

# EFFICIENT AND EFFECTIVE ECO-FRIENDLY VEHICLES

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## ABSTRACT

*This paper proposes a high gain non –isolated soft switching bi- directional dc–dc converter. This converter is suitable for high step-up and step-down applications. The proposed converter can achieve zero voltage switching turn on of all switches and zero-current-switching turn off of some switches in continuous conduction mode in both forward and reverse modes. This improves efficient charge of regenerative energy as well as voltage boost and regulation for efficient operation of inverters and motors. An optimized switching strategy is presented to minimize switch current rating and achieve soft switching in wider range. An intermediate switching pattern is introduced to carry out seamless mode change. Experimental results from a 5-kW prototype are provided to validate the proposed concept.*

**Keywords:** *Bi-Directional Dc–Dc Converter (BDC), Continuous Conduction Mode (CCM), High Step-Up, High Voltage Gain, Non-Isolated, Soft Switched.*

## I. INTRODUCTION

### 1.1 Existing System

The basic nature and the previous work has been with the bi-directional converter using switched capacitor cells. The BDC using switched-capacitor converter cells could have more modular structure and higher power handling capability, but the required number of switches becomes high . They are hard-switched, and high current pulse occurs since two capacitors with different voltages are connected in parallel at each switching instant. A major drawback of the switched capacitor- based converter is that ESR(electric series resistance) drop of the active and passive devices is considerable due to high number of series connected devices in the current path, resulting in reduced output voltage.

### 1.2 Proposed System

In this paper, a new non isolated BDC for high step-up/step down and high-power applications is proposed. The optimized PWM switching technique for boost and buck operations and smooth mode transition is also presented. The proposed converter has the following advantages:

- 1) High voltage gains for both boost and buck operations;
- 2) Reduced (nearly half) voltage stresses of switches;
- 3) ZVS turn on and ZCS turn off of switches in CCM operation;
- 4) reduced energy volumes of passive components;
- 5) Seamless mode transition.

### 1.3 Hybrid Vehicle

Hybrid passenger cars have been on the market since 1997, with hybrid buses and delivery trucks emerging in the last 3-4 years. Widespread use in industrialized markets is now leading to use in developing countries through second hand markets. A well-functioning and efficient transport sector is a requirement for economic and social development, bringing people together and enabling the trade and exchange of goods and ideas. However, the transport sector is also responsible for a number of negative social and environmental effects, including a significant contribution to global greenhouse gas emissions and air pollution.

## II. MODELING OF EFFICIENT AND EFFECTIVE ECO-FRIENDLY VEHICLE

The principle parts and functions of efficient and effective eco-friendly vehicles are explained in this session. A block diagram is a specialized, high-level type of flowchart. Its highly structured form presents a quick overview of major process steps and key process participants, as well as the relationships and interfaces involved. A block diagram is a useful tool both in designing new processes and in improving existing processes. In both cases the block diagram provides a quick, high-level view of the work and may rapidly lead to process points of interest.

### 2.1 Block Diagram

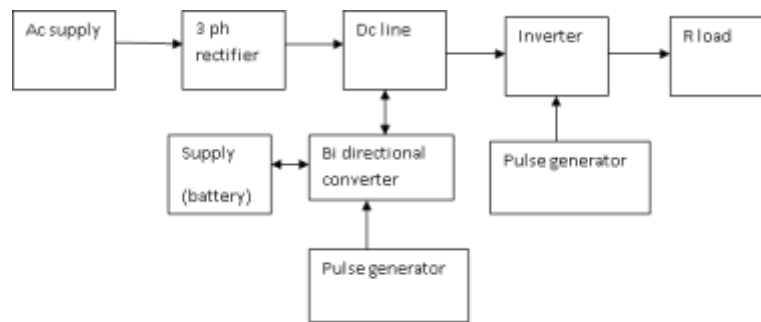


Fig.1.Block Diagram of Efficient and Effective Eco Friendly System

### 2.2 Components of Block Diagram

#### 2.2.1 Rectifier Circuit

A rectifying circuit is one which links an AC supply to dc load, that is, it converts an alternating voltage supply to a direct voltage. Here the rectifier used is a full bridge rectifier. A rectifier utilizes unidirectional conducting device ex: P-N junction diode.

#### 2.2.2 Bi-Directional Converter

A bi-directional converter is a device which converts alternating-current power to direct-current power and vice-versa. The converter is based on a cascaded buck-boost structure with active snubber circuits in order to achieve zero voltage and zero current transition, showing high efficiency.

#### 2.2.3 Pulse Generator

A pulse generator is either an electronic circuit or a piece of electronic test equipment used to generate rectangular pulses. Simple bench pulse generators usually allow control of the pulse repetition rate (frequency), pulse width, delay with respect to an internal or external trigger and the high- and low-voltage levels of the pulses. More-sophisticated pulse generators may allow control over the rise time and fall time of the pulses. Pulse generators are available for generating output pulses having widths (duration) ranging from minutes down to under 1 picosecond.

#### 2.2.4 Inverter

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

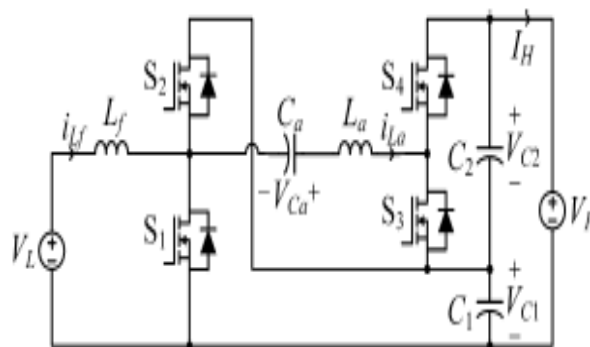
#### 2.2.5 working

Initially an AC supply is given. Then the rectifier circuit converts the AC to DC supply and the output is filtered and given to the bi-directional converter and the final results is viewed in the cathode ray oscilloscope.

### III. BI-DIRECTIONAL DC-DC CONVERTER

This paper presents a power converter for a fuel cell electric vehicle driving system. A new bidirectional, isolated topology is proposed in consideration of the differing fuel cell characteristics from traditional chemical-power battery and safety requirements. The studied converter has the advantages of high efficiency, simple circuit, and low cost. The detailed design and operating principles are analysed and described. The simulation and experimental waveforms for the proposed converter are shown to verify its feasibility. The proposed converter achieves zero-voltage switching (ZVS) for the entire main switches and zero-current switching for the rectifier diodes in the large-load range. These features reduce switching loss, voltage and current stresses, and diode reverse-recovery effect. A typical non-isolated bi-directional dc-dc converter technology is to combine a buck converter and a boost converter in a half-bridge configuration. In this paper, a new non-isolated BDC for high step-up/step-down and high-power applications is proposed. The optimized PWM switching technique for boost and buck operations and smooth mode transition is also presented.

Figure 2. shows the circuit diagram of the proposed BDC. The proposed converter consists of a general half-bridge converter as the main circuit and an auxiliary circuit that includes the capacitor  $C_a$ , inductor  $L_a$ , and two high-voltage side (HVS) switches  $S_3$  and  $S_4$ . The goal of control, in this paper, is assumed to regulate the HVS voltage  $V_H$ , while allowing bidirectional power flow according to the direction of inductor current  $I_L$ . Operating Principle is assumed that capacitances  $C_1$ ,  $C_2$ , and  $C_a$  are large enough so that voltages  $V_{C1}$ ,  $V_{C2}$ , and  $V_C$  across them are constant during the switching period  $T_S$ .



**Fig.2. Proposed High Step up Soft Switched Bi-Directional DC-DC Converter**

### 3.1 Boost Operation (Forward Mode)

Figs.3. and fig.4 show key waveforms and operation states of the boost operation, respectively. In this mode, low-voltage side (LVS) switches  $S_1$  and  $S_2$  are operated with asymmetrical complementary switching with duty cycles of  $D$  and  $1-D$ , respectively. In the meantime, HVS switches  $S_3$  and  $S_4$  are turned ON with delay times of  $td_3$  and  $td_4$ , respectively. The operation of the proposed converter can be divided into five modes.

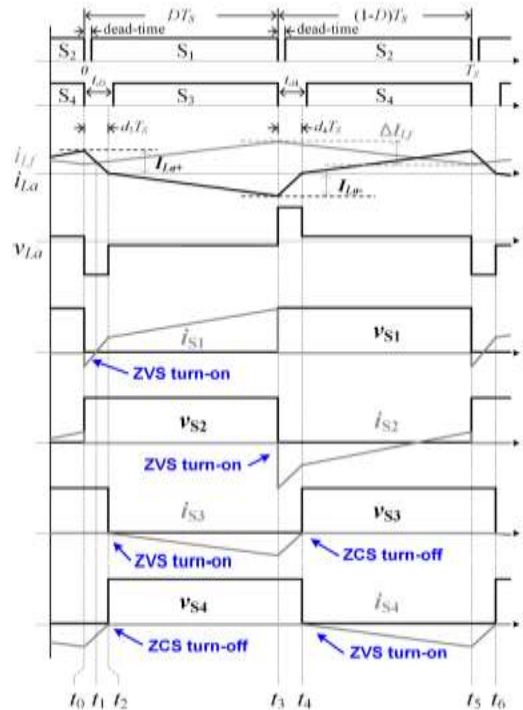


Fig.3. Key Waveforms of the Proposed Converter (Boost Operation)

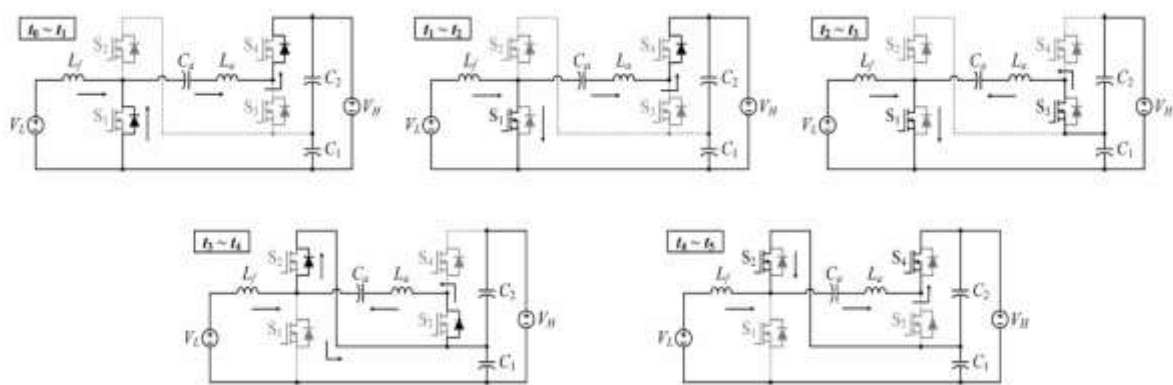


Fig.4 Operation States of Proposed Converter (Boost Operation)

Mode I operation: This mode I [ $t_0 \sim t_1$ ], begins with turning OFF of  $S_2$  and  $S_4$ . Then, the body diodes of  $S_1$  and  $S_4$  are turned ON. The gating signal for  $S_1$  is applied with appropriate dead-time during this mode, and then  $S_1$  could be turned ON under ZVS condition. Inductor currents  $i_{Lf}$  and  $i_{La}$  start to increase and decrease, respectively, with the slopes determined by the following equations:

$$di_{Lf}/dt = V_L/L_f \dots \dots \dots (1)$$

$$di_{La}/dt = [V_{Ca} - V_{C1} - V_{C2}]/L \dots \dots \dots (2)$$

Mode II operation: In this mode II [t1–t2], the increasing current  $i_{Lf}$  becomes greater than the decreasing current  $i_{La}$ , current flowing through S1 is reversed, and the main channel of S1 conducts. This mode ends when the decreasing current  $i_{La}$  reaches 0 A. Note that switch S4 is also turned OFF under ZCS condition.

Mode III operation: In this mode III [t2 –t3], at t2 current  $i_{La}$  is reversed and the body diode of S3 is turned ON. For synchronous rectification the gating signal for S3 can be applied after t2. Note that S3 is turned ON under ZVS condition. Inductor current  $i_{La}$  linearly increases with the slope determined by the following equation:

$$di_{La}/dt = [V_{Ca} - V_{C1}]/L_a \dots \dots \dots (3)$$

Both inductor currents  $i_{Lf}$  and  $i_{La}$  flow through switch S1.

Mode IV operation: In this mode IV [t3–t4], all 3 switches S1 and S3 are turned OFF, and then body diodes of S2 and S3 are turned ON. Both inductor currents  $i_{Lf}$  and  $i_{La}$  start to decrease with the slopes determined by the following equations:

$$di_{Lf}/dt = [V_L - V_{C1}]/L_f \dots \dots \dots (4)$$

$$di_{La}/dt = V_{Ca}/L_a \dots \dots \dots (5)$$

The gating signal for S2 is applied with appropriate dead-time during this mode, and then S2 could be turned ON under ZVS condition. This mode ends when the decreasing current  $i_{La}$  reaches 0 A. Note that switch S3 is also turned OFF under ZCS condition.

Mode V operation: This mode v [t4 –t5], begins when current  $i_{La}$  is reversed and the body diode of S4 is turned ON. For synchronous rectification, the gating signal for S4 can be applied after t4 .Note that S4 is turned ON under ZVS condition. Inductor current  $i_{La}$  linearly increases with the slope determined by the following equation:

$$di_{La}/dt = [V_{Ca} - V_{C2}]/L_a \dots \dots \dots (6)$$

This is the end of one complete cycle.

### 3.2 Buck Operation (Reverse Mode)

Fig.5 show key waveforms and Fig.6.shows operation states of the buck operation, respectively. In this mode, HVS switches S3 and S4 are operated with asymmetrical complementary switching with duty cycles of D and 1–D, respectively. In the mean time, LVS switch S2 is turned ON with delay time of  $t_{d2}$ . The operation of the proposed converter can be divided into six modes.

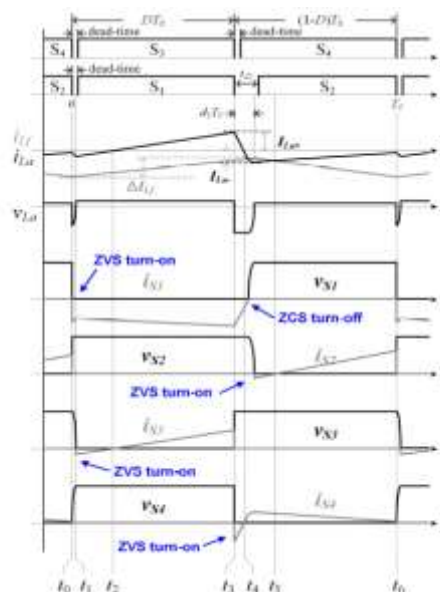
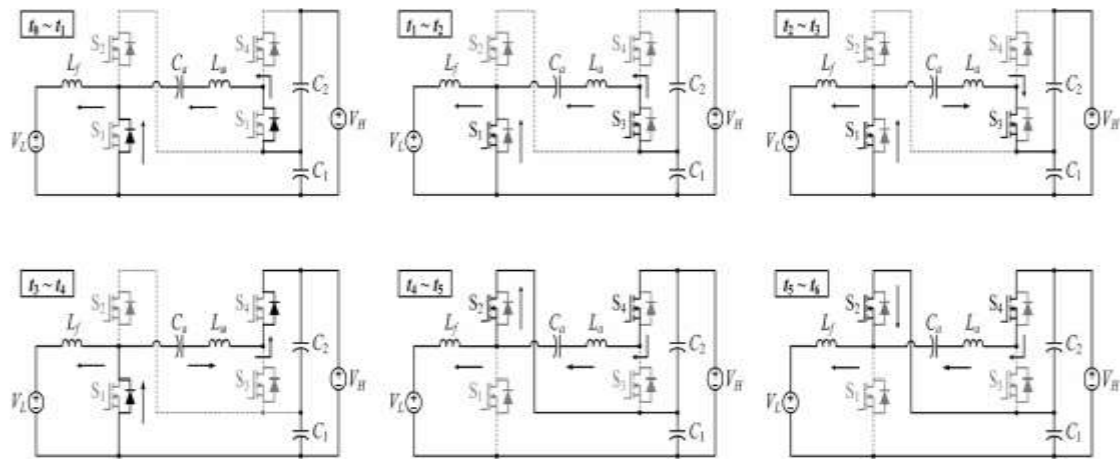


Fig.5. Key Waveform of the Proposed Converter



**Fig.6.Operation States of Proposed Converter (Buck Operation)**

Mode I operation: This mode I [t0-t1] begins with turning OFF of switches S2 and S4. Then, the body diodes of S1 and S3 are turned ON after the parasitic capacitors of S3 and S4 are completely discharged. Inductor current  $i_{Lf}$  starts to decrease.

Mode II operation: This mode II [t1-t2] at t1 inductor current  $i_{La}$  starts to decrease with the slope. After appropriate dead-time switches S1 and S3 are turned ON. The gate signal for S3 should be applied before reversal of current  $i_{La}$  for ZVS turn ON. Note S1 is turned ON without any delay for synchronous rectification. This mode ends when the decreasing current  $i_{La}$  reaches 0 A.

Mode III operation: This mode III [t2-t3] at t2 inductor current  $i_{La}$  is reversed and starts increasing with slope. the positive peak value of  $i_{La}$  can be obtained as follows:

$$i_{La+} = [VC_a - VC_1]/L_a \cdot [DTS - VC_2] \cdot \sqrt{2 \cdot COSS/L_a} \dots (7)$$

Where, COSS is the output capacitance of the switch.

Mode IV operation : This mode IV [t3-t4], Switches S1 and S3 are turned OFF at t3, and the n body diodes of S1 and S4 are turned ON. Inductor current  $i_{La}$  starts to decrease with the slope determined by (2). Note that S4 could be turned ON under ZVS condition if the gate signal for S4 is applied with appropriate dead-time before reversal of current  $i_{La}$ . This mode ends when the decreasing current  $i_{La}$  reaches 0A.

Mode V operation: In mode V [t4-t5], the increasing current  $i_{La}$  becomes greater than the decreasing current  $i_{Lf}$ , body diode of S1 is turned OFF under ZCS condition. Then, after parasitic capacitors of S1 and S2 are completely charged and discharged, respectively, the body diode of S2 is turned ON and inductor currents  $i_{La}$  and  $i_{Lf}$  start to decrease and increase, respectively, with slopes. The negative peak value of  $i_{La}$  is determined by the following equation:

$$i_{La-} = i_{Lf} + \Delta i_{Lf}/2 - VC_1/\sqrt{\frac{L_a}{2 \cdot COSS}} \dots (8)$$

Where,  $\Delta i_{Lf}$  is current ripple of  $L_f$ . For ZVS turn on of S2, the gate signal for S2 should be applied before the decreasing current  $i_{La}$  becomes smaller than the increasing current  $i_{Lf}$ .

Mode VI operation: This mode VI [t5-t6], at t5 switch current  $i_{S2}$  is reversed. Inductor currents  $i_{La}$  and  $i_{Lf}$  keep decreasing and increasing with slopes. At the end of this mode S2 and S4 are turned OFF. This is the end of one complete cycle.

The explained above are the two different modes of operation, the forward mode (boost operation) and reverse mode (buck operation).

#### IV. SIMULATION AND ANALYSIS OF EFFICIENT AND EFFECTIVE ECO-FRIENDLY VEHICLES

Simulation and analysis of high gain soft switching bi-directional dc-dc converter for eco-friendly vehicles is demonstrated using MATLAB Simulink software. Each and every component is designed using MATLAB/SIMULINK and Sim Power System software package to verify the effectiveness of the system.

##### 4.1 Matlab Simulation of Forward Direction

The interleaving technique can be applied to reduce the size of passive components and current stresses. A 5-kW prototype of the two-phase interleaved version of the proposed converter shown in Fig. 5.1 was built according to the following specification:  $P_o = 5$  kW,  $f_s = 30$  kHz,  $V_H = 400$  V,  $V_L = 72$ – $100$  V,  $L_f = 130$   $\mu$ H,  $L_a = 13$   $\mu$ H,  $C_a = 30$   $\mu$ F,  $C1=C2=470$   $\mu$ F.

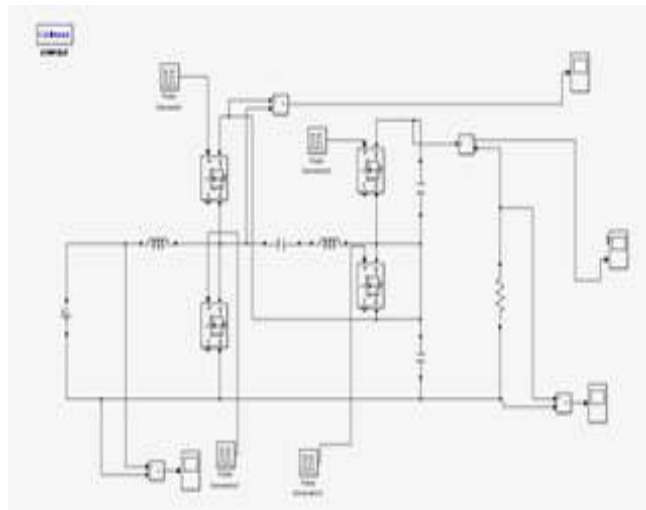


Fig.7.Simulation Circuit for Forward Direction

##### 4.2 Waveforms of Forward Direction

Below shows the input and output voltage waveform of forward direction.

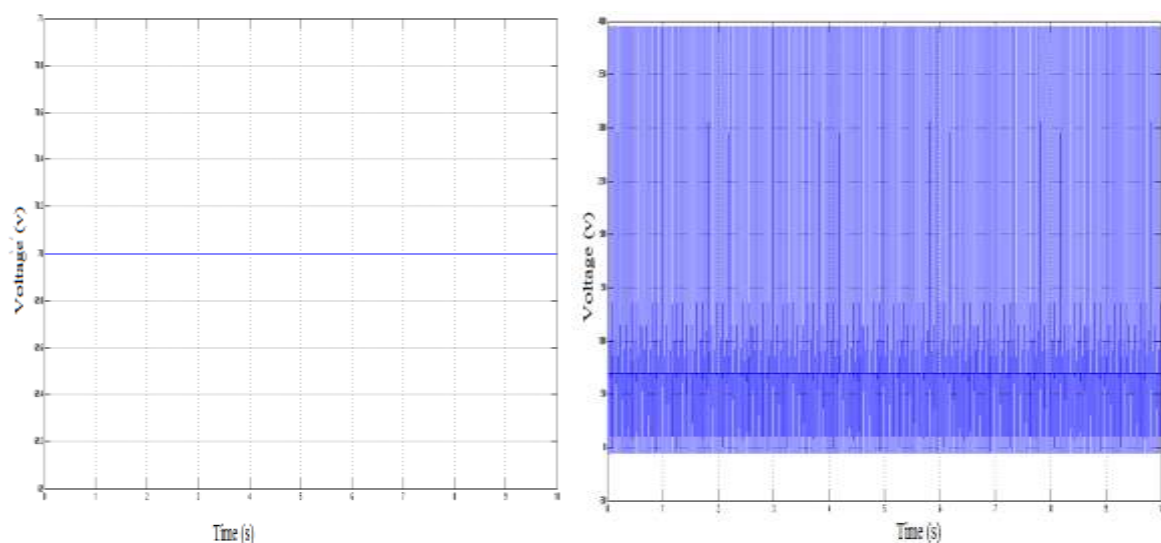


Fig.8. Waveform of Input Voltage and Output Voltage



#### 4.3 Matlab Simulation of Reverse Conduction

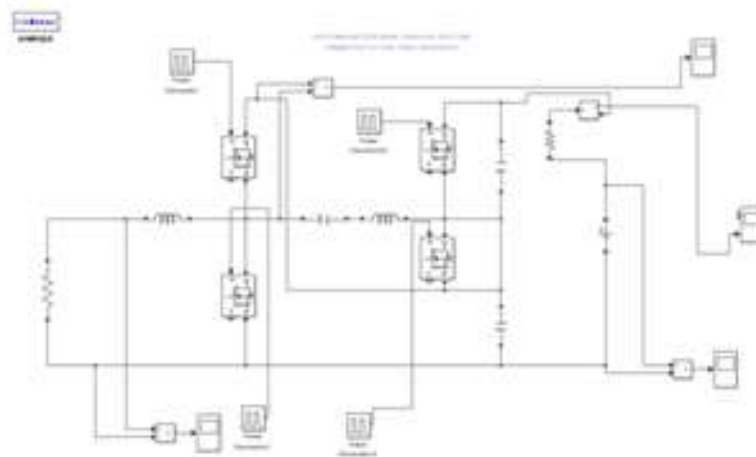


Fig.9. Simulation Circuit for Reverse Direction

#### 4.4 Waveforms of Reverse Conduction

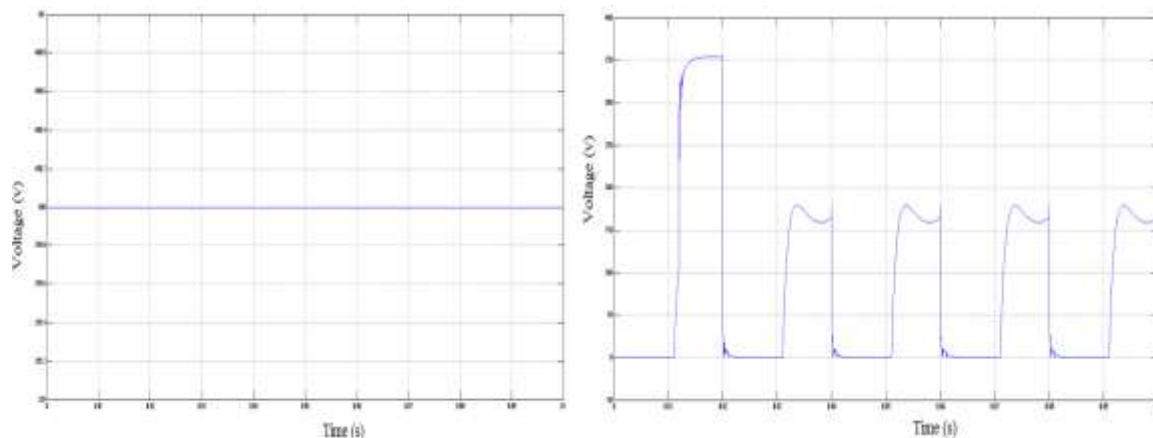


Fig.10. Output Waveform of Input Voltage and Output Voltage

#### 4.5 Modified Matlab Simulation of Forward Direction

The Simulink model used for the implementation of modified high gain soft-switching bidirectional dc-dc converter for eco-friendly vehicles.

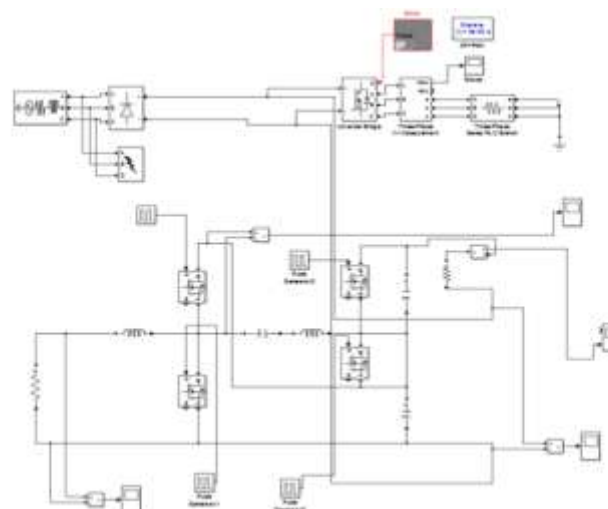


Fig.11 Modified Simulation Circuit for Forward Direction



#### 4.6 Input waveforms of Forward Direction

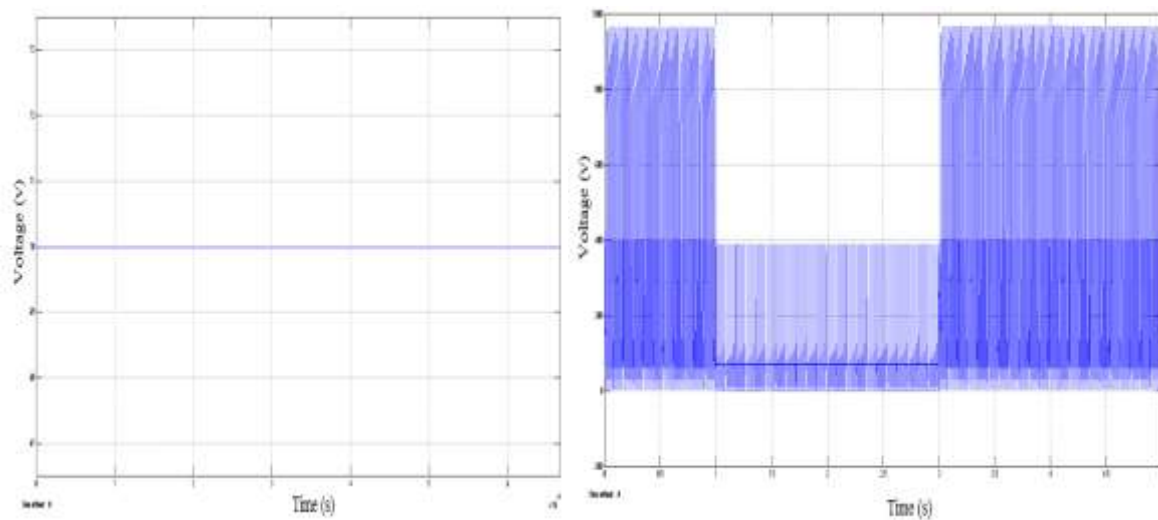


Fig.12 Waveform of Input Voltage and Output Voltage

#### 4.7 Modified Matlab Simulation of Reverse Direction

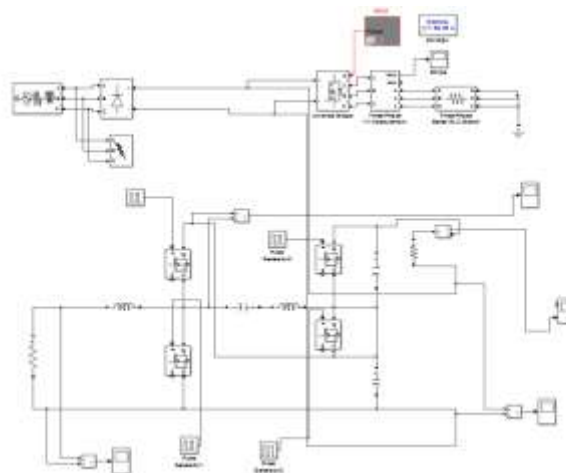


Fig.13 Modified Simulation Circuit for Reverse Direction

#### 4.8 Input waveforms of Reverse Direction

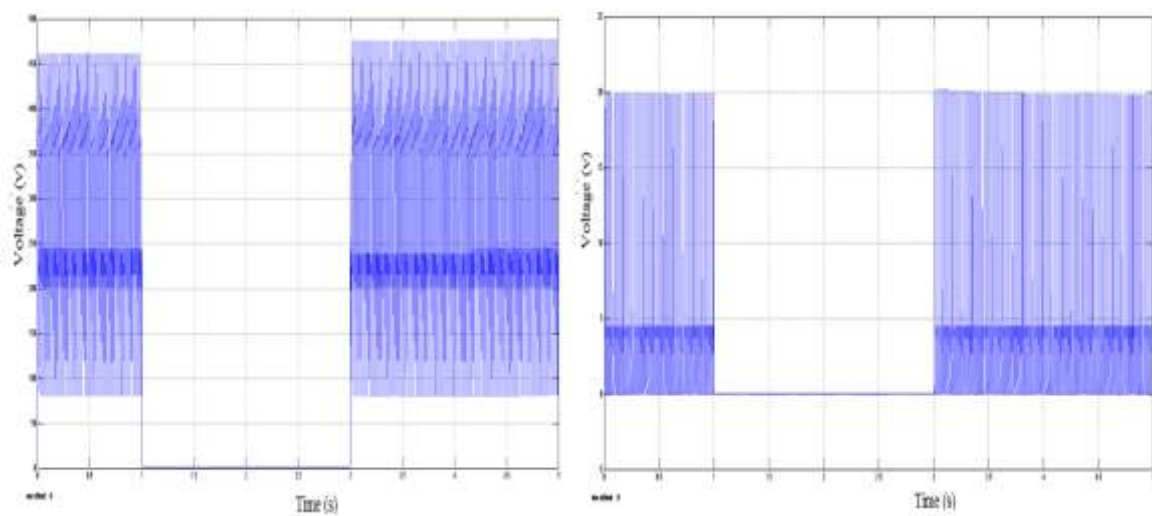


Fig.14 Waveform of Input Voltage and Output Voltage

It is seen that there are no transients caused by change of switching patterns during the mode change. The measured efficiencies under different LVS voltage conditions in forward and reverse modes.

#### 4.9 Comparison

The comparison of the proposed converter circuit and modified converter circuit is analysed and found out that, in the modified converter circuit the regenerative capability is being improved and net efficiency of the eco-friendly vehicle is improved to a higher level.

### V. CONCLUSION

In this paper, a non-isolated soft switching BDC has been proposed for high voltage gain and high-power applications. The proposed converter can achieve ZVS turn on of all switches and ZCS turn off some switches in both boost and buck operations. An optimized switching sequence has been presented along with an intermediate switching pattern to carry out seamless mode change. A 5-kW prototype of the proposed converter has been built and tested to verify the validity of the proposed operation. A nominal duty cycle of 0.64 was used to achieve voltage gain of 5.5. The maximum efficiencies in forward and reverse modes are 97.9% and 97.7%, respectively. It has also been shown in the experiment that the mode change is seamless due to the proposed switching sequence. In future, grid connected applications like a solar roof panel for the hybrid vehicle, which makes it's a renewable application improved battery backup and regenerative capability and hence overall improvement of efficiency is being worked on.

### VI. ACKNOWLEDGEMENT

First and Foremost, I owe my colossal gratitude to the **ALMIGHTYGOD** for blessing me with his grace and taking my endeavour to a successful culmination. I am highly obliged to express my sense of gratitude to the Principal of our institution **Dr.GeorgeChellianChandran,B.E., M.E., Ph.D., PGDBM.**, Head of the Department **Prof.P. Pradeepa, B.E., M.E.,(Ph.D).**, and to my guide **Miss.V. Priya, B.E.,M.E.**,Asst. Professor, Electrical and Electronics Engineering.

### REFERENCES

- [1] Minho Kwon, "High Gain Soft-Switching Bidirectional DC–DC Converter for Eco-Friendly Vehicles", IEEE Transactions on Power Electronics, vol. 29, no. 4, april 2014.
- [2] J. Zhang, R. Y. Kim, and J. S. Lai, "High-Power density design of a soft- switching high-power bidirectional DC-DC converter," in Proc IEEE Power Electron. Spec. Conf., 2006, vol. 2, pp. 1–7.
- [3] Y. Du, X. Zhou, S. Bai, S. Lukic, and A. Huang, "Review of non-isolated bi-directional DC–DC converters for plug-in hybrid electric vehicle charge station application at municipal parking decks," in Proc. 25th IEEE Appl. Power Electron. Conf. Expo., 2010, pp. 1145–1151.
- [4] W. Li, X. Lv, Y. Deng, J. Liu, and X. He, "A review of non-isolated high step-up DC/DC converters in renewable energy applications," in Proc. 24th Annu. IEEE Appl. Power Electron. Conf. Expo., Washington, DC, USA, Feb. 15–19, 2009, pp. 364–369.
- [5] Muhammad H. Rashid, Power Electronics Circuits Devices and Applications (Pearson, Noida 2012).
- [6] Dr.P.S.Bhimra, Power Electronics and Drives (Khanna publishers, New Delhi 2012).