Simulation of High Voltage Gain Zero Voltage Switching Boost Converter

M. M. Irfan

Abstract: This paper proposes a new soft-switched continuous conduction-mode (CCM) boost converter suitable for high-voltage gain applications such as hybrid electric vehicles, and fuel cell power conversion systems. The proposed converter achieves zero-voltage switched (ZVS) turn-on of active switches in CCM .Voltage gain is almost increased four times compared to the conventional boost converter. Moreover, soft-switching charac- teristic of the proposed converter reduces switching loss of active power switches and raises the conversion efficiency.

Keywords: CCM, ZVS, Boost converter

I.INTRODUCTION

In many industrial applications, it is required to convert a fixed voltage dc source into a variable voltage dc source.A dc chopper converts directly from dc to dc..A chopper can be considered as dc equivalent to an ac transformer with a continuously variable turn's ratio.Like a transformer, it can be used to step-down or step-up a dc voltage source.

Choppers are widely used for traction motor control in electric automobiles, trolley cars, marine hoists, forklift trucks, and mine haulers. they provide smooth acceleration control,high efficiency, and fast dynamic response. choppers can be used in regenerative braking of dc motors to return energy back in to the supply ,and this feature results in energy savings for transportation systems with frequent stops. choppers are used in dc voltage regulators, and also used,in conjuction with an inductor, to generate a dc current source ,especially for the current source inverter. the energy shortage and atmosphere pollution have led to renewable and green energy sources such as solar arrays and fuel cells.[1-3]

A. Photovoltaic cell

A solar cell (also called a photovoltaic cell) is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. Solar power is pollution-free during use. Production end-wastes and emissions are manageable using existing pollution controls. End-of-use recycling technologies are under development and policies are being produced that encourage recycling from producers.

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In this paper a solar based soft switching dc-dc converter with high voltage gain is proposed. A CCM boost cell provides a continuous input current. To increase the voltage gain ,the output of the coupled inductor cell is laid on the top of the output of the CCM boost cell.

II.CONVENTIONAL CONVERTERS

B. Hard switching converters

Hard switching refers to the stressful switching behavior of the power electronic devices. During the turn-on and turn-off processes, the power device has to withstand high voltage and current simultaneously, resulting in high switching losses and stress. Dissipative passive snubbers are usually added to the power circuits so that the dv/dt and di/dt of the power devices could be reduced, and the switching loss and stress be diverted to the passive snubber circuits. However, the switching loss is proportional to the switching frequency, thus limiting the maximum switching frequency of the power converters.

C. Soft switching converters

Soft-switched converters that combine the advantages of conventional PWM converters and resonant converters have been developed. These soft-switched converters have switching waveforms similar to those of conventional PWM converters except that the rising and falling edges of the waveforms are 'smoothed' with no transient spikes. Unlike the resonant converters, new soft-switched converters usually utilize the resonance in a controlled manner. Resonance is allowed to occur just before and during the turn-on and turn-off processes so as to create ZVS and ZCS conditions. In order to increase the efficiency and power conversion density, a soft switching method is required in dc-dc converters.[4]-[7].Because the switching loss and stress have been reduced, soft-switched converter can be operated at the very high frequency (typically 500kHz to a few Mega-Hertz). Soft-switching converters also provide an effective solution to suppress EMI and have been applied to DC-DC, AC-DC and DC-AC converters.

III.SOFT SWITCHING DC-DC CONVERTER

The objectives of many of these topologies are to develop high switching converters with high power density and high efficiency.

This was accomplished by adding additional components to the power stage to either limit the resonant period and/or to utilize power device parasitic components.

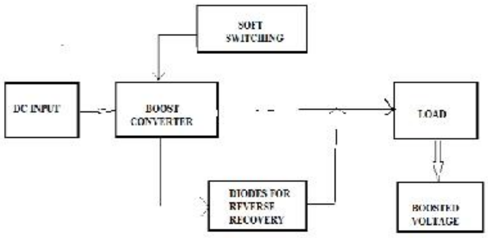

Fig.1.Basic block diagram of the soft switching converter

In general, The various DC-DC converters which we use have small voltage gain because of high input current ripples. The reverse recovery problem of the output diodes is an important factor in dc-dc converter with high voltage gain[8],[9].

To get high voltage gain, which includes following considerations.i.e.low current ripple, high efficiency, fast dynamics, light weight,and high power density;a new converter is designed here.

IV.PROPOSED CONVERTER

The proposed converter have CCM(continuous conduction mode)boost cell and coupled inductor cell

1. CCM is used to get low current ripples.
2. Coupled inductor cell is used to minimize the reverse recovery characteristics of the rectifier.

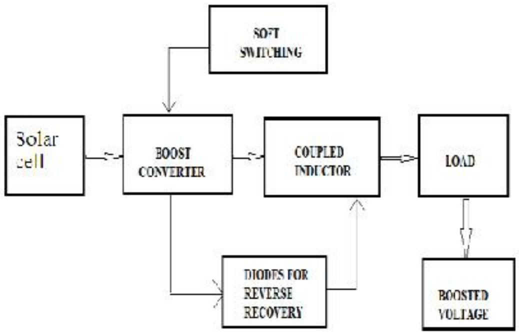

Fig.2.Basic block diagram of proposed converter

A soft-switching dc/dc converter with high voltage gain is proposed. It provides a continuous input current and high voltage gain. Moreover, soft-switching characteristic of the proposed converter reduces switching loss of active power switches and raises the conversion efficiency. The reverse-recovery problem of output rectifiers is also alleviated by controlling the current changing rates of diodes with the use of the leakage inductance of a coupled inductor.

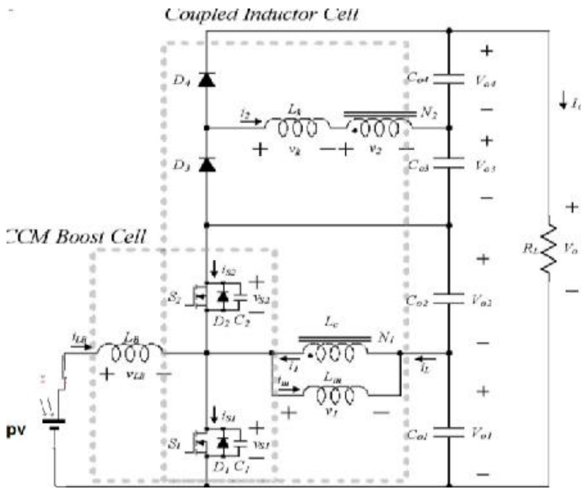

Fig.3.Circuit diagram of the proposed dc/dc converter.

This paper proposes a new soft-switched CCM boost converter suitable for high-power applications such as power factor correction, hybrid electric vehicles, and fuel cell power conversion systems.

A soft-switching dc/dc converter with high voltage gain, which is shown in Fig.3, is proposed. A CCM boost cell provides a continuous input current. To increase the voltage gain, the output of the coupled inductor cell is laid on the top of the output of the CCM boost cell. Therefore, the high voltage gain is obtained without high turn ratio of the coupled inductor, and the voltage stresses of the switches are confined to the output voltage of the CCM boost cell. A zero-voltage-switching (ZVS) operation of the power switches reduces the switching loss during the switching transition and improves the overall efficiency.

A. Analysis of the proposed converter

Fig. 3 shows the circuit diagram of the proposed soft switching dc/dc converter with high voltage gain. Its key waveforms are shown in Fig. 4. The switches S1 and S2 are operated asymmetrically and the duty ratio D is based on the switch S1. D1 and D2 are intrinsic body diodes of S1 and S2. Capacitors *C*1 and *C*2 are the parasitic output capacitances of S1 and S2. The proposed converter contains a CCM boost cell. It consists of LB*,* S1*,* S2*, Co*1, and *Co*2. The CCM boost cell provides a continuous input current. When the switch S1 is turned on, the boost inductor current iLB increases linearly from its minimum value ILB2 to its maximum value ILB1. When the switch S1 is turned off and the switch S2 is turned on, the current iLB decreases linearly from ILB1 to ILB2.

Therefore, the output capacitor voltages Vo1 and Vo2 can be derived easily as

$$V_{01} = V_{in} \qquad (1)$$

$$V_{02} = \frac{D}{1-D} V_{in.} \qquad (2)$$

The coupled inductor current iL varies from its minimum value −IL1 to its maximum value IL2. The operation of the proposed converter in one switching period Ts can be divided into six modes as in Fig.3

Mode 1 [t0, t1]: At $t0$, the switch S2 is turned off. Then, the boost inductor current iLB and the coupled inductor current iL start to charge C2 and discharge C1. Therefore, the voltage Vs1 across S1 starts to fall and the voltage Vs2 across S2 starts to rise.

Mode 2 [t1, t2]: At $t1$, the voltage vS1 across the lower switch S1 becomes zero and the lower diode D1 is turned on. Then, the gate signal is applied to the switch S1.

Mode 3 [t2, t3]: At t2, the secondary current $i2$ changes its direction. The diode current iD4 decreases to zero and the diode D4 is turned off.

Mode 4 [t3, t4]: At t3, the lower switch S1 is turned off. Then, the boost inductor current iLB and the coupled inductor current iL start to charge $C1$ and discharge $C2$.

Mode 5 [t4, t5]: At t4 , the voltage vS2 across the upper switch S2 becomes zero and the diode D2 is turned on. Then, the gate signal is applied to the switch S2.

Mode 6 [t5, t6]: At t5, the secondary current $i2$ changes its direction. The diode current iD3 decreases to zero and the diode D3 is turned off.

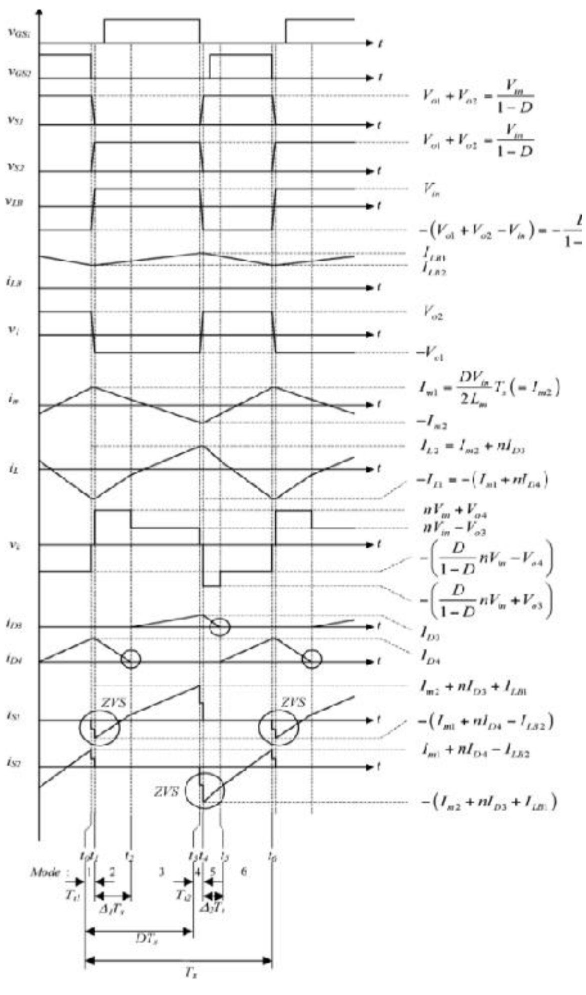

Fig. 4. Key waveforms of the proposed converter.

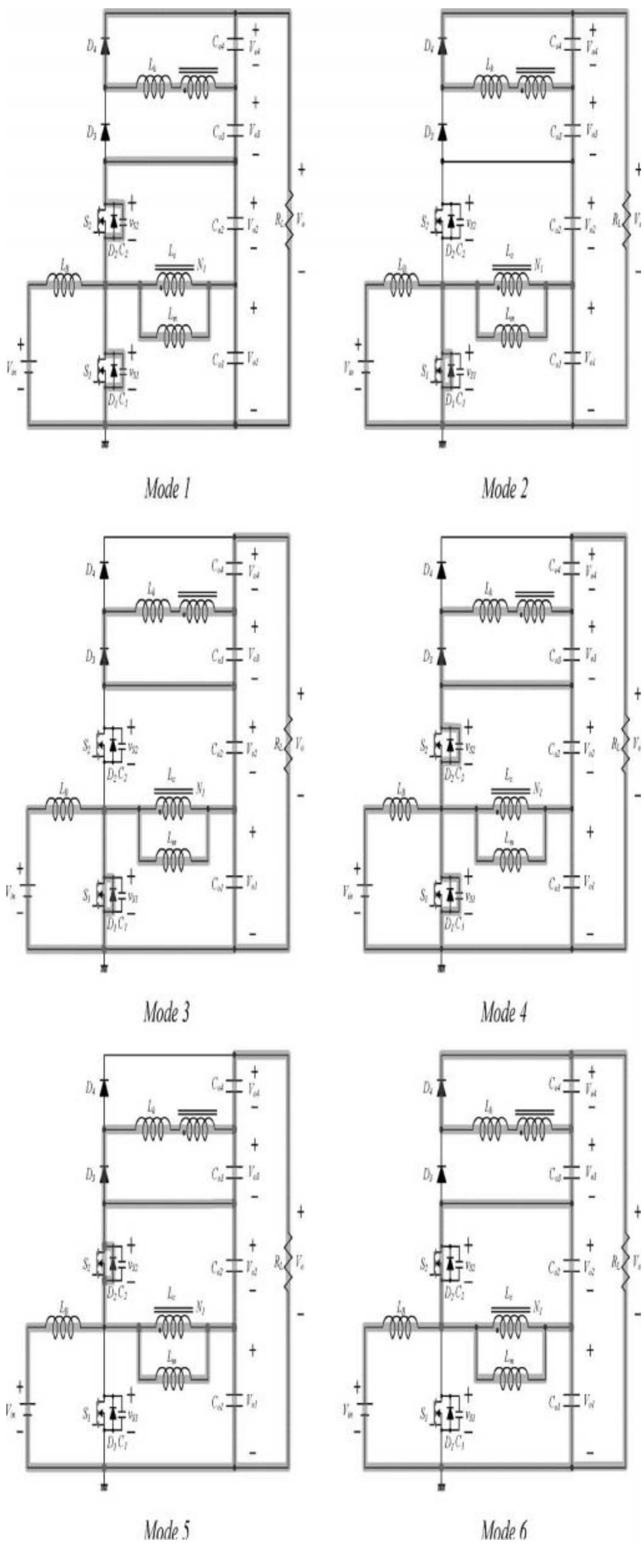

Fig. 5. Operating modes.

V.SIMULATION RESULTS

The proposed soft-switching dc/dc converter with high voltage gain is implemented using MATLAB.

Simulation results:

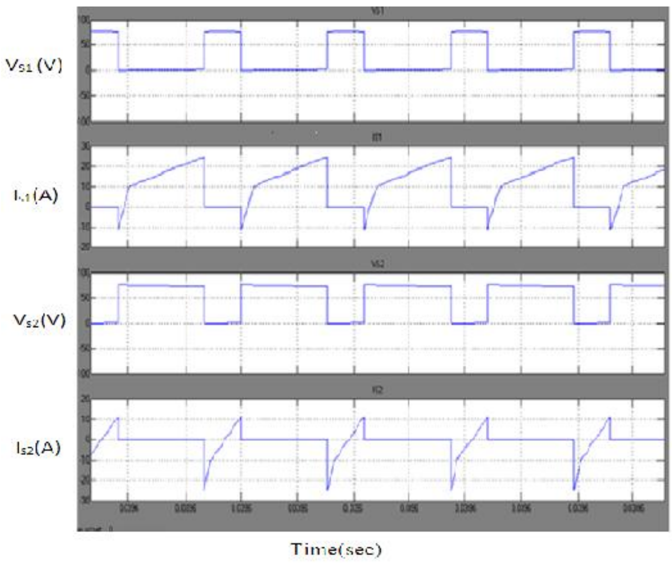

Fig.6.Vs1,Is1,Vs2,Is2

Fig.6 shows the voltage V_{s1} across the switch S_1 reaches zero before the gate pulse is applied to switch S_1.And it also shows the current flowing through switch s_1,voltage V_{s2} across switch s_2,current flowing through switch s_2.

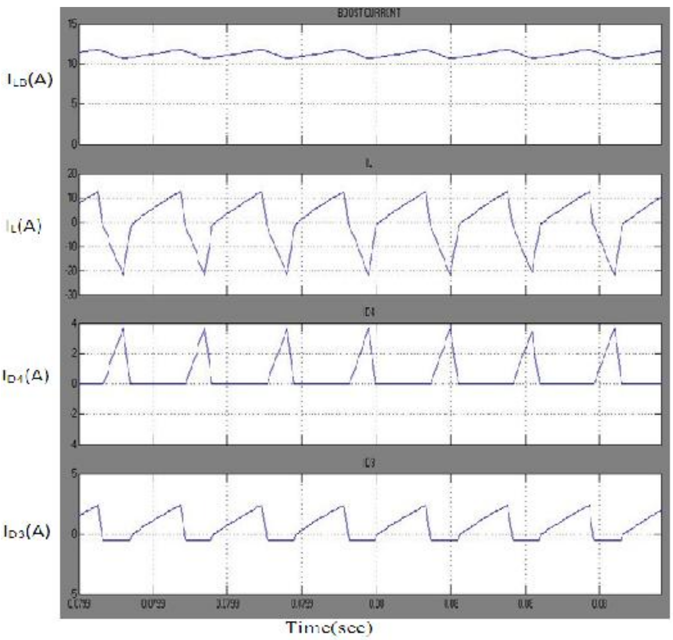

Fig.7.I_{lb},I_L,I_{D4},I_{D3}

Fig.7 shows the inductor currents I_{LB} and I_L,and the turn-off current of diodes D_3 and D_4.It is clear that the reverse recovery current is significantly reduced and the reverse –recovery problem is alleviated by the leakage inductance of the coupled inductor L_C.

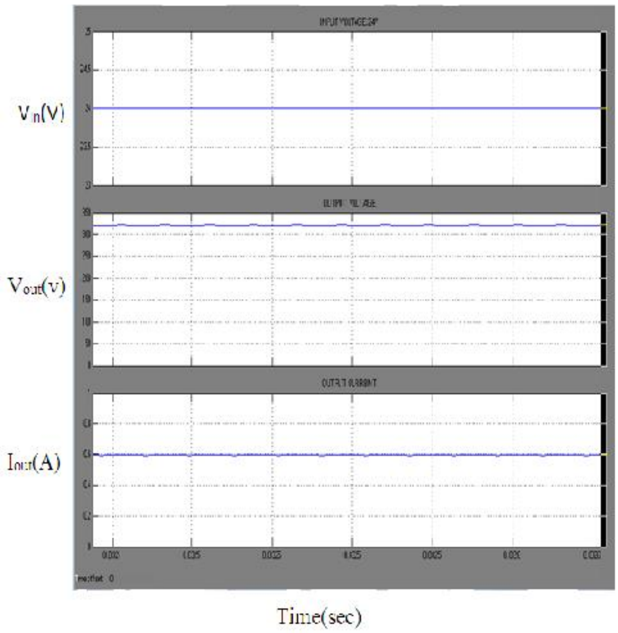

Fig.8.V_{in},V_{out},I_{out}.

Fig.8 shows the input voltage, and the output voltage and output current across load.

Comparison between hard switching and soft switching for R_L=540ohms

	V_{in}	V_{out}	I_{out}	P_{out}	Gain
Soft swithing Dc-Dc convereter	24	321.6	0.62	200	13.4
Hard switching Dc-Dc converter	24	82.2	0.162	13.3	3.53

Soft switching dc-dc converter is simulated for 24V input, and load resistance of 540ohms.The gain observed for this converter is 13.4.conventional boost converter using hard switching is simulated for 24V input and load resistance of 540ohms,the gain is observed for this converter is 3.53.Comparing proposed converter with conventional converter the gain of proposed converter is increased 4 times than conventional converter.

For different values of duty ratio, proposed converter is simulated and the outputs are tabulated.Volage gain versus Duty ratio curve is shown below.

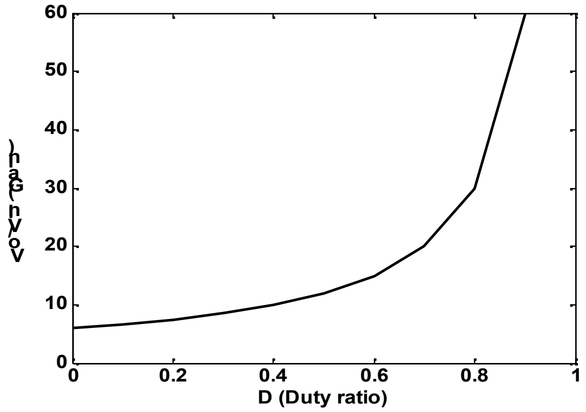

Fig.9.Voltage gain curve for soft switching dc-dc boost converter

Fig.9 shows the voltage gain curve for soft switching dc-dc boost cinverter.As the duty ratio increases,voltage gain also increases linearly for proposed converter.

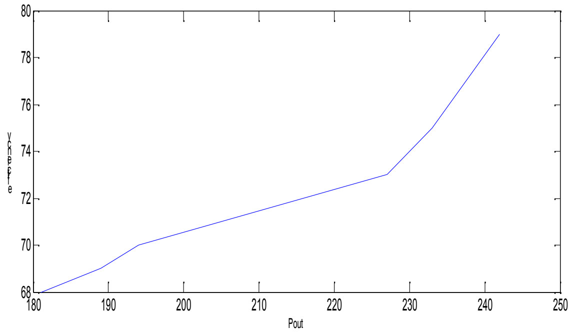

Fig.10.Efficiency curve for soft switching dc-dc boost converter for different loads.

Fig.10 shows the measured efficiency of the proposed converter. It exhibits different values of efficiency for different values of loads. The overall efficiency was improved by around 2%compared with the conventional converter.

VI.CONCLUSION

Due to the effect of parasitic elements the output voltage and power transfer efficiency of DC-DC converters are limited. These limitations are overcome by using the voltage lift technique, opens a good way to improve the performance characteristics of DC-DC converter. These converters perform positive DC-DC voltage increasing conversion with high efficiency, low cost in simple structure, small ripples, and high voltage gain. Simulation results using MATLAB along theoretical analysis are provided to verify its performance. The reverse-recovery problem of output rectifiers is also alleviated by controlling the current changing rates of diodes with the use of the leakage inductance of a coupled inductor Voltage gain of the proposed converter is 13.4 and efficiency is 96.66%,as duty ratio is increased, voltage gain also increases.

VII.REFERENCES

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