COMPARITIVE ANALYSIS OF HIGH GAIN NON-ISOLATEDCONVERTERS FOR DC MICROGRID

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Abstract.

DC microgrids are becoming most popular because of easier interconnection of non-conventional energy sources like photovoltaic array, batteries and fuel cells. It is obvious fact that the output voltage generated by these sources are low, therefore it is necessary to overcome this drawback by selecting a suitable DC-DC converter with high gain and works effectively. Further, the different types of non-isolated DC-DCconverter with high gain is proposed by avoiding a technique of voltage multiplier cell. The converters consist of certain number of switches which operates in different duty ratio. The simulation work is carried out using PSIM software tool and analysis is carried out for different conditions.

Keywords. DC Microgrid, Non-isolated Converters High Gain Converter, Photovoltaic Array, Batteries and Fuel Cells.

1. Introduction

DC Microgrid methodology is tremendously increasing its importance due to the local power generation. The voltage produced by DC power sources like DC generators, solar panels, batteries and fuel cells are quite low[2.5]. Therefore, it is necessary to use high gain efficient DC-DC converters in order to match the requirements of DC loads. Recently the high gain converters are widely used in various fields like battery charging system and uninterrupted power supplies in addition to renewable energy field[1.2].

In order to increase the DC input voltage, the conventional method is using of boost converter. Even though the boost converter increases input voltage, the switching stress is very high. Therefore, it is necessary to use high rating switches[2.3]. Also, the duty cycle requirement is very high which increases additional losses like power dissipation. Several isolated converters produce high gain but because of presence of transformer these become bulky and costly.

To achieve high voltage gain, the non-isolated DC-DC converters are used which reduces switching stress, size and cost.

In this paper, the different types of non-isolated high gain converters are analyzed with modes of operation. These converters are designed for some output voltage by selecting some input voltage and switching frequency. The parameters like duty cycle requirement, gain factor, inductors, capacitor, voltage stress and current stress are compared with conventional boost converter.

2. Proposed converters

2.1. Boost converter

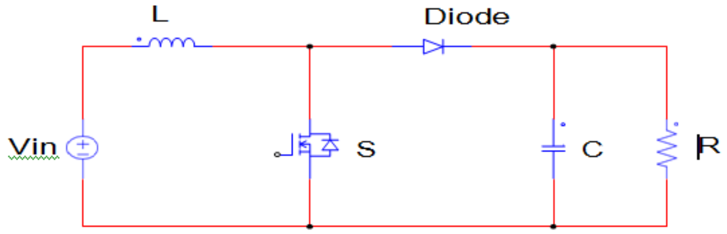


Figure 2.1. Circuit of Conventional Boost Converter

The circuit topology of step-up DC-DC converter is as shown above [2]. It consists of input voltage source Vin , inductor L, capacitor C , MOSFET, diode and load resistor R. It can be operated in two modes. In the first mode, the MOSFET switch is ON, therefore diode is reverse biased. The equivalent circuit is as shown in fig. 2.2.

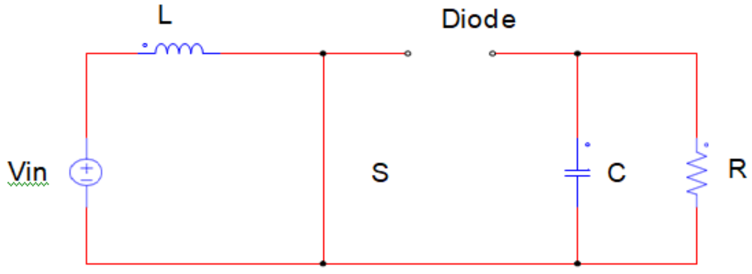


Figure 2.2. Equivalent Circuit of Conventional Boost Converter when Switch S is closed

Further in the next mode, the MOSFET switch will be OFF therefore the inductor current forces diode to operate.The equivalent circuit is as shown below:

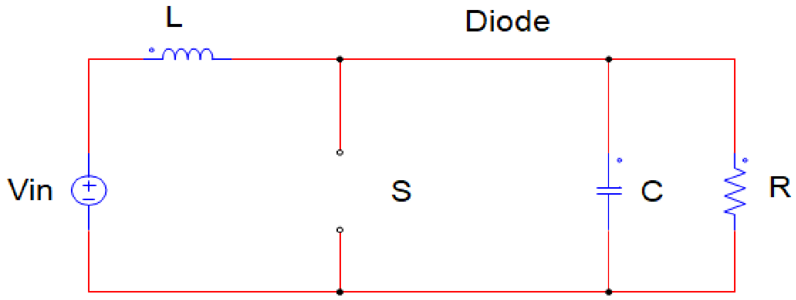


Figure 2.3. Equivalent Circuit of Conventional Boost Converter when Switch S is opened

2.2. *Non-isolated converter 1*

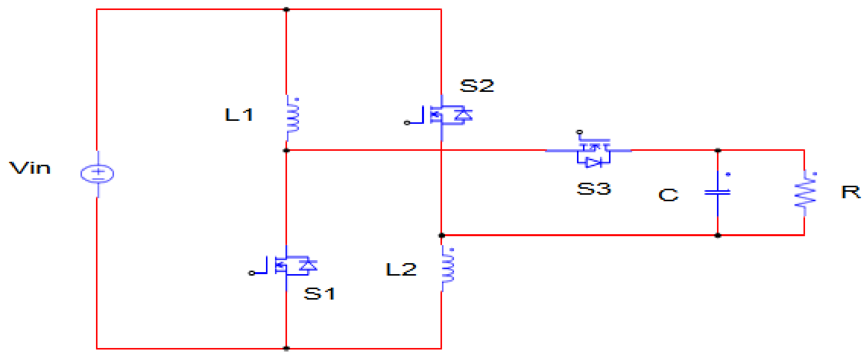


Figure 2.4. Circuit Diagram of Non-isolated Converter 1

The circuit topology of non-isolated converter 1 is as shown in fig.2.4. It consists of an input voltage source Vin, a pair of inductors L1 and L2 with equal values, capacitor C and three MOSFET switches (S1, S2 and S3) [3.5].

In the first mode, the switches S1 and S2 will be ON, the equivalent circuit is as shown below. Here both the inductors are connected in parallel and it is equal to input voltage. The capacitor is connected across load resistor and starts discharging

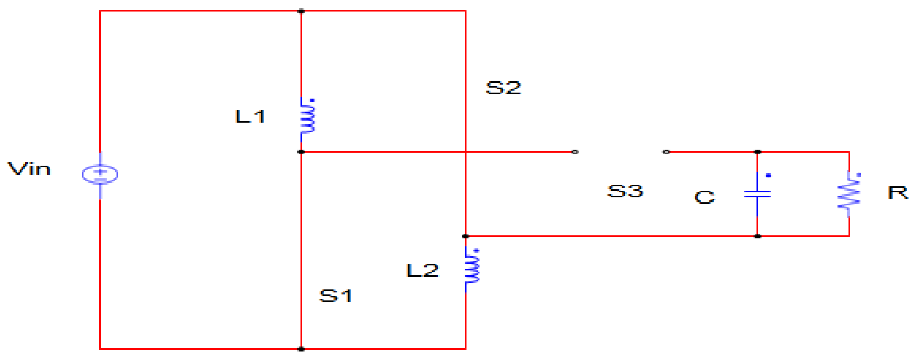


Figure 2.5. Equivalent Circuit when S_1 and S_2 are Closed

In the second mode, the switches S_1 and S_2 will be OFF, S_3 will be ON. The equivalent circuit is as shown in fig.2.5.The input voltage is obtained across load terminals via switches S_3. The capacitor starts charging.

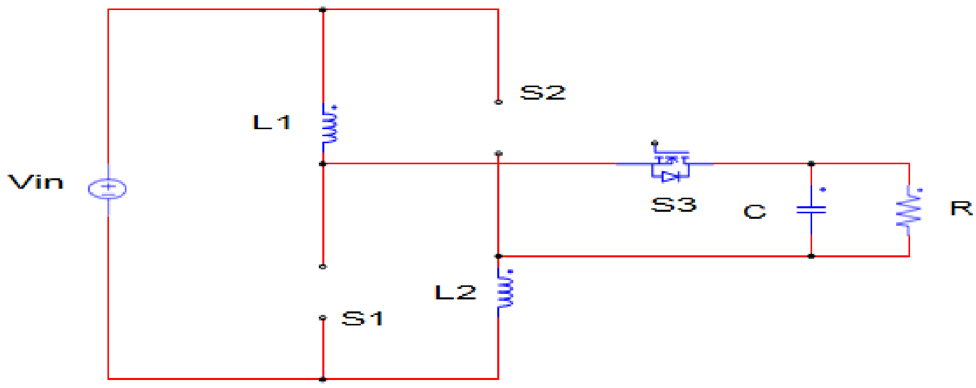


Figure 2.6. Equivalent Circuit when S_3 is Closed

2.3. *Non-isolated Converter 2*

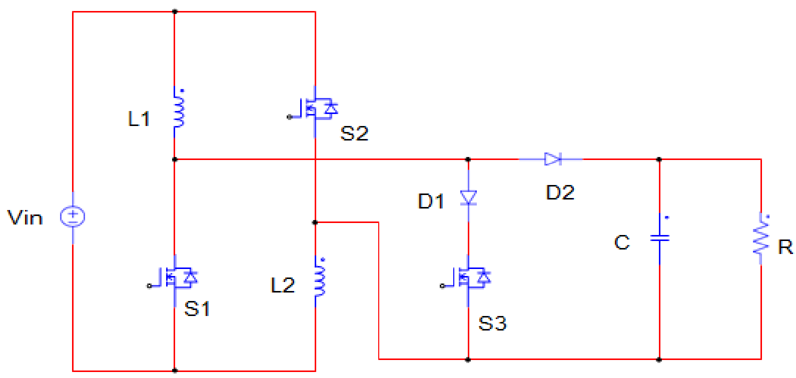


Figure 2.7. Circuit Diagram of Non-isolated Converter 2

It is also similar to non-isolated converter 1. Further, it includes input voltage source V_{in}, a pair of inductors L_1 and L2, Capacitor C, three MOSFET switches $S_{1,}$ S_2 and S_3 and diodes D_1 and D_2. This can be operated in three mode.In the first mode the switches S_1 and S_2 will be ON and S_3 will be OFF[5.6]. Here both the inductors are connected inparallel and having equal values. The voltage across both the inductors will be same as input voltage. The capacitor connected across load resistor and starts discharging. The diodes are reverse biased [3.6].

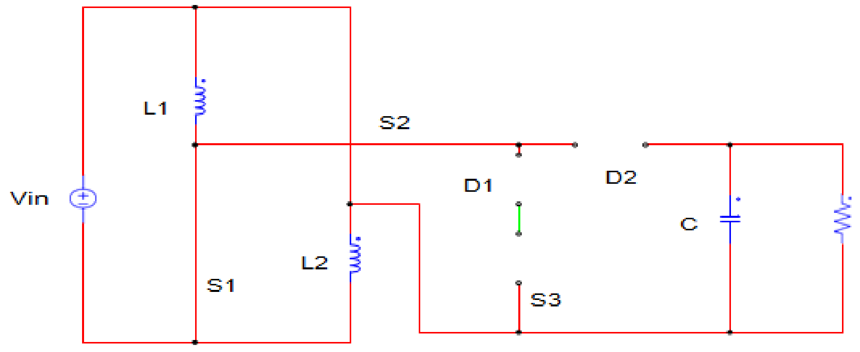


Figure 2.8. Equivalent Circuit when S_1 and S_2 are ON and S_3 is OFF

In the second mode the switches S_1 and S_2 will be OFF and S_3 will be ON. Hence the diode D_1 is forward biased and D_2 is reverse biased as shown in equivalent circuit below. The capacitor is connected across load resistor R and startsdischarging.

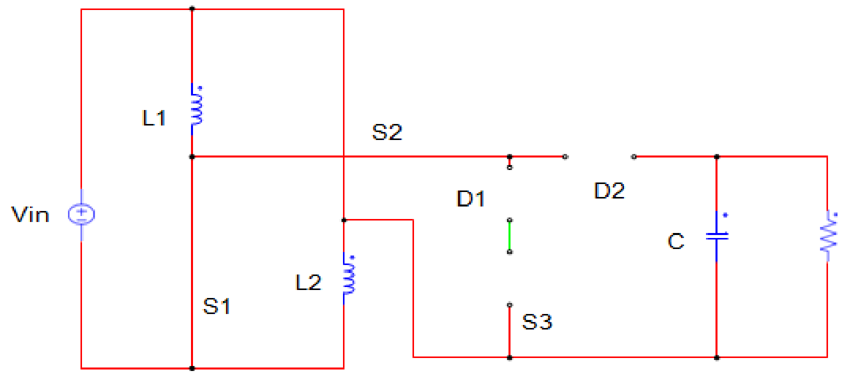


Figure 2.9. Equivalent Circuit when S_1 and S_2 are OFF and S_3 is ON

In the third mode, all the switches will be OFF, the diode D_1 is reverse biased and diode D_2 is forward biased as shown in Fig.2.9. The input voltage is obtained across load terminals through diode D_2. The capacitor starts charging during this mode[2].

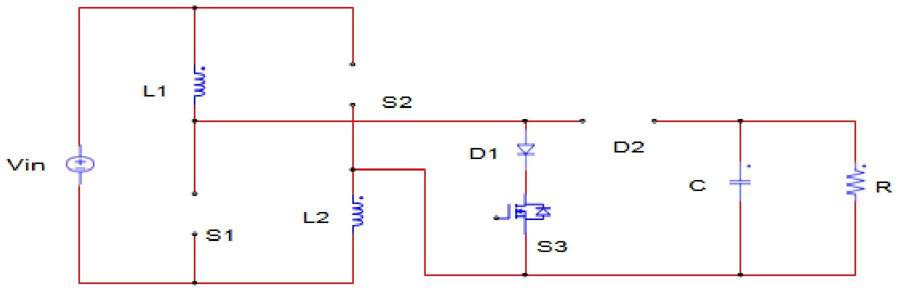
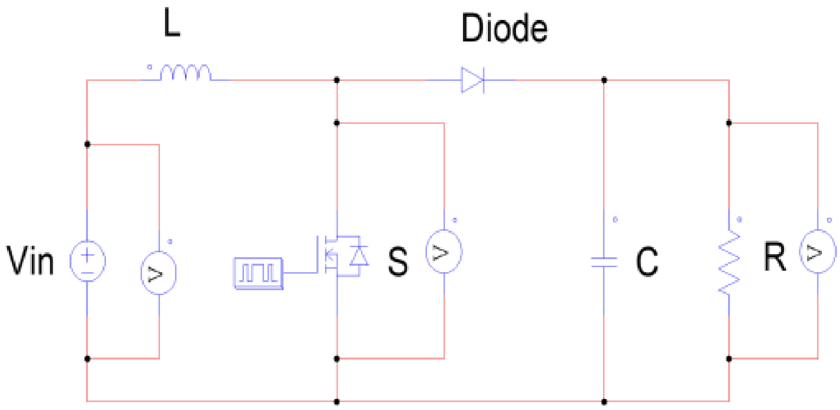


Figure 2.10. Equivalent Circuit when S_1, S_2 and S_3 will be OFF

3. Results and discussions



Conventional boost converter

Figure 3.1. Simulation Model of Conventional Boost Converter

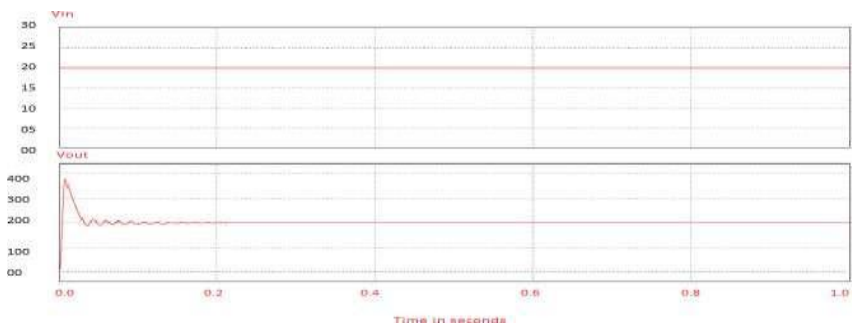


Figure 3.2. Input and Output Voltage Waveform of Boost Converter

The Fig. 3.2 shows waveforms of input and output voltage of conventional Boost converter with input as 20V andoutput as 200V [2]

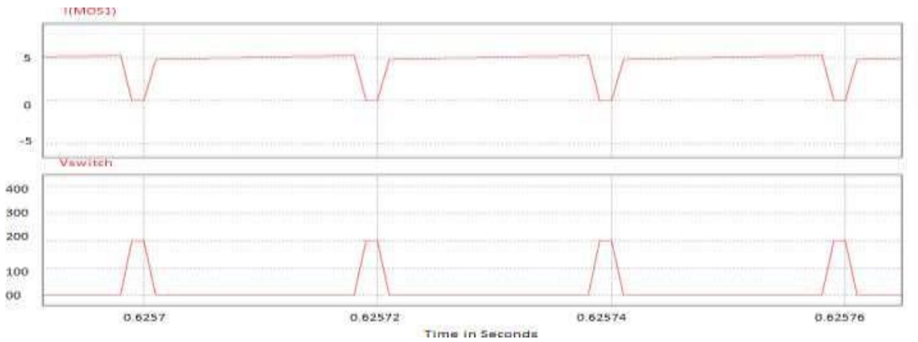


Figure 3.3. Simulation of conventional Boost Converter (SWITCH WAVEFORMS)

The Fig 3.3 shows waveforms of switch current and voltage of conventional Boost converter.The switching currentis 5A and voltage across the switch is 200V which is equal to output voltage.

Simulation Model of Non-isolated Converter 1

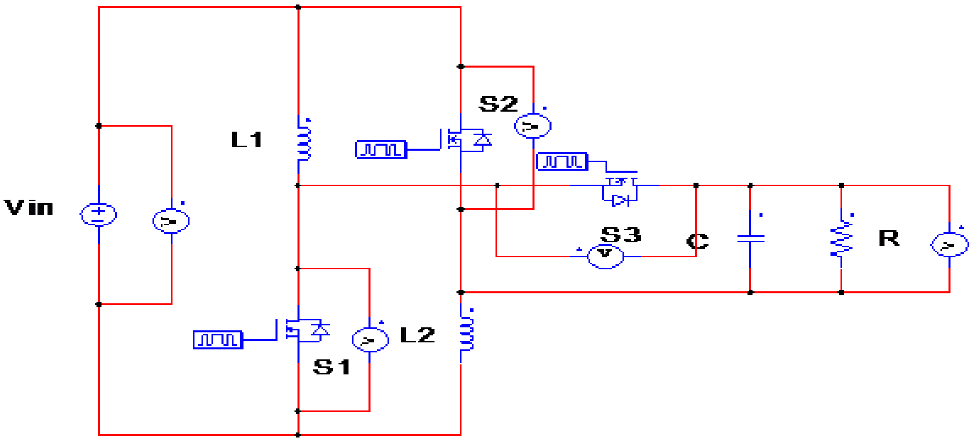


Figure 3.4 Simulation model of non-isolated converter 1

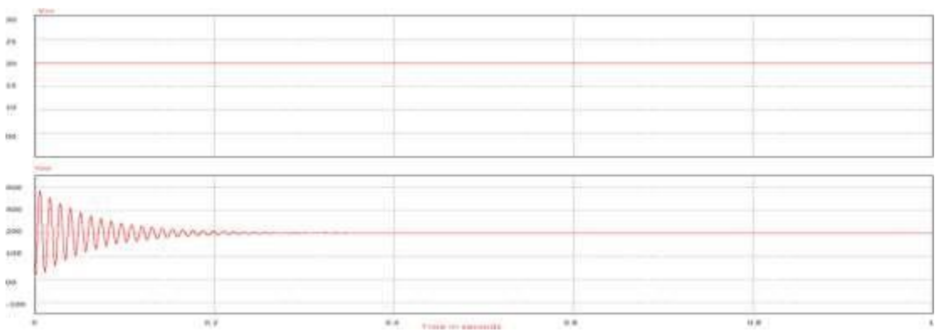


Figure 3.5. Simulation Results of Non-isolated Converter 1

The Fig.3.5 shows waveforms of i/p and o/p voltage of proposed DC-DC converter withinput as 20V and output as200V.

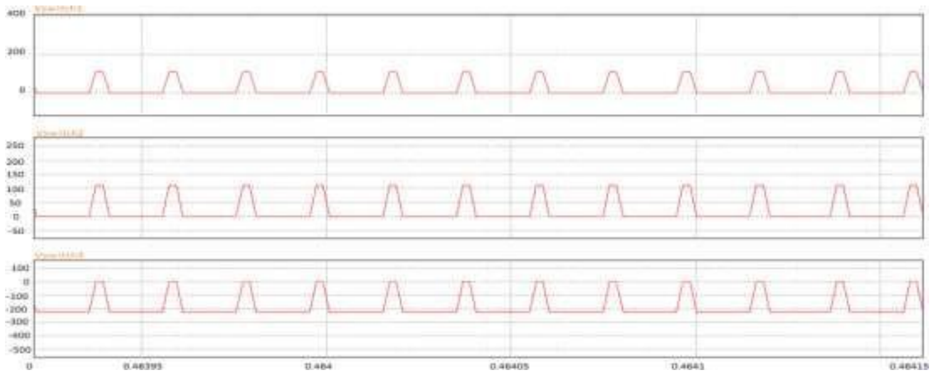
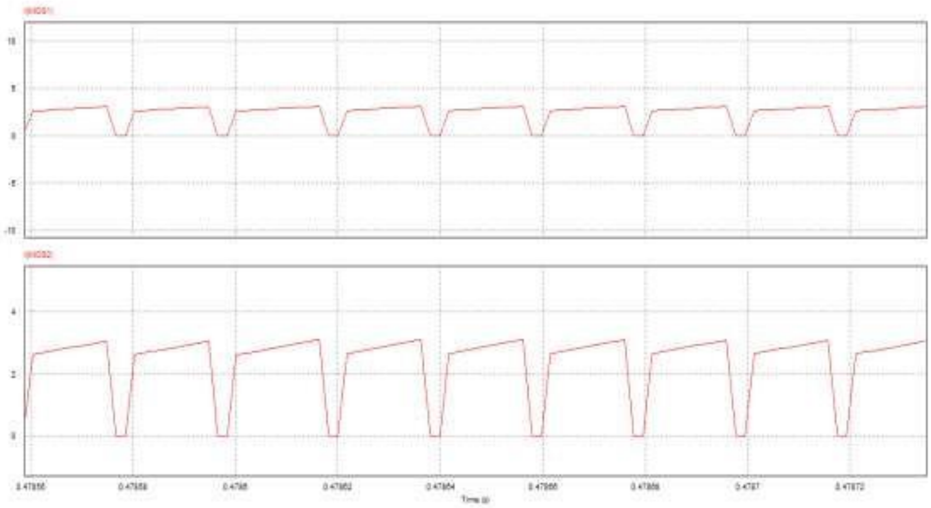


Figure 3.6. Simulation Results of Non-isolated Converter 1(Voltage Stress)



The Figure 3.7. Simulation Results of Non-isolated Converter 1(Current Stress)

Simulation Model of Non-isolated Converter 2

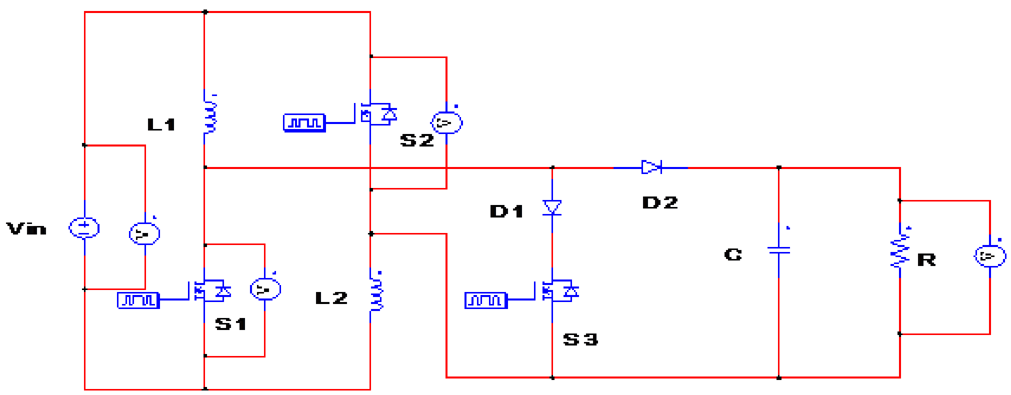


Figure 3.8. Simulation Circuit Model of Non-isolated Converter 2

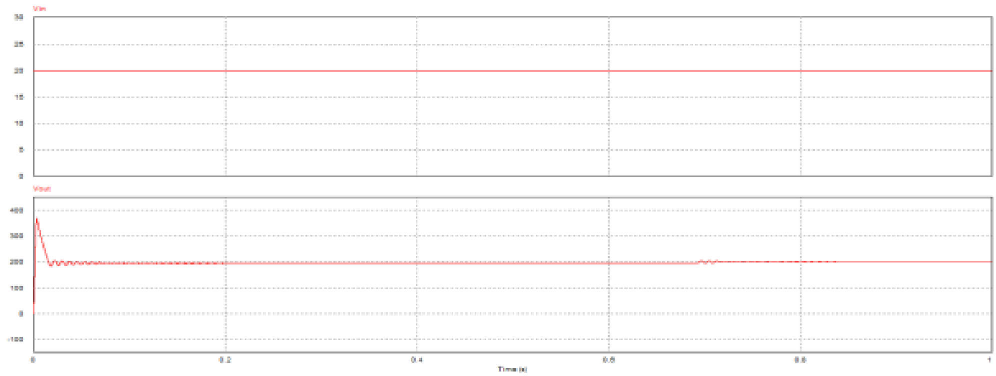


Figure 3.9. Simulation Results of Non-isolated Converter 2 (i/p and o/p Voltage)

The Fig.3.9 shows waveforms of input and output voltage of proposed converter 2 with i/p as 20V and o/p as200V.

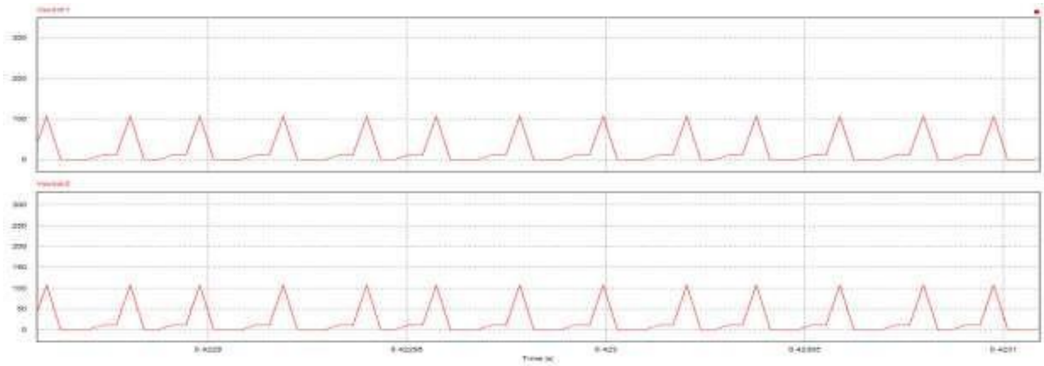


Figure 3.10 Simulation of Non-isolated Converter 2(Voltage Stress)

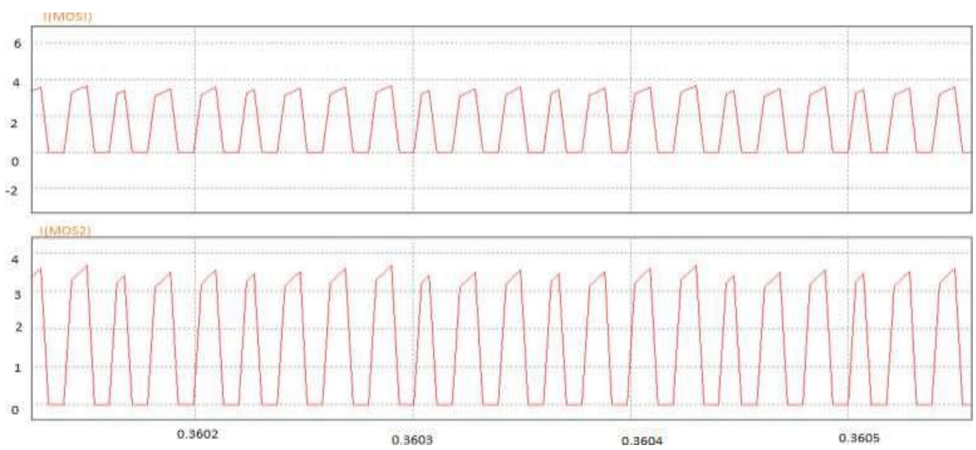


Figure 3.11 Simulation of Non-isolated Converter 2(Current Stress)

The Fig.3.10 and 3.11 shows the waveforms of switch voltage and current of proposed DC-DC converter 2. Theswitching current is 3.5A and voltage across the switch is 100V which is equal to half of o/p voltage [2].

4. Comparison of conventional boost converter, non-isolated converter 1 and non-isolated converter 2

In the present study, the distinct converters for DC micro grid are simulated using PSIM. The input voltage is taken as 20V and output voltage is designed for 200V with a switching frequency of 50kHz.The various parameters of different converters is as given below [1.2]:

SI NO.	Parameter	Conventional Boost Converter	Non-isolated Converter 1	Non-isolated Converter 2
1	Input Voltage	20	20	20
2	Output Voltage	200	200	200
3	Switching Frequency (KHz)	50	50	50
4	Duty Cycle	0.9	0.818 1	0.5
5	Gain Factor	1/(1-D)	(1+D)/(1-D)	$(1+D_1)/(1-D_1-D_2)$
6	Inductor (in µH)	720	650	360
7	Capacitor (in µF)	90	82	50
8	Voltage across Switch (in volts)	200	100	100
9	Current stress in Switch (in Amps)	5	3.5	3.5

5. Conclusion

In this paper, various types of DC-DC converters are analyzed and represented to obtain maximum possible voltagegain.

From the simulation results it is observed that,

- The conventional DC-DC boost converter is designed 200V output from 20V input. Here the duty cycle required is 0.9 to achieve required voltage. The voltage and current stress is also high and becomes bulky due to large values of passive elements like inductors and capacitor.
- Because of the above drawbacks, the non-isolated converter 1 is designed for the same output 200V from 20V. Here it is observed that duty cycle requirement reduces. Comparatively the size of passive elements also reduces. The voltage & current stress reduces to some extent.
- The non-isolated converter 2 is also designed for same output 200V from 20V. It is observed the duty cycle requirement still reduces and stress also reduces.
- Because of this the conventional boost converter has limited application. The non-isolated converter 1 can be used for standalone applications. The non-isolated converter can be used for high power applications because of low switching stress.

6. REFERENCES

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Biographies

Malathi S N, received the bachelor's degree in Electrical and Electronics Engineering VTU in 2012, pursuing the Master's degree in Power Electronics from Siddaganga Institute of Technology.

Dr. Rashmi, working as professor and Head in the Department of Electrical & Electronics Engineering, SIT, Tumkur, having total of 23 years of teaching experience, published 17 research papers in international journals, presented 25 numbers of research papers in national and international conferences. She is guiding 3 Ph.D. students and has guided 15 number of M.Tech. Projects and guided 30 UG projects.

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