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A Study of Interleaved Boost Converter for Renewable Energy Systems

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ABSTRACT

This paper describes the Interleaved Boost Converter and simulated on matlab / simulink. An Interleaved Boost Converter provides a medium output voltage which is intended to power an inverter that subsequently drives a single phase AC motor. The input considered is to be necessarily from constant DC supply or from solar panel. The choice of the interleaved boost converter is justified by simulating and comparing various boost converter topology combinations and it is found that the chosen topology is the best option from the view of minimum output voltage ripple, current ripple and maximum conversion efficiency.

Keywords- Interleaved Boost Converter, renewable energy, etc.

I. INTRODUCTION

Solar energy is the most low cost, competition free, universal source of energy as sun shines throughout. This energy can be converted into useful electrical energy using photovoltaic technology. Energy is essential to life. Without it, many billions of people would be left cold and hungry. The energy requirement at global level is seeing an ever increase. Apart from using the non – renewable fossil fuels, importance is being given to renewable energy resources like solar, wind, geothermal energy and many more. But the voltage levels obtained from such energy sources are low and unregulated. This necessitates usage of suitable converter to increase and regulate this output voltage level. Most commonly used converter to accomplish this is a Boost converter.

The block diagram representing such a power electronic system is as shown in the following Fig. 1.

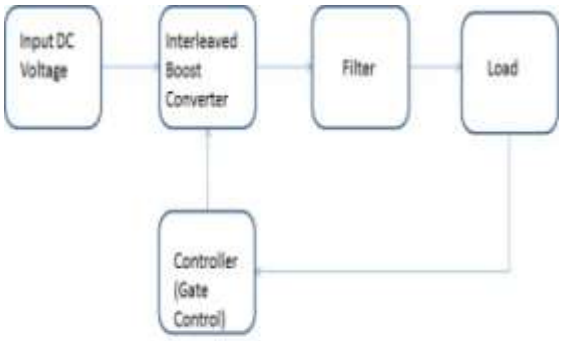

Fig. 1: Block Diagram of a Power Electronic DC-DC Converter system

The specific exemplary converter design considered in this paper involves a boost converter which should boost the input voltage from a battery of voltage level 48V, to that level sufficient to drive a single phase inverter which in turn drives an AC motor. Then, the maximum DC link voltage, which is the output of the Boost converter and hence the input to the inverter, is around 240 V. The converter is designed to give a power output of 250 W.

Various combinations of boost topologies to realize these conversions are:

1.1.Conventional Boost, without interleaving:

In this case, the simulated output voltage is about 1.5% less than theoretical values of two-stage cascaded converters with substantial output voltage ripple of 0.2V. The simulation analysis has been performed in MATLAB schematic environment and verified using mathematical model of the same. The simulated output voltage waveform is as shown in Fig. 6.

1.2. Two cascaded Boost converter stages, without interleaving:

In this case, the simulated output voltage is 2% less than theoretical values of two-stage cascaded converters with substantial output voltage ripple of 0.2 V. The simulation

analysis has been performed in MATLAB schematic environment. The simulated output voltage waveforms of first and second stages are respectively shown in Fig. 7 & Fig. 8.

In order to further minimize output voltage ripple and the error between expected and simulated output voltages, an interleaved boost converter is proposed. It has been observed that, the simulation results obtained through this proposed modelling method of interleaved boost converter provides better results, higher efficiency in comparison with above two methods.

1.3. Interleaved boost converter :

Interleaved Boost Converter is that specialized boost converter topology which offers certain advantages over traditional single stage boost converter, like substantial reduction in output voltage ripple & input current ripple, higher power density, higher current handling capacity, improved efficiency, reduced EMI and faster response. Here, the converter components are paralleled into number of stages, with the parallel stages having common source and load.

II. DESIGN OF INTERLEAVED BOOST CONVERTER

The circuit diagram of an interleaved boost converter is as shown in Fig. 2.

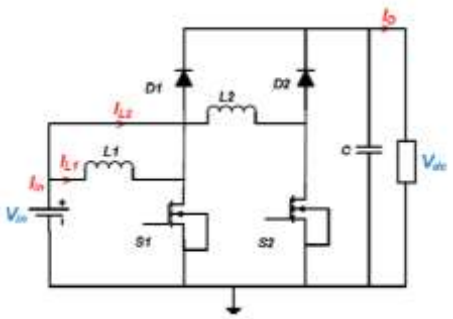

Fig. 2 Circuit diagram of an interleaved boost converter

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The following three cases can be identified for the operation of the interleaved boost converter.

Case 1: S1 is ON, S2 is OFF, D1 is OFF, D2 is ON.

In this case, the equivalent circuit is as shown in Fig. 3.

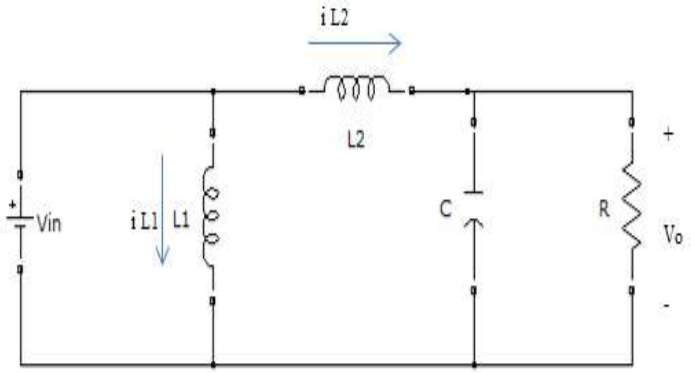

Fig. 3: Equivalent circuit for *Case 1 of operation*

The expressions for voltage across capacitor and inductor currents are as follows

$$V_c = 1/C \int (i_{L2} - V_0 / R)\, dt \qquad (1)$$

$$i_{L1} = 1/L1 \int V_{in}\, dt \qquad (2)$$

$$i_{L2} = 1/L2 \int (V_{in} - V_0)\, dt \qquad (3)$$

Case 2: **S_1 is OFF, S_2 is ON, D_1 is ON, D_2 is OFF.**

Equivalent circuit is as shown in Fig.4.

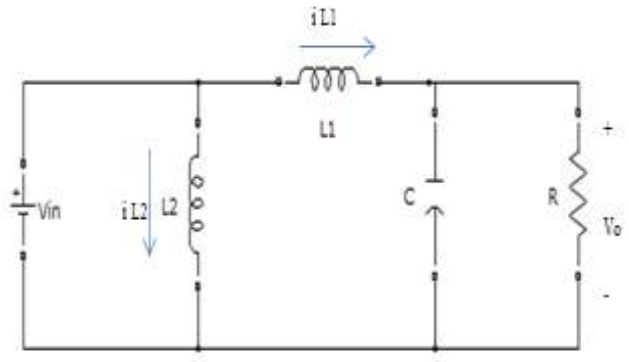

Fig. 4: Equivalent circuit for *Case 2*

Equations are as following:

$$V_c = 1/C \int (i_{L1} - V_0 / R)\, dt \qquad (4)$$

$$i_{L2} = 1/L2 \int V_{in}\, dt \qquad (5)$$

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$$i_{L1} = 1 / L1 \int (V_{in} - V_0)\, dt \qquad (6)$$

Case3: **Both S_1& S_2 are ON, D_1& D_2 are OFF.**

Equivalent circuit is as shown in Fig. 5.

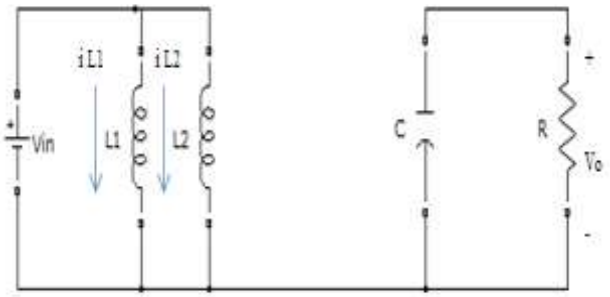

Fig. 5: Equivalent circuit for *Case 3*

$$V_c = 1/ C \int -V_0 / R\, dt \qquad (7)$$

$$i_{L1} = 1 / L1 \int V_{in}\, dt \quad \&$$

$$i_{L2} = 1 / L2 \int V_{in}\, dt \qquad (8)$$

III. MATLAB / SIMULINK MODEL OF BOOST CONVERTER

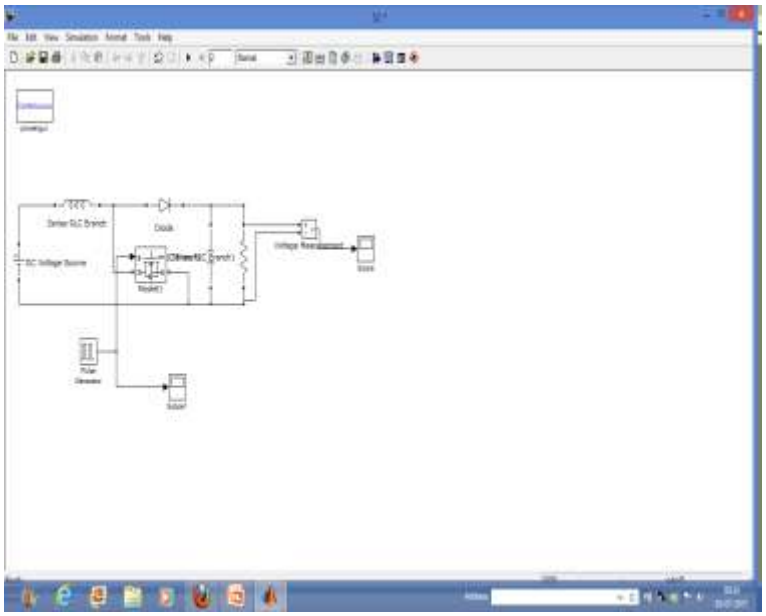

Fig. 6: Schematic circuit diagram of Boost Converter

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IV. MATLAB / SIMULINK MODEL OF INTERLEAVED BOOST CONVERTER

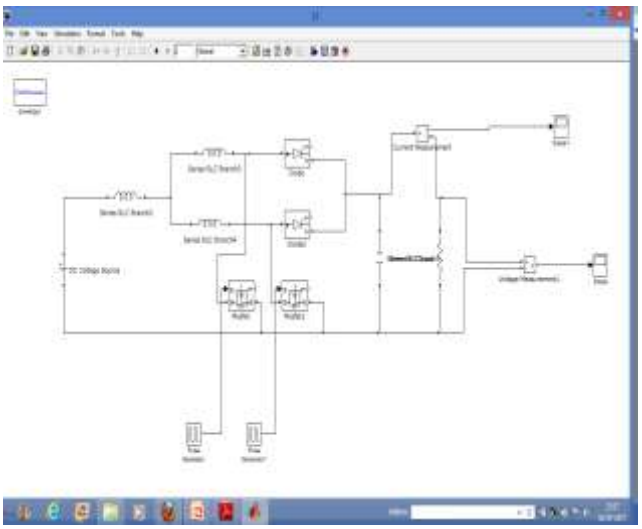

Fig. 7: Schematic circuit diagram of Interleaved Boost Converter

V. SIMULATION RESULT

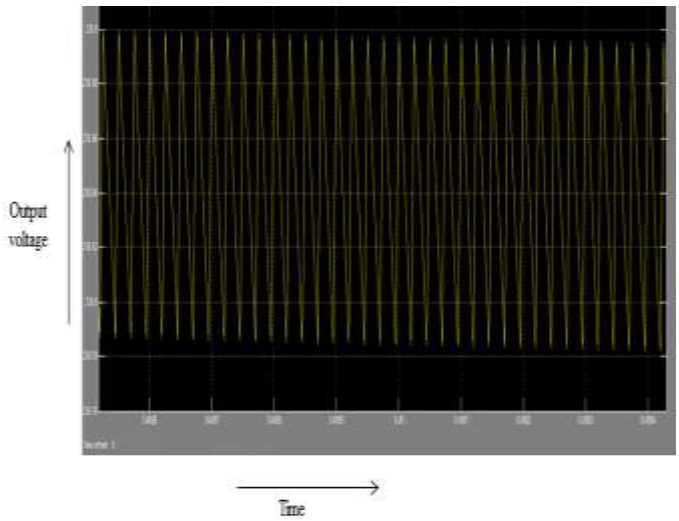

Fig. 8: Output voltage waveform of Single stage Boost converter showing average output of 236.8 V and ripple of around 0.2 V.

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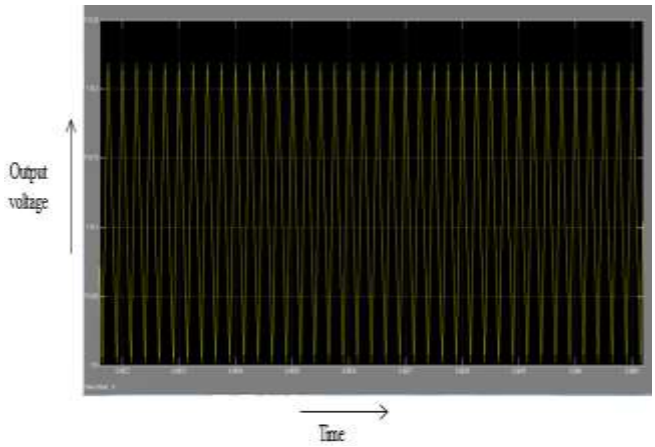

Fig. 9: Output voltage waveform of first stage of the cascaded Boost converter showing average value of around 118 V and ripple of 0.2 V.

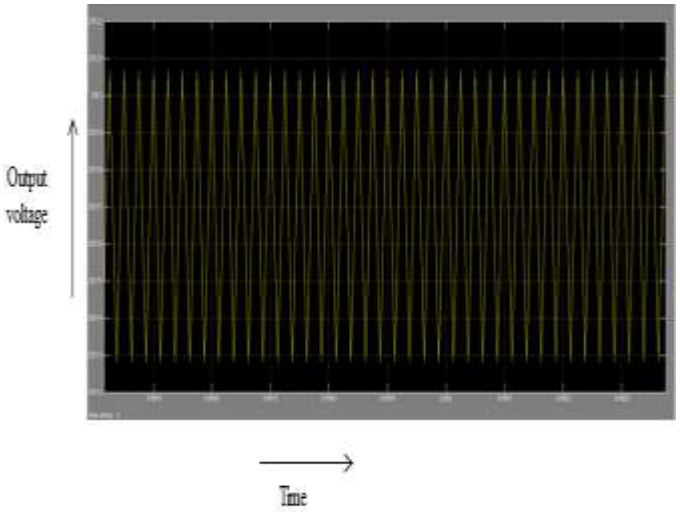

Fig. 10: Output voltage waveform of second stage of the cascaded Boost converter showing average value of around 235 V and ripple of 0.15 V.

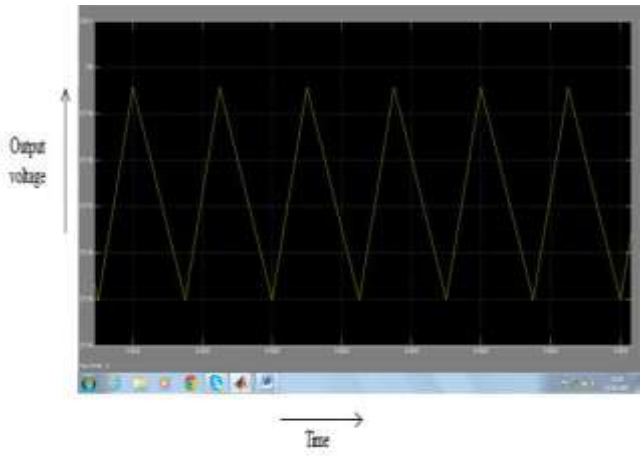

Fig. 11: Output voltage waveform of the interleaved Boost converter showing average output voltage of 237 V and ripple of 0.05 V, simulated using schematic circuit.

The simulation of an interleaved boost converter has been done using MATLAB / SIMULINK. With a duty cycle of D=0.8, DC input being Vin = 48 V, switching frequency fs = 40 kHz, the designed component values are L1 = L2 = 18.43 mH, C=200 F, R = 230 ohm. The power output is 250 W.Fig. 11 shows the output voltage waveform obtained from the schematic circuit simulation, showing an average output voltage of about 237 V and ripple of around 0.05 V.

VI. CONCLUSION

The simulation of an Interleaved Boost Converter has been done using MATLAB / SIMULINK .It is also seen that this result offers least output voltage ripple (less than 0.05V), improved output voltage and better conversion efficiency. The inductor rating is also substantially reduced because of current sharing between interleaved stages.

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Mr. Sunil Kumar Jain He published some technical papers in countries journals & conferences . He is a member of IEEE. He has some year of teaching experinece. He received his M.Tech with Power Electronics & ASIC Design from MNNIT Allahabad. He received his B.Tech with Electrical Engg. from M.M.M. Engg. College Gorakhpur.

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