ANALYSIS OF A WIDE VOLTAGE GAIN BI DIRECTIONAL DCTO DC CONVERTER FOR CHARGING OF ELECTRIC VEHICLES

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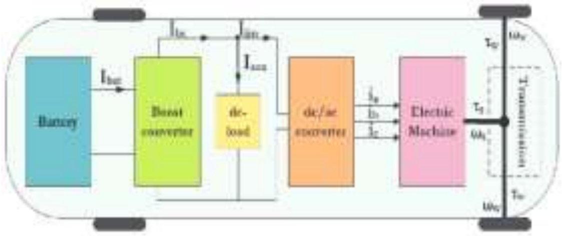
ABSTRACT- A bidirectional converter is used in electric vehicles (EVs) because the power flow will be in reverse while regenerative braking, and by collecting this power, effective operation can be achieved. In this paper, a bidirectional D C -D C converter with high voltage gain, continuous current conduction at both ports, and good steady state response is described. Three M O SFE T switches, two inductors, and four capacitors comprise the converter topology. Furthermore, decreasingswitching losses improves converter efficiency. This is applicable in the following areas: electric vehicles, distribution generation, energy storage units, and microgrids. The proposed converter has a power rating of 1.5kW and a voltage rating of 400V.The designed converter can be compared to standardconverters in terms of voltage gain and steady-state response, to emphasise the uniqueness of theproposed converter.

KEYWORDS: Electric Vehicle (EV), Bidirectional DC-DC Converter, Wide Voltage Gain, Steady State Response.

INTRODUCTION:

Due to limited energy resources and the continuous increase of pollutant factors around the world, researchers are looking into the use of renewable energy sources. More opportunities exist in the transportation industry for electric vehicular technologies, such as designing battery-powered electric vehicles with greater drive-in range and less charging time. Furthermore, an efficient Battery Management System (BMS) can significantly improve power saving capability and thus increase battery life cycle.

Figure 1 depicts the general architecture of an electric vehicle. The voltage from the utility grid contains ripple, and feeding this supply directly to vehicles may result in dangerous conditions. As a result, a power smoothing adapter must be used to charge the battery. The battery must provide the necessary power for the motor. To provide power from the battery to the motor, a step-up DC-DC converter is required. The power flow will be in the reverse direction during regenerative braking. Onboard converters must be bidirectional in order to store regenerative power. As a result, Bidirectional Buck Boost converters (BBBC) can be used. The designed converter should be light in weight because adding weight to an electric vehicle reduces overall efficiency.



PROPOSED KIT

Any Electric Vehicle configuration consists of a converter, a motor, and a controller. The converter is responsible for both charging the battery and powering the motor. A power electronic controller regulates the flow of power and is used to keep the vehicle running smoothly. The vehicle is propelled by the motor. The standard BBBC is used in low voltage applications and has only two switches. The conventional voltage gain is limited, and the losses are increased due to inductor and capacitor resistances. Most papers on bidirectionalconverters focused on continuous current operation in only one direction of power. How. Cuk Converter can be used in some storage applications, but it has some drawbacks such as low voltage gain and stress on the capacitor. The switch count is high. Similarly, bidirectional Single Ended Primary Inductor Current,

(SEPIC) converters have higher voltage stress on switches and continuous current conduction at one of their ports. Because of these limitations, the above converters are only suitable for low voltage applications. The KY and Synchronous-based converters have advantages such as low voltage stress on switches and continuous current at its ports , but theyhave a low voltage gain.

As a result, an efficient DC-DC converter with high voltage gain, continuous current at both ports, and small component size is proposed in this paper. To analyse the steady state response, a motor is connected to the proposed converter design.

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When the Switch SI is turned on in forward mode, energy is stored in the inductor L. When SI is turned off and S2 is turned on, power from both sources as well as the inductor is fed to the load, causing the voltage level to step.

When SI is turned off and S2 is turned on in reverse, the converter operates in buck mode. The voltage gain of the converter can be calculated using the voltsec balance condition.

PROPOSED CONVERTER DESIGN:

Depicts the proposed converter's configuration. Three MOSFET switches (Ql, Q2& Q3), two inductors (LI, L2), and four capacitors (Cl, C2, C3& C4) are used in the converter. There are two ports on the converter:port A and port B. The proposed converter operates as a boost converter in forward mode and as a buck converter in reverse mode. Gating signals (Gl, G2, and G3) are generated based onthe duty cycle of the converter for a given outputvoltage.

To reduce switching losses, synchronous rectification can be used for Switches Q2 and Q3in forward operation and Switch Q lin backwardoperation.

For the analysis of the proposed converter design, certain assumptions are made: I All capacitors and inductors are initially charged; and ii) All inductors and capacitors are identical.
iii) MOSFETS ON state resistance is ignored.

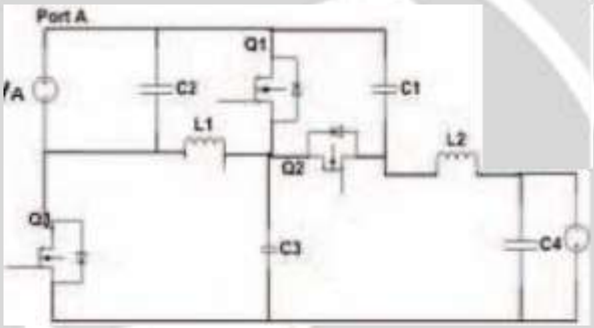


Fig 2 Proposed Configuration.

FORWARD OPERATION (A TO B): IN THIS MODE, switch Ql is turned ON by giving gate pulse Gl, and switches Q2 and Q3 are turned OFF. The current path in this mode is from Va to Q l, LI, and Va. The initially charged inductors and capacitors can supply current to port B. When a resistive load is connected, the output current is reversed. The gating signal is diT, where di is the duty cycle and T is the switching frequency time period. The gain can be calculated from mesh analysis using voltage equations (1) to (2).

$$vc1 = va /1-d1 \text{ ....}1$$

$$vC3 = d1 /1-d1 \cdot \text{..................}2$$

$$vB = 2d/1-d1\ va \text{..................}3$$

The gain for A to B operation (Boost operation) is given as,

$$vB\ va = d1/ 1-d1 \ \dots \dots \dots \dots \dots \dots \ 4.$$

Where Vb = Output voltage Va = Input voltage di= Duty cycle for A to B operation. BACKWARD OPERATION (B to A operation): In this mode, Ql is turned off, while Q2 and Q3 are turned on via gate signals G2 and G3, respectively. The timing signal is represented by d2T, where d2 is the duty cycle and T is the time period. The voltage equations that are required for B to A operation are.

$$\mathbf{vC1} = \mathbf{vB}\ /2(\mathbf{1} - \mathbf{d2}\ ) \dots \dots \dots \text{..}\ .\ \mathbf{5}$$

$$\mathbf{vC3} = \mathbf{vB}\ \mathbf{2} \dots \dots \dots \dots \dots \dots \dots \dots \ \mathbf{6}$$

$$vA = d2vB\ /2(\mathbf{1} - \alpha\mathbf{2}\ ) \dots \dots \dots \dots \dots \ \mathbf{8}$$

The voltage Gain for B to A (BUCK operation Are :

$$\mathbf{vA\ vB} = \mathbf{d2}\ /\mathbf{2}(\mathbf{1} - \mathbf{d2}\ ) \ldots \ldots \ldots \ldots \ldots \ldots .\ \mathbf{9}$$

DESIGN OF INDUCTORS AND CAPACITORS: The critical values of inductor can be calculated by considering the volt second balance equations of converter are

$$\mathbf{L1} = \mathbf{vAdL}\ /\mathbf{f0\Delta 1\ \ 0\ \ l2} \ldots\ldots\ldots\ldots\ldots 10$$

$$\boldsymbol{L2} = \boldsymbol{vAd2}\ /\boldsymbol{f\sigma\Delta 1\ \ 0L2} \ldots \ldots \ldots \ldots \ldots \ldots \ldots .\ \mathbf{11}$$

Where Va = Voltage at port A Fs = Switching frequency. Il & Il 2 are inductor ripple currents. Table 1 provides the designed inductor and capacitor values for a given duty ratio, input voltage and switching.

Circuit Parameter	Value
Input voltage	85V
Switching Frequency	50KHz
Duty cycle	0.7
Inductors L1, L2	300uh
Capacitors c1,c2	240uf
Capacitors c3 c4	50uf

SIMULATION RESULTS AND DISCUSSION:

1). **PROPOSED CONVERTER**: The Gating signals for Ql, Q2& Q3 for a duty cycle of 0.7, current in inductors are shown in Fig. 4(a)& 4(b) and voltage waveforms across capacitors are shown in Fig. 5(a), 5(b), 5(c)& 5(c) for boost mode of operation.

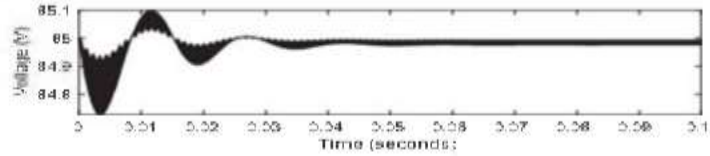


Fig. 5(b)

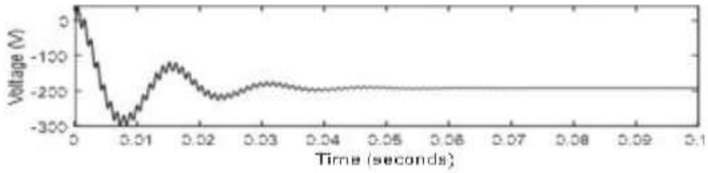


Fig. 5(c)

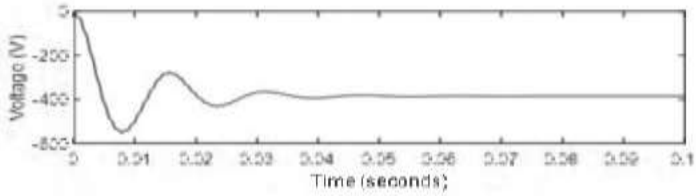


Fig. 5(d)

Fig. 5(a), 5(b), 5(c), 5(d) Voltage across Capacitors C1, C2, C3& C4

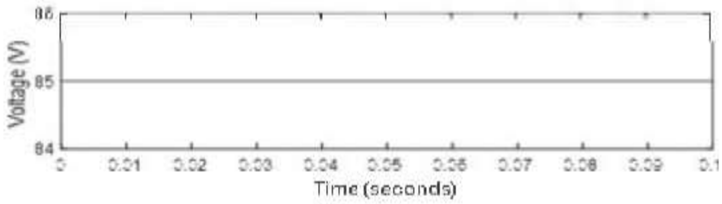


Fig. 6(a)

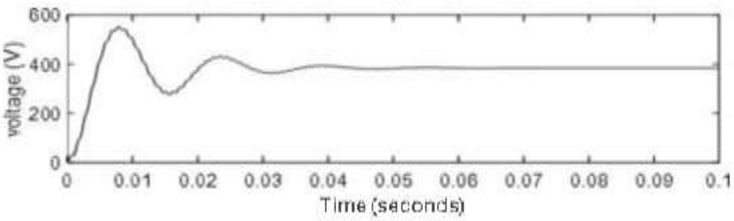


Fig. 6(b)

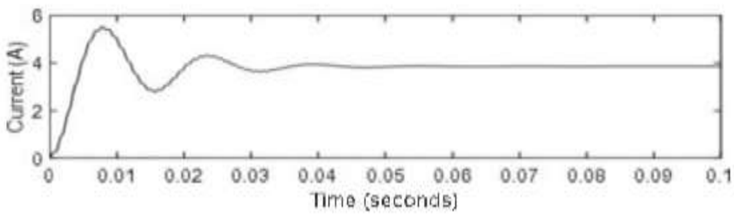


Fig. 6(c)

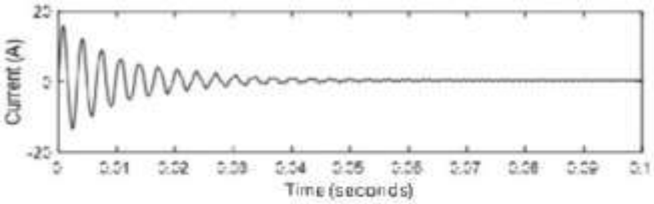


Fig. 7(a)

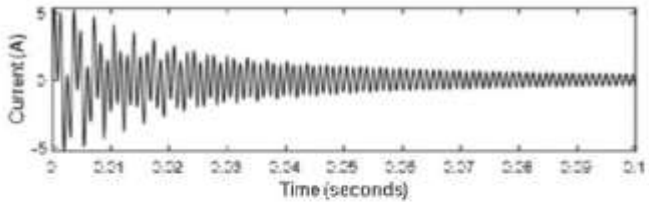


Fig. 7(b)

Fig. 7(a), 7(b) Current in Inductors L1& L2

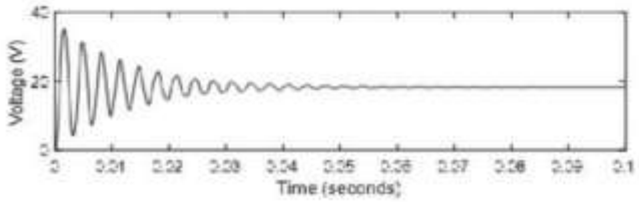


Fig. 8(a)

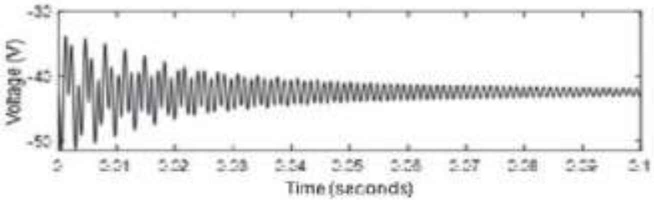


Fig. 8(b)

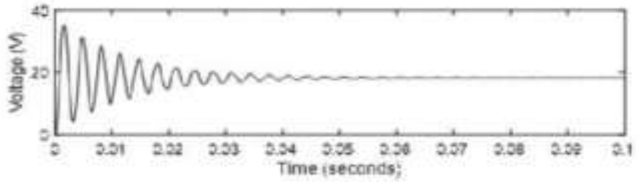


Fig. 8(c)

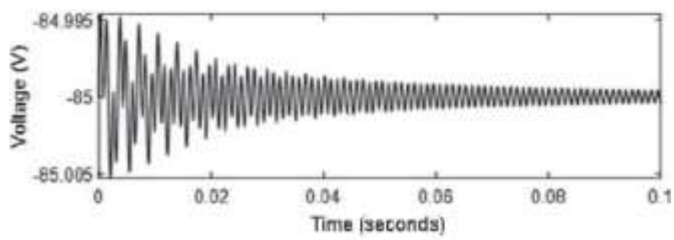


Fig. 8(d)

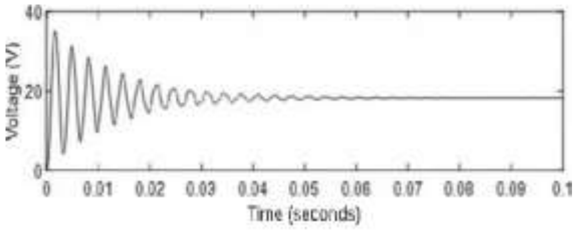


Fig. 9(a)

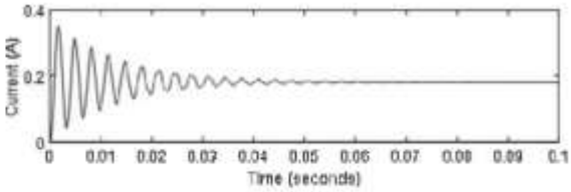


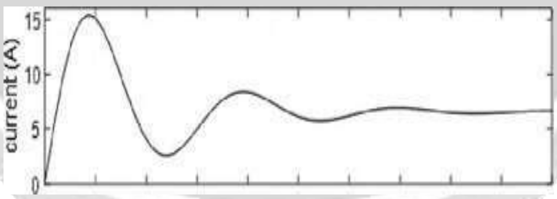
Fig. 9(b)

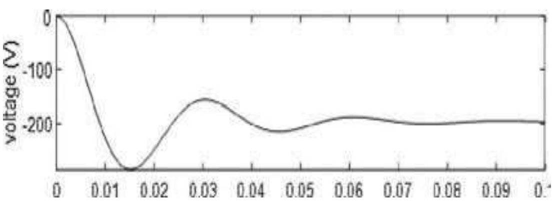
Fig: Voltage and current waveforms in buck mode.

CONVENTIONAL CONVERTER

With an input voltage of 85V, a duty cycle of 0.7, and a switching frequency of 50kHz, the conventional converter is simulated. Figure 10depicts the current in the inductor, while Figure 11depicts the voltage across the capacitor.

In forward operation, the converter operates in boost mode. The waveforms for voltage and current are given in Fig. 12(a)& 12(b). In backward operation the converter operates in buck mode. The output waveforms for voltage





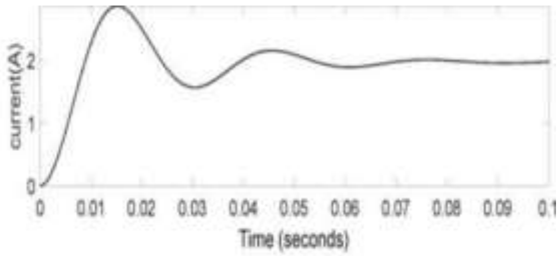


Fig. 12(b)

Fig. 12(a), 12(b) Voltage and Current waveforms in boost mode

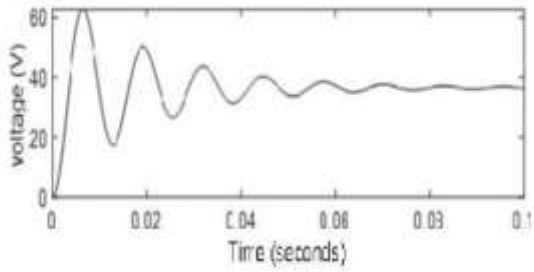
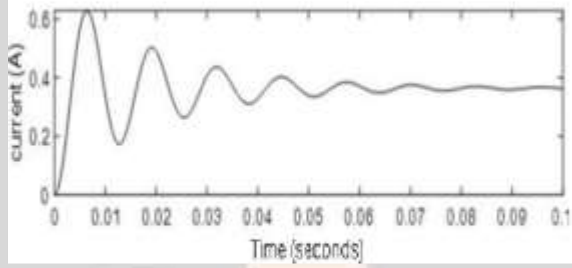


Fig. 13(a)



MOTOR LOAD:

Bidirectional DC to DC converters are used in avariety of applications, including energy storageunits renewable energy applications , microgrids , nano grids, DC grids , and electric vehicles.

When a conventional converter is connected to a motor load for a given input voltage of 85V, the output voltage is 220V with low speed, high torque, high armature current, and poor response. Voltage and current waveforms for 110V input are shown in Figs. 14(a) and 14(b), and speed, torque, and armature current waveforms are shown in Figs. 16(a), 16(b), and 16(c) (c). Using the proposed converter design with the motor connected load, the output. voltage is 360V for an input voltage of 85V, resulting in highspeed medium torque. Furthermore, the response time is shorter

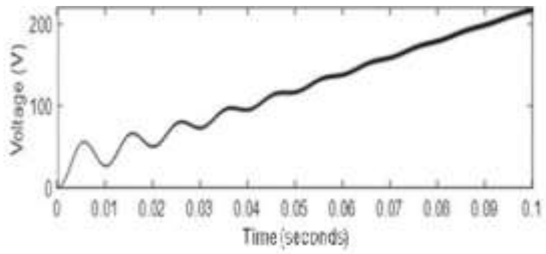


Fig. 14(a)

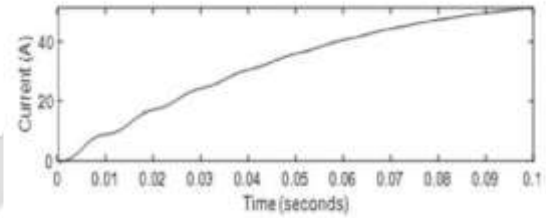


Fig. 14(b)

. 14(a), 14(b) Voltage and Current waveforms for motor connected load of Conventional converter

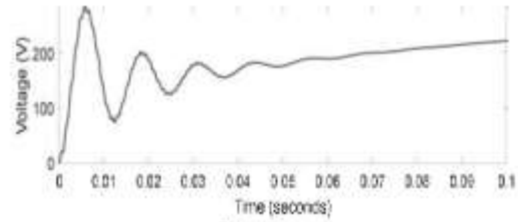


Fig. 15(a)

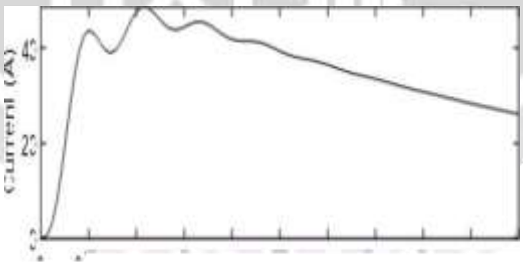


Fig. 15(a), 15(b) Voltage and Current waveforms for motor connected load of proposed converter.

of proposed converter

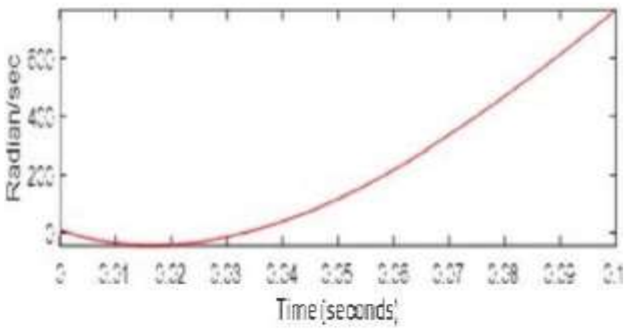


Fig. 16(a)

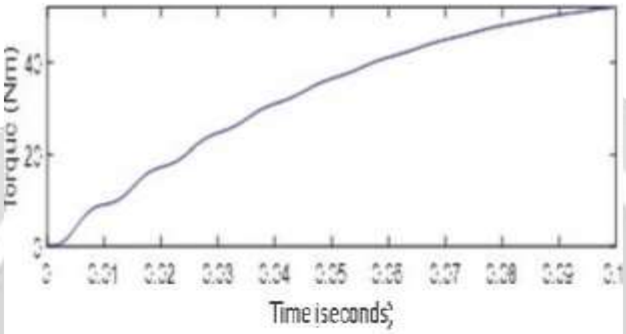


Fig. 16(b)

Fig. 16a 16b 16c speed torque armature conductor of motor of proposed converter

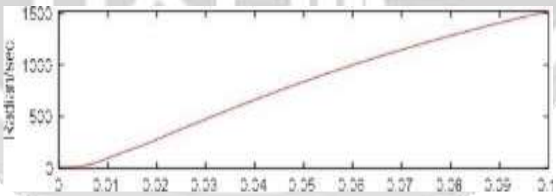
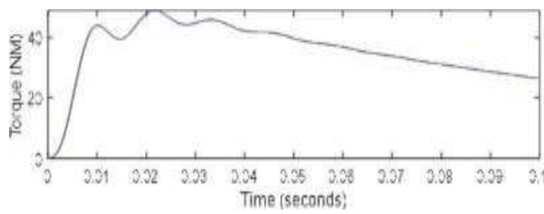


Fig 17(a)



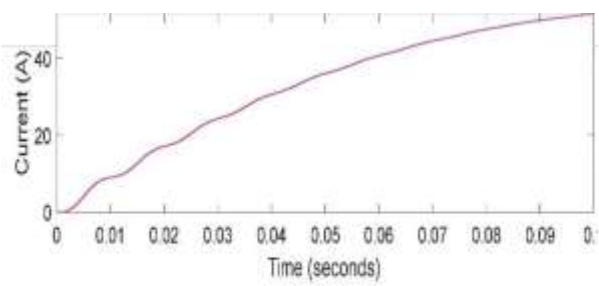


Fig. 16(c)

Fig 17 (b)

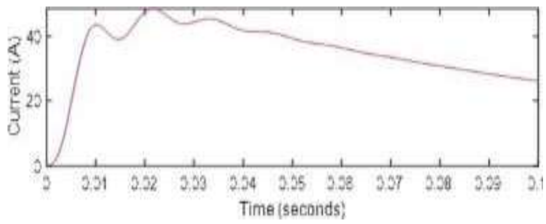


Fig 17 (c)

Fig. 17(a), 17(b), 17(c) Speed, Torque& ArmatureCurrent of motor with proposed converter

COMPARISION TABLE FOR CONVENTIONAL CONVERTER

FOR PROPOSED CONVERTER:

PARAMETR	CONVENTIONAL CONVERTER	PROPOSED CONVERTER
Voltage gain	2.33	4.6
Voltage stress	314.42V	214.2V
Response time	0.08s	0.04S
Effciency	89	93.2

CONCLUSIONS

The voltage gain of both the traditional and proposed converters is validated in this research. The proposed converter has a rapid reaction, taking only 0.02s to reach peak value, as well as a high voltage gain of 2.3 times that of thetraditional BBBC.

The proposed BBBC operates in Boost mode in one direction and Buck mode in another direction with low voltage stress on MOSFETS and less switching losses. Synchronous rectification greatly enhances the efficiency of converter. All these advantages made thisconverter versatile to high power applications mostly in power applications.

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