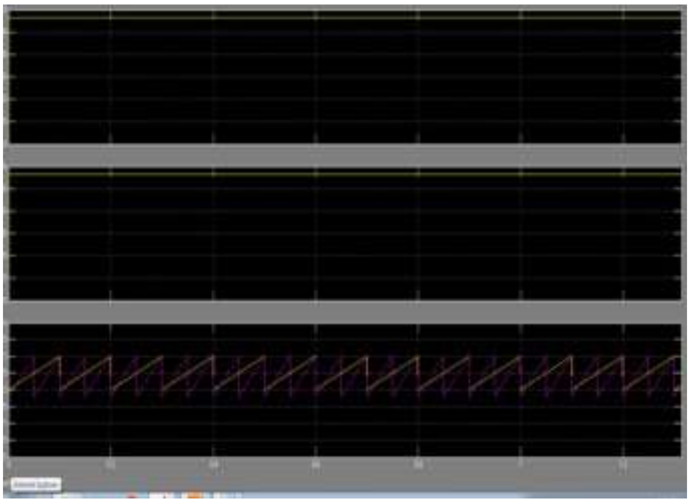


Fig 7.2 Measured waveforms for high-voltage dc-bus energy-regenerating mode

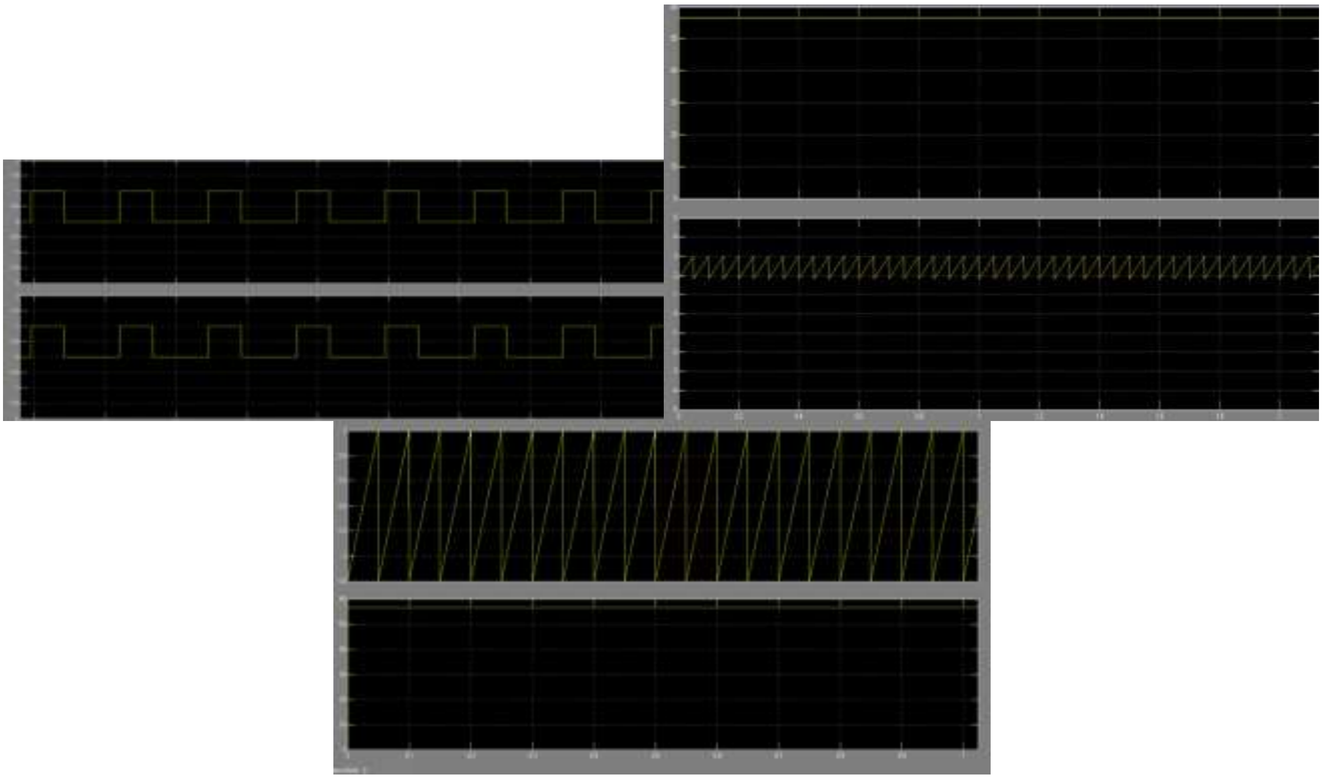


Fig 7.3 Measured waveforms of gate signals, output voltage and inductor currents for the low-voltage dual-source buck/boost mode

Specifications

ES1 voltage , VES1: 96 V ES2 voltage, VES2: 48 V DC-bus voltage, VH: 430 V Output power, Po: 1 kW

Switching frequency, fSW: 40 kHz Parameters

Inductors L1, L2: CH330060, 250 uH

High-side capacitor CH: aluminum capacitor, 1880 µF Low-side capacitor CES1&CES2:aluminum capacitor, 400 µF

Charge-pump capacitor CB: film capacitor, 10 µF Switches S, SES1, SES2: IXFK360N15T

Q1, Q4, Q2, Q3: W45NM60

CONCLUSION

A new BDC topology was presented to interface dual battery energy sources and high-voltage dc bus of different voltage levels. The circuit configuration, operation principles, analyses, and static voltage gains of the proposed BDC were discussed on the basis of different modes of power transfer. Simulation waveforms for a 1 kW prototype system highlighted the performance and feasibility of this proposed BDC topology. The highest conversion efficiencies were 97.25%, 95.32%, 95.76%, and 92.67% for the high-voltage dc-bus energy- regenerative buck mode, low-voltage dual-source- powering mode, low-voltage dual-source boost mode (ES2 to ES1), and low-voltage dual-source buck mode (ES1 to ES2), respectively. The results demonstrate that the proposed BDC can be successfully applied in FC/HEV systems to produce hybrid power architecture.

FUTURE SCOPE

- Urbanization has caused numerous effects on public life

- Now a days, the everyday exercises are for the most part dependent on vehicles.
- A large number of vehicles are generally subject to non-renewable energy resources like petroleum and diesel.
- Lack of resources the fuel costs increasing then we shift to different types of engines.

So here's all you need to know about hybrid electric vehicles

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