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Comparative Analysis of Soft Switching Boost Converter

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Abstract

The objective of this paper is to analyse different topologies of interleaved soft switching boost converter for photovoltaic cell and hence draw a comparison between them. The topologies analysed in this paper are interfaces for photovoltaic power generation system.

Keywords: Soft switching, ZVS, ZCS, ZVT.

Introduction

Renewable energy sources are now-a-days preferred over traditional sources, since it overcomes issues like global warming and exhaustion of energy. But it is yet to replenish the conventional energy sources as it is still emerging. Research is still going on to make this budding technology into developed one. Interleaved soft-switching boost converters are taking renewable energy sources into one step ahead by making more efficient power conversion systems for photovoltaic cell. The power conversion system for solar cells needs a controlled DC-DC converter[1]. Boost converters having simple topology and stepped up output voltage is chosen for this case[2]. The power conversion systems consisting of hard switched conventional boost converters has high switching losses, high input current ripples and electromagnetic interferences, which reduce the efficiency significantly[3]. All these disadvantages can be avoided using interleaved soft-switching boost converter as interface for PV system.

Material and Methods

For ease of comparative analysis both the simulated topologies have output power rating of 1.2 KW. For the converter using two switches, IGBTs are used as switches[4]. For the converter using four switches, MOSFETs are used as switches[5]. The simulated switching frequency is 60 KHz. The circuit parameters for the converter using two switches are taken from and the parameters for converter using four switches are taken from[4,5]. The topologies are simulated using MATLAB[6]. The simulation results are shown in the results section.

Results and Discussion

Inter leaved Soft Switching Boost Converter topologies: In interleaved soft-switching boost converter one soft-switching boost converter is placed inside another soft-switching boost converter[7]. In other words, we can say two soft-switching boost converter circuit are connected in parallel. Hence it is also known as two phase boost converter. Use of interleaved soft switching boost converter reduces input current ripple and electromagnetic interferences. It also reduces the ratings of the resonant inductors and capacitors.

The topologies analysed in this paper are shown figure-1, Interleaved Soft Switching Boost Converter (ISSBC) using two switches and figure-2, ISSBC using four switches[4,5]. The soft switching technologies adopted in the topology shown in Figure-1 are ZCS turned on and ZVS turned off[4,8]. In case of ISSBC using four switches the main switches are turned on at zero current and turned off at zero voltage[5]. Other than the main switches there are two auxiliary switches, which adopt ZVT technology for switching[5,9].

Simulation: In this section the simulation result for both the circuits are to be analysed. The simulation results of ISSBC using two switches are shown in figure-3, figure-4 and figure-5. Figure-3 shows the waveforms of pulse generators (Vg1,Vg2), resonant inductor currents (Ilr1,Ilr2), Switch currents (Isw1,Isw2). From these waveforms it can be observed that both the switches of the interleaved soft switching boost converter is turning on at zero current switching i.e the resonant inductor currents are zero at the time of switching on. It also can be seen that both the currents have equal behaviour, equal magnitude and both are180^0 phase shifted[10,11]. The waveforms of pulse generators (Vg1, Vg2), Switch voltages (Vs1, Vs2) are shown in figure-4, from which the zero voltage switching off characteristic can be observed. In figure-5 the waveforms of pulse generators (Vg2), auxiliary capacitor voltages (Vca1, Vca2), resonant capacitors voltages (Vcr1, Vcr2), output capacitor voltage (Vcout) and output voltage (Vout) are shown.

The simulation results of ISSBC using four switches are shown in figure-6, figure-7, figure-8 and figure-9. The waveforms in the figure-6 represents pulse generator voltages (Vg1, Vg2, Vg3, Vg4) and inductor currents (IL11, IL21). It can be verified that the main switches are turning on at zero current. The voltages across capacitors (Vc1, Vc2) and output voltage (Vo) are shown in figure-7.

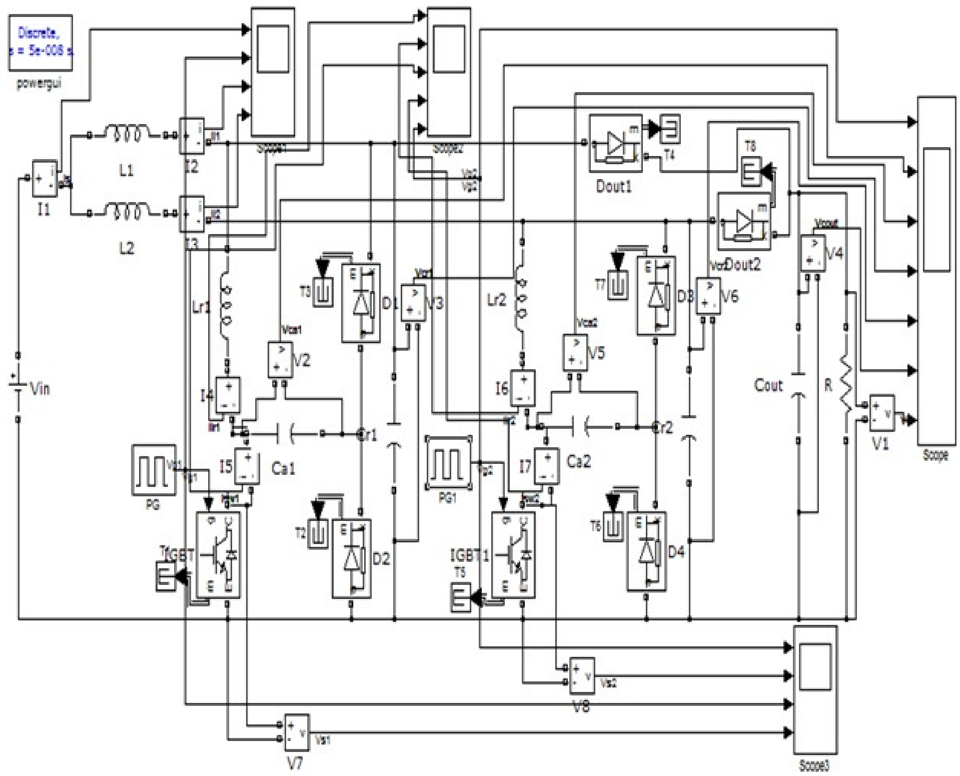

Figure-1
Inter leaved Soft Switching Boost Converter topologies using two switches

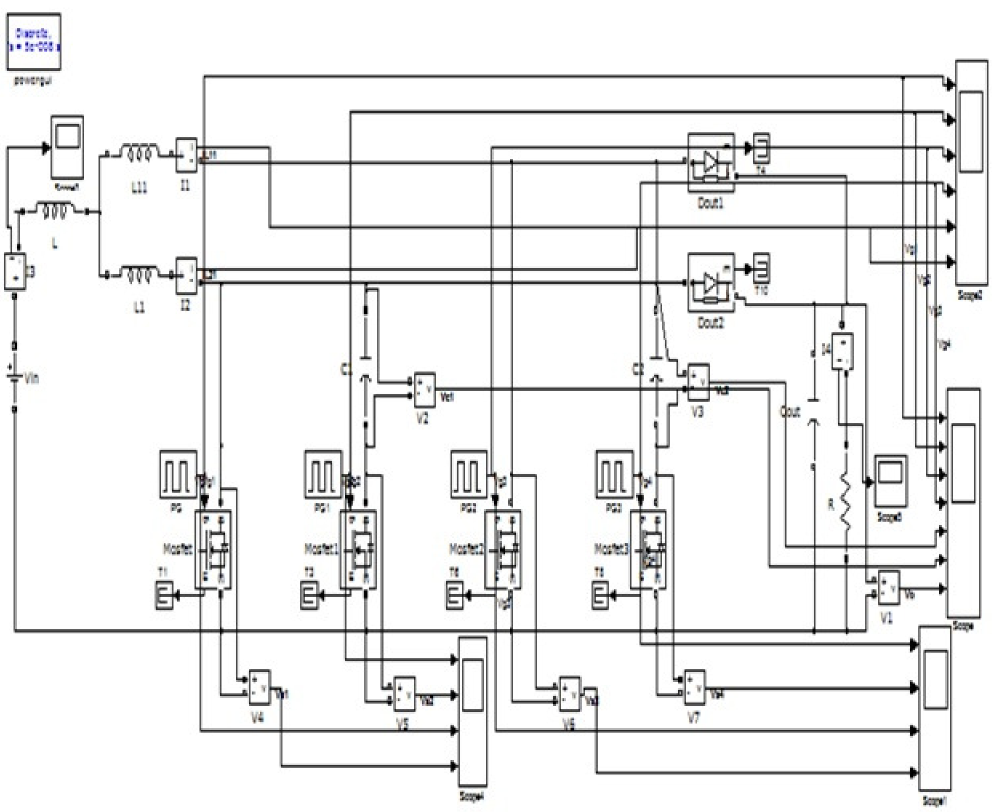

Figure-2
Inter leaved Soft Switching Boost Converter topologies using four switches

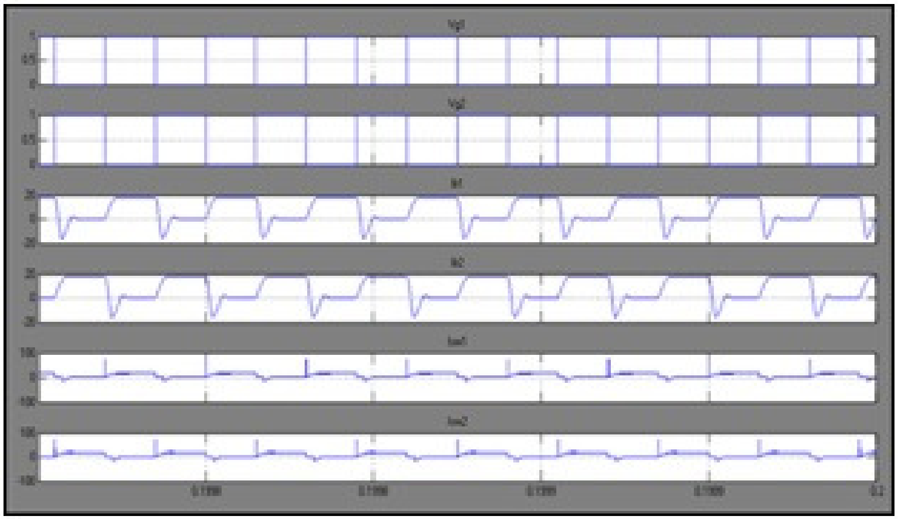

Figure-3
The waveforms of pulse generators (Vg1,Vg2), resonant inductor currents (Ilr1,Ilr2), Switch currents (Isw1,Isw2)

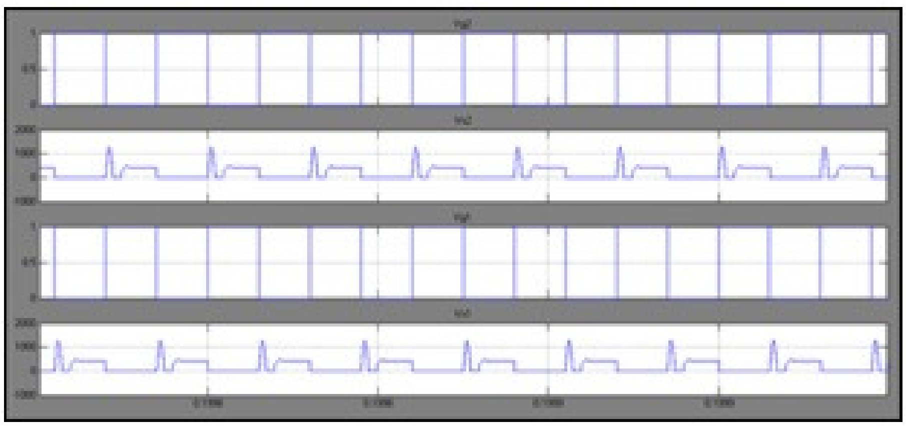

Figure-4
The waveforms of pulse generators (Vg1, Vg2), Switch voltages (Vs1, Vs2)

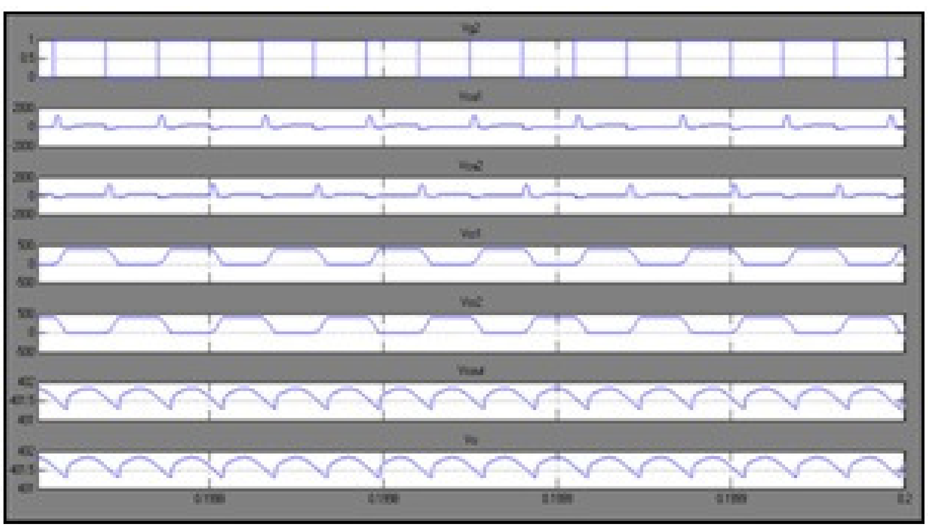

Figure-5
The waveforms of (Vg2), (Vca1, Vca2), (Vcr1, Vcr2), (Vcout) and (Vout)

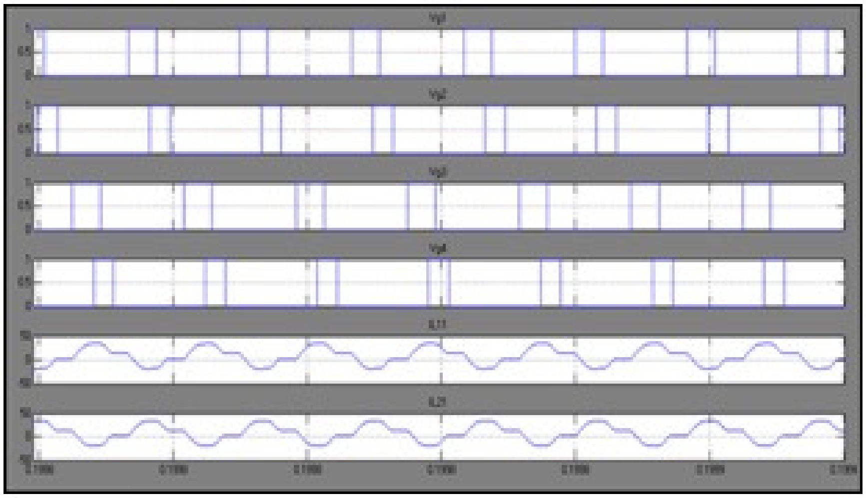

Figure-6
Waveforms of pulse generator voltages (Vg1, Vg2, Vg3, Vg4) and inductor currents (IL11, IL21)

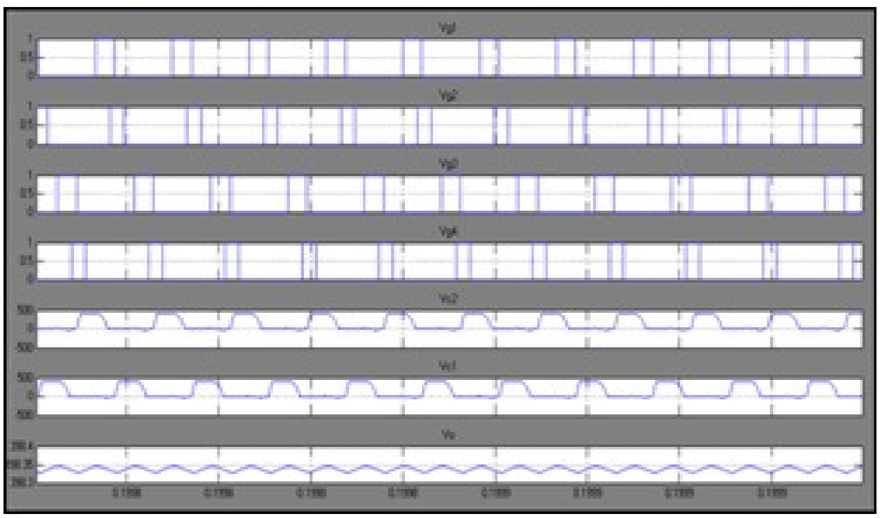

Figure-7
The waveforms of voltages across capacitors (Vc1, Vc2) and output voltage (Vo)

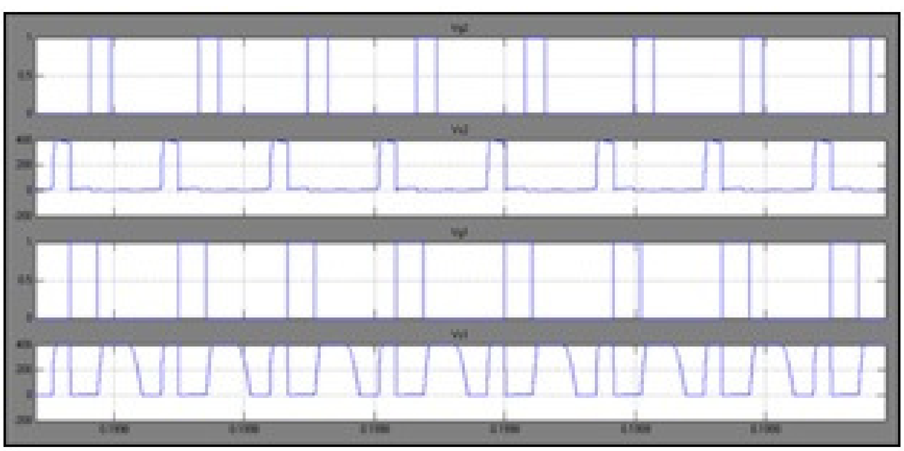

Figure-8
Voltage waveforms of the switches (Vs1, Vs2)

Figure-8 and figure-9 shows voltage waveforms of the switches (Vs1, Vs2) and (Vs3, and Vs4) respectively with reference to the respective gate pulses. The ZSC turn on and ZVS turn off can be verified from these above waveforms. It can also be observed that the auxiliary switches are ZVT throughout the switching transition.

Comparative analysis: Peak Switch Voltage: Every switch in the converter has to withstand the peak switch voltage, which can be a disadvantage of soft switching converters as it is high in comparison to generic boost converter. But here we are interested in the mentioned topologies; hence the graph shows only the comparison between the two. It can be concluded from the plot in Figure-10 that the switches have to withstand high voltage in both the converters, but in case of ISSBC using two switches the is higher in comparison to the four switches. The voltage value increases with the increase in duty cycle. However in ISSBC using four switches the voltage is not so high for lower duty cycles.

Efficiency Vs Load: Efficiency is the most important aspect of performance analysis of any device. The plot shows the efficiency curve with respect to load. According to the plot both the converters have better performance at higher load and it can be said that ISSBC using two switches is a better converter as its efficiency curve is more satisfactory than the other one.

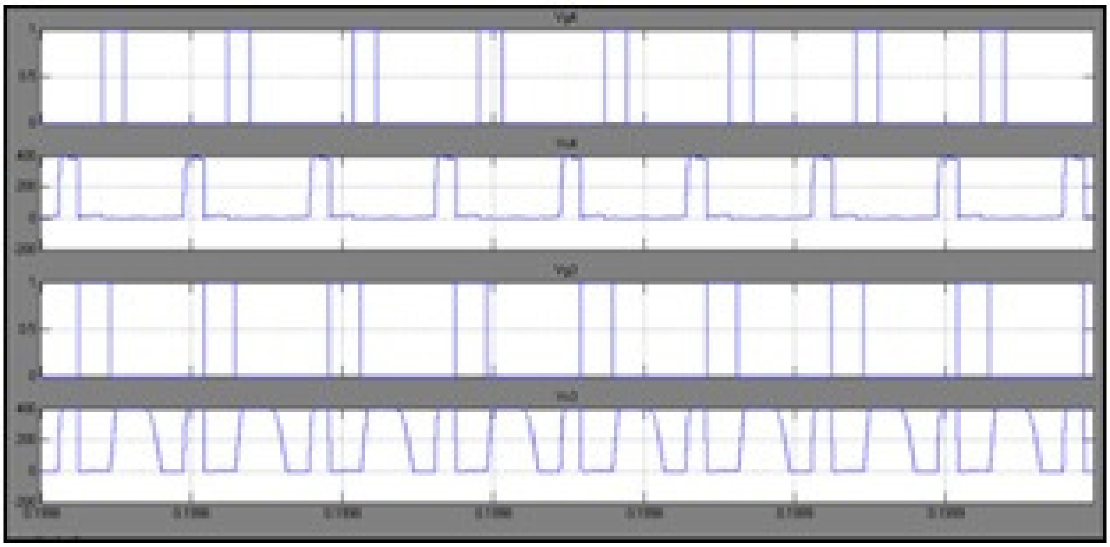

Figure-9
Voltage waveforms of the switches (Vs3 and Vs4)

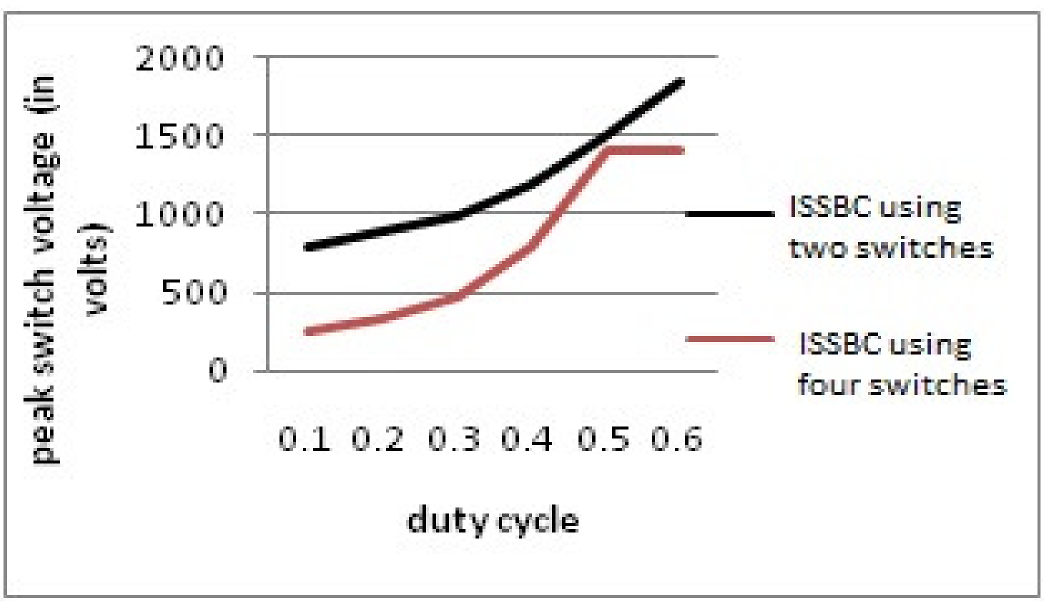

Figure-10
Peak Switch Voltage curve with respective duty cycle

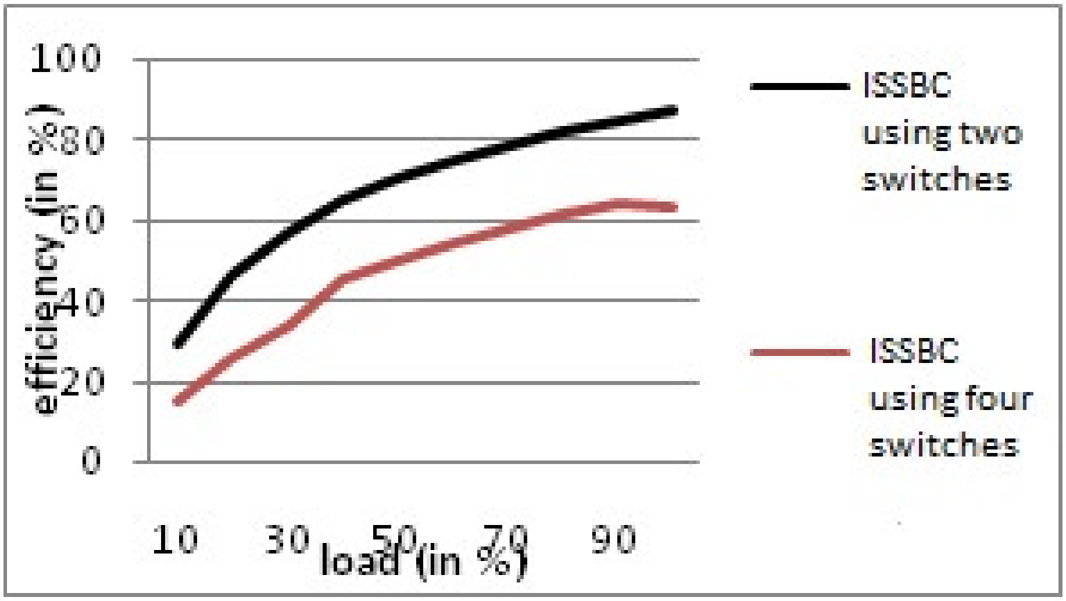

Figure-11
Efficiency curve with respect to load

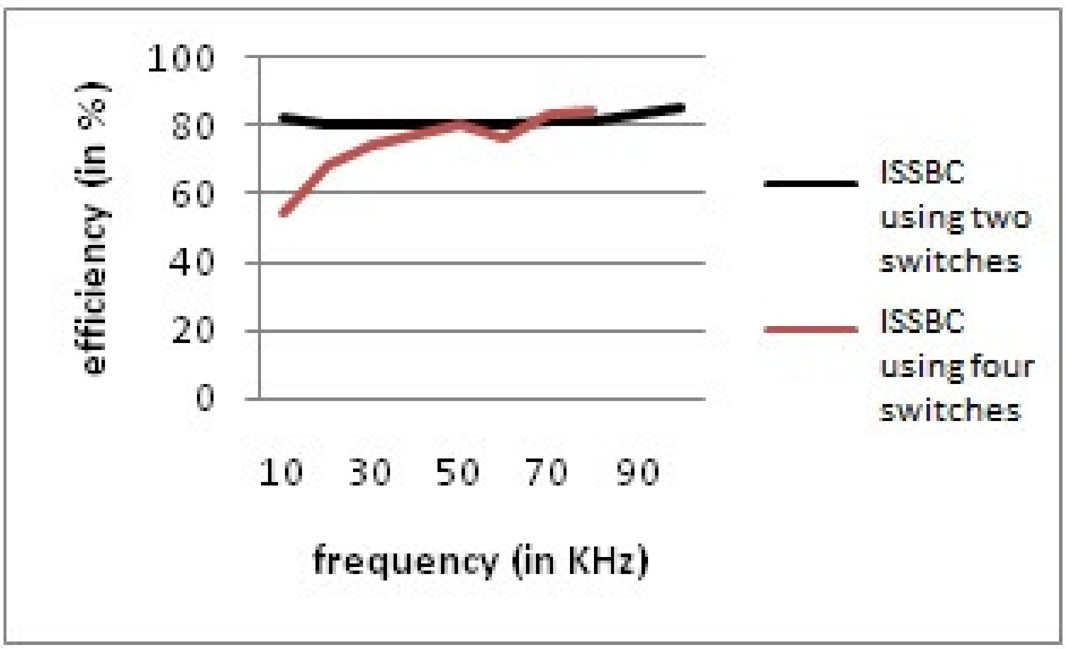

Figure-12
Efficiency Vs Switching Frequency

Efficiency Vs Switching Frequency: ISSBC using two switches has a nearly constant efficiency with respect to switching frequency. In other words the efficiency is almost in sensitive to switching frequency in two switch converter, whereas the value increases with increasing switching frequency in case of four switch converter, which can be counted as a disadvantage for four switch converter as at lower frequencies the efficiency values are not satisfactory.

Current Ripple Vs Switching Frequency: The current ripple is nearly absent in case of two switch converter, adding unto its advantages. In case of four switch converter ripple decreases with the increase of switching frequency. For higher switching frequency it is very less in later case.

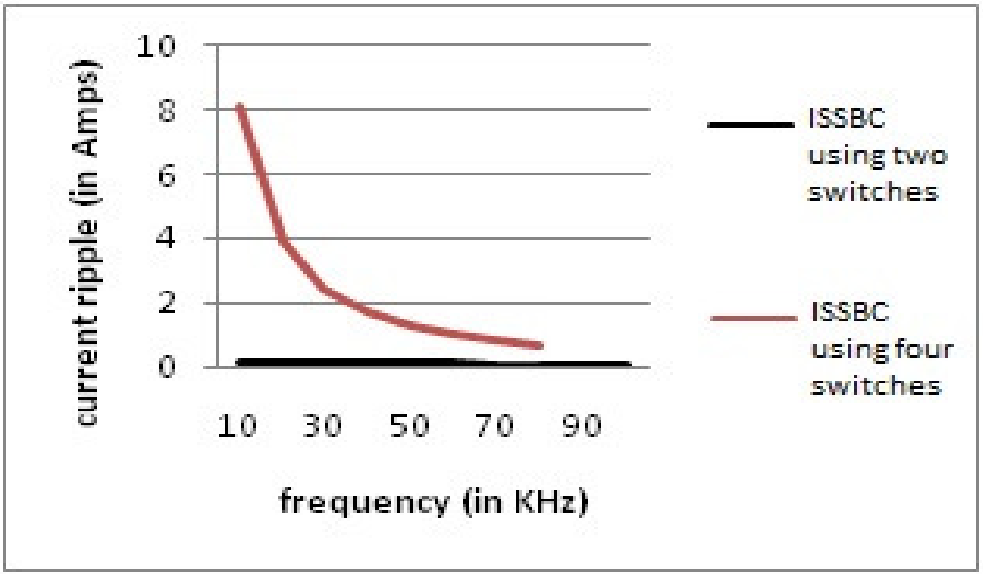

Figure-13
Current Ripple Vs Switching Frequency

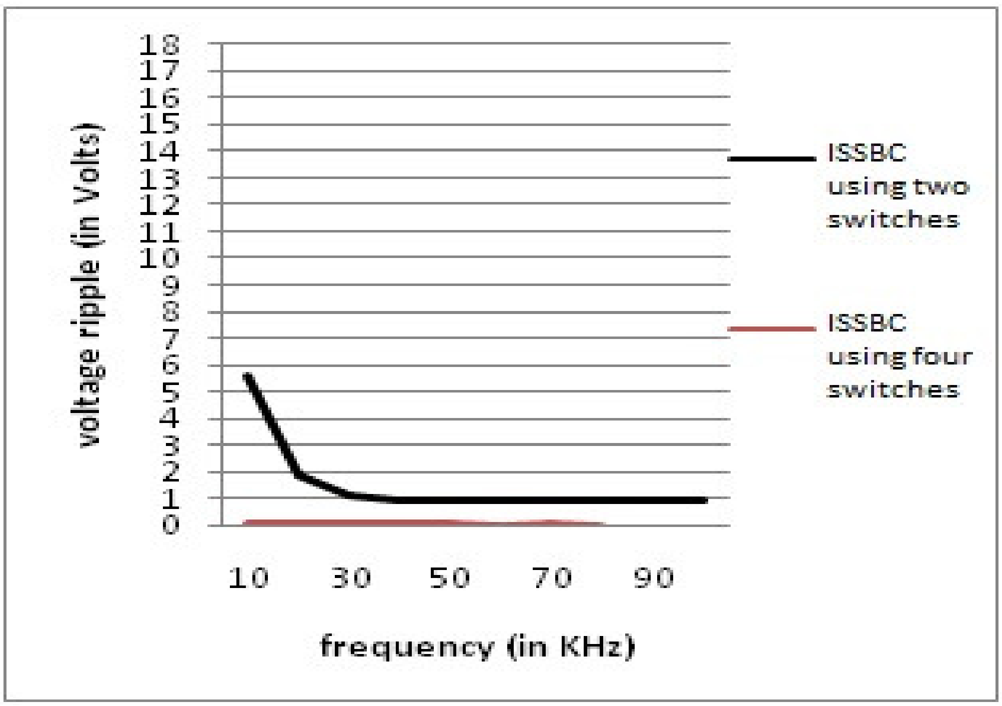

Figure-14
Voltage ripple Vs Frequency

Voltage ripple Vs Frequency: Figure-14 shows that voltage ripple in both the converters is very low though in case of four switch converter it represents an ideal curve.

Conclusion

An analytical study on Interleaved Soft switching boost converter has been done in this paper. The comparison between the two topologies of ISSBC implies that the converter using two switches is better one. However for higher switching frequency and higher duty cycle the four switch converter gives ideal performance.

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