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# Effect of Voltage Multiplier Cell in High Gain DC-DC Converter

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**ABSTRACT**: High gain dc-dc converter with moderate duty ratio, reduced power losses in switches, and switch stress are gaining importance in many applications .Several non isolated high gain dc-dc converters have been introduced based, voltage lift techniques and capacitor diode voltage multiplier cell. In this paper two high gain DC-DC converters one based on self-lift technique and the other with capacitor diode voltage multiplier is presented. Both the converter is designed for same power rating and duty ratio. The converters are compared in terms of semiconductor device stress, output voltage and number of components. Simulation of both the converter is done in MATLAB/Simulink.

**KEYWORDS:** High gain dc-dc converter, Voltage lifts techniques, Capacitor diode voltage multiplier cell.

## I.INTRODUCTION

The requirement of high voltage and renewable energy demands high gain DC-DC converter. Conventional boost converter can achieve a high voltage gain of around twelve times the input at an extremely high duty ratio of 91% .The high duty ratio will create reverse recovery problems for the output diode. In order to reduce the diode stress the switching frequency must be very low, which necessitate large boost inductor and larger filter capacitor, correspondingly the system become heavier and less efficient. To realize an efficient system the converter must operate with moderate duty ratio and at higher switching frequency. But there is a direct proportionality between switching losses and switching frequency .So a compromise has to be made between switching frequency and duty ratio.

Voltage lift technique and capacitor diode voltage multipliers are popularly employed in power electronics circuit to obtain new series of high gain DC-DC converter and to overcome the difficulties associated with conventional boost converter and hybrid boost topologies.

## II.LITERATURE REVIEW

Many converter topologies have been introduced to rectify the problems associated with conventional boost converter. The converter in[1] is a modified boost converter in which the boost inductor is replaced by two inductors and three diodes to obtain a switched inductor structure .The converter has same voltage boost at a reduced duty ratio so that the output diode reverse recovery problem is very much reduced, but the switch stress remains the same. The converter in [2] is a boost converter with capacitor diode voltage multiplier cell. The output voltage is a function duty ratio and number of multiplier cell. The components and semiconductor device stress is reduced here. In order to get a higher voltage gain at low duty ratio the multiplier cells must be added, which will increase the circuit complexity, size and cost. The converter in [3] a modified Luo converter in which voltage lifts technique is used to enhance the voltage transformation ratio. The switch and output diode stress is higher than the output voltage, which necessitates a higher R_DSon MOSFET and output diode with higher rating.

## III.TOPOLOGY DESCRIPTION AND ASSUMPTIONS

In this paper two converter are analysed and designed by considering the following assumptions

1. The circuit is operating in continuous conduction mode
2. All the circuit components are ideal
3. Input is pure dc
4. Output capacitor is taken as large enough to keep the output almost ripple free
5. C,Ca and Cb are initially charged.

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6. Current direction and Voltage polarity shown in figure1 and figure4 are assumed to be positive

Also let

i. D - duty ratio,Ts - switching period

ii. $L_a=L_b, C_a=C_b=C_{in}=C_f$

1) Relift Converter(Converter I): The basic working principle of this converter is based on voltage lift technique. This converter is derived from the self lift circuit[4].The cicuit representation is given in Fig.1.The converter is a single switch topology which consists of two inductors (La,Lb) they act as energy storing device and significantly reduce the current stress in MOSFET switch(S).The input diodes(Di1,Di2,Di3) provides a path for the inductor current when the switch is ON. Diode Do act as energy transferring path for the inductor stored energy when the switch is OFF .The capacitor C act as energy transferring and storing device during switch ON and switch OFF of MOSFET switch respectively..The diode Dc connect the load during switch ON and disconnect the load during switch OFF from the source. The capacitor (Cf) act as filter capacitor. The working of the converter can be explained in two modes.

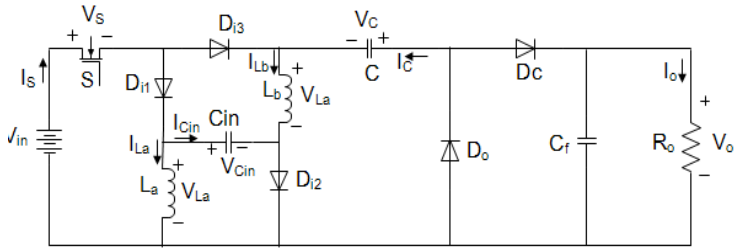


Fig. 1 Relift Converter(Converter I)[4]

Mode1:The circuit representation for mode 1 is given in Fig.2.During this mode the MOSFET switch(S) is on for a duration of DTs,diodes Di1,Di2,Di3 and Dc are forwar biased so that La,Lb and Cin chages in parallel combination at the same time C will discharge the previously stored energy through source and load.

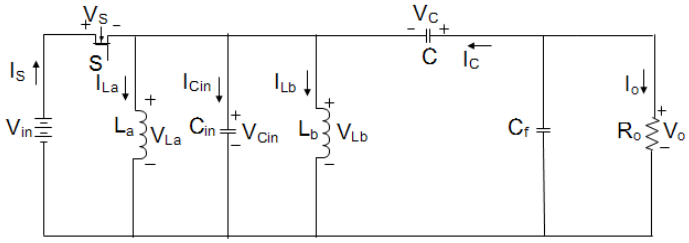


Fig. 2 Relift Converter –Switch on topology

Mode2:The circuit representation for mode 2 is given in Fig.3.During this mode the MOSFET switch(S) is OFF for a duration of (1-D)Ts,diodes Di1,Di2,Di3 and Dc are reverse biased so that La,Lb and Cin discharges in series combination and C will be charge since diode Do is forward biased but the load will be isolated from the source.

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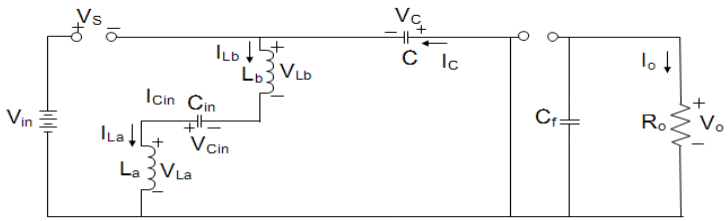


Fig. 3 Relift Converter –Switch off topology

2) High Gain DC-DC Converter with Voltage Multiplier(Converter II)[5]: The converter is a modification of relift converter in which the energy transferring capacitor C and the diode Do are split into two. The two diode (Do1,Do2)and two capacitor (Ca,Cb) combination act as capacitor diode voltage multiplier cell. The cicuit representation is given in Fig.4.The converter is a single switch topology which consists of two inductors (La,Lb) they act as energy storing device and significantly reduce the current stress in MOSFET switch(S).The input diodes(Di1,Di2) provides a path for the inductor current when the switch is ON. Diodes Do1,Do2 act as energy transferring path for the inductor stored energy when the switch is OFF .The capacitors Ca ,Cb act as energy transferring and storing device during switch ON and switch OFF of MOSFET switch respectively. The diode Dc connect the load during switch ON and disconnect the load during switch OFF from the source .The capacitor (Cf) act as filter capacitor. The working of the converter can be explained in two modes.

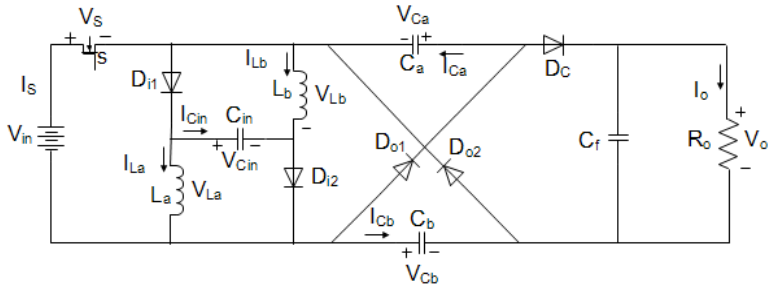


Fig. 4 High Gain DC-DC Converter with Voltage Multiplier(Converter II)[5]

Mode1:The circuit representation for mode 1 is given in Fig.5.During this mode the MOSFET switch(S) is on for a duration of DTs,diodes Di1,Di2 and Dc are forwar biased so that La,Lb and Cin chages in parallel combination at the same time Ca and Cb will discharge the previously stored energy through source and load.

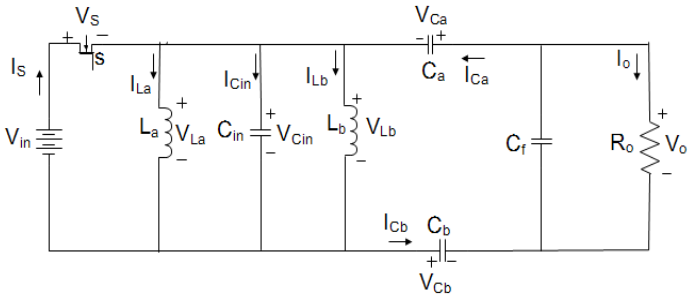


Fig. 5 High Gain DC-DC Converter with Voltage Multiplier-Switch on Topology

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Mode2:The circuit representation for mode 2 is given in Fig.6.During this mode the MOSFET switch(S) is OFF for a duration of (1-D)Ts,diodes Di1,Di2 and Dc are reverse biased so that La,Lb and Cin discharges in series combination and Ca and Cb will be charged in parallel combination since diode Do1,Do2 are forward biased but the load will be isolated from the source.

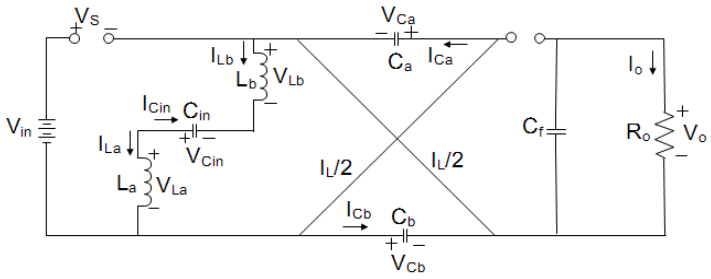


Fig. 4 High Gain DC-DC Converter with Voltage Multiplier-Switch off Topology

## III.SIMULATION RESULT

The two converters described in section III are simulated in MATLAB/Simulink and comparison is done in terms of semiconductor device stress and number of components. The simulation parameter is given in Table-1.

Table-1: Simulation Parameter

| Simulation parameter | Relift Converter (Converter I) | Converter with Multiplier (Converter II) |
|---|---|---|
| Output power(Po) | 3.65W | 3.65W |
| Output voltage (Vo) | 78V | 144V |
| Input voltage(Vin) | 12V | 12V |
| Duty ratio(D) | 69% | 69% |
| Switching frequency(fs) | 50kHz | 50kHz |
| Inductor | 850µH | 850µH |
| Capacitor | 47µF | 47µF |
| Resistive Load(Ro) | 1660Ω | 5681Ω |

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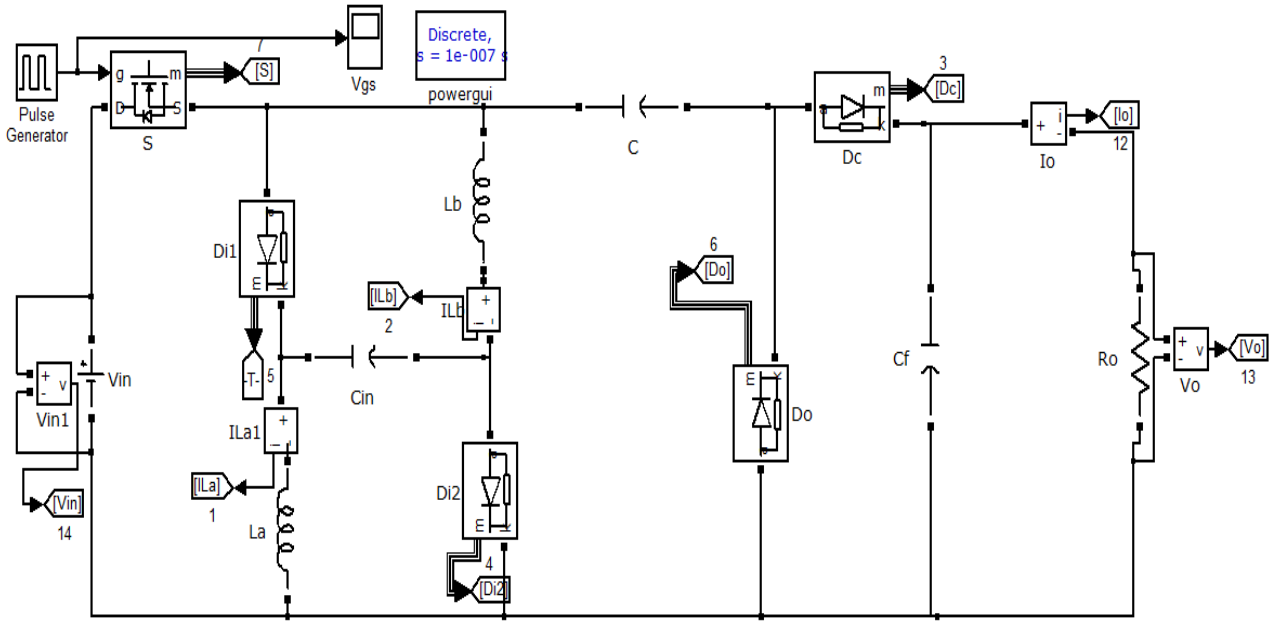


Fig .6 Relift converter simulation diagram

The MATLAB simulation diagram for Relift converter is shown in Fig .6.The output voltage waveform for an input of 12V for the Relift converter is shown in Fig .7.From the simulation result it is clear that the output voltage obtained is 76.62V,so that the gain of the converter is 6.38 for a duty ratio of 69%. The drop in voltage from the design value of 78V is due to the diode forward drop.

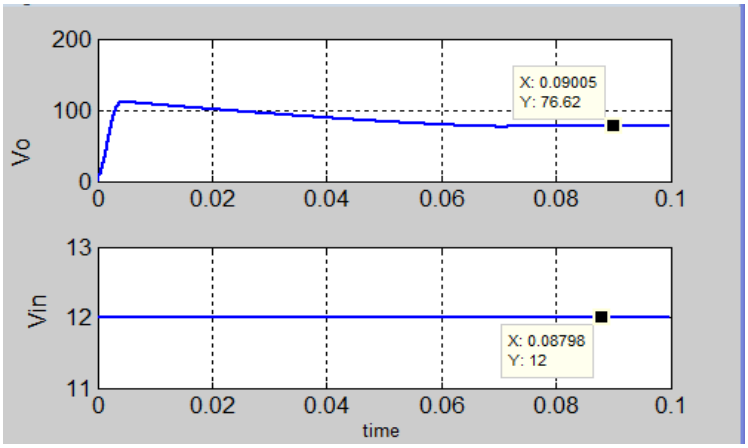


Fig .7 Output voltage(Vo) waveform of Relift converter (Vin=12V,Ro=1660Ω)

The voltage waveform across all the semiconductor devices of Relift converter are shown in Fig .8.The maximum reverse voltage(Vs) across the switch (S) is 76.68 V and it is equal to the output voltage.The reverse voltage drop across input diodes Di1and Di2(ie;VDi1 and VDi2 ) are 38.3V and it is one half of output voltage. Considering the voltage waveform of Di3(VDi3) it is clear that by excluding Di3 from the circuit by shot circuit the nature of the circuit will not change. The reverse voltage across Dc and Do(VDc and VDo) are equal to the output voltage

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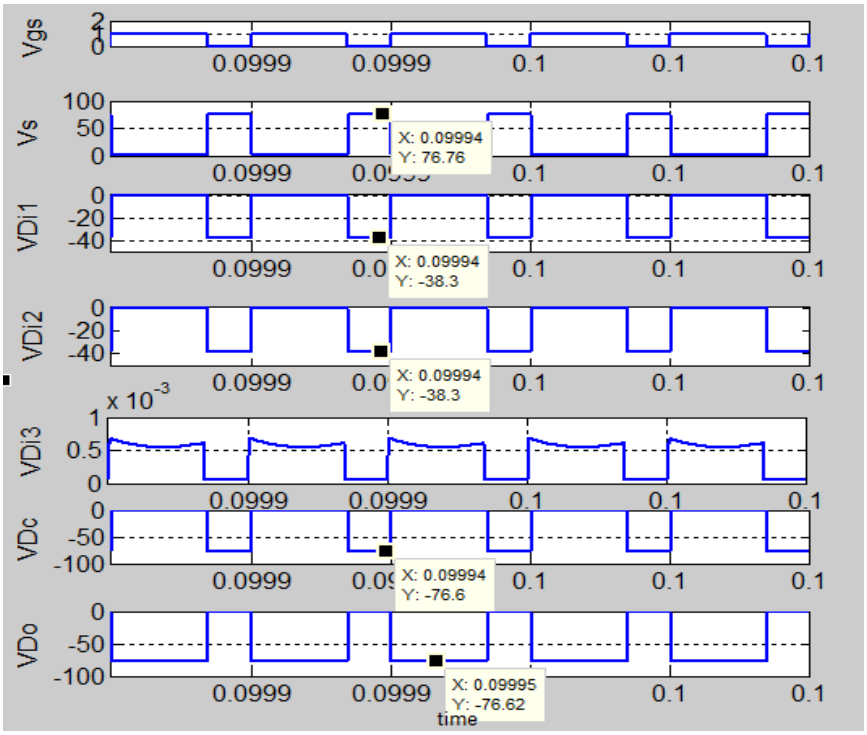


Fig .8 Voltage across semiconductor devices of Relift converter (Vin=12V,Ro=1660Ω)

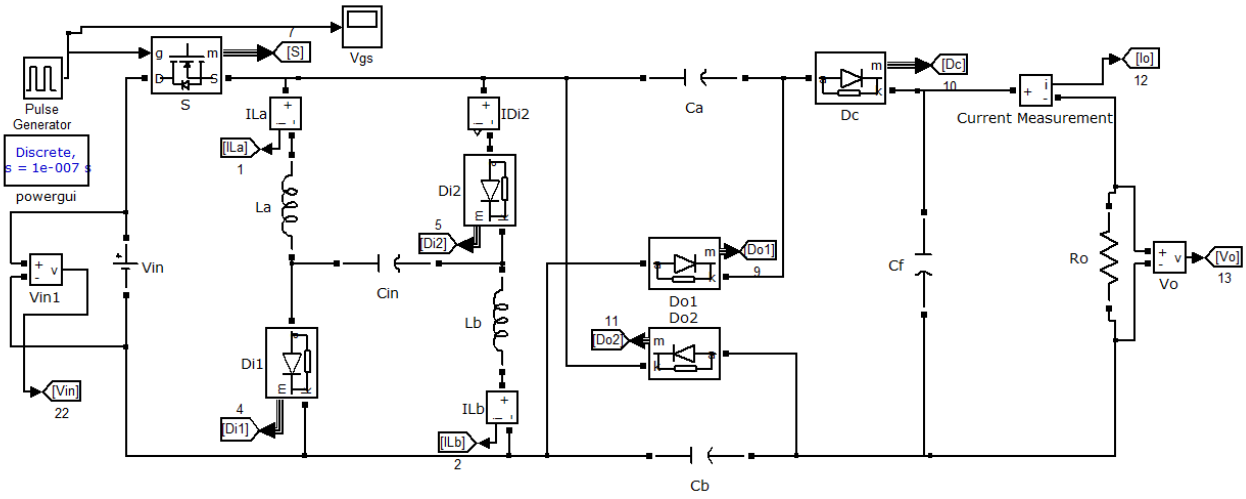


Fig .9 High Gain DC-DC Converter with Voltage Multiplier simulation diagram

The MATLAB simulation diagram for High Gain DC-DC Converter with Voltage Multiplier is shown in Fig .6.The output voltage waveform for an input of 12V for the converter is shown in Fig .10.From the simulation result it is clear that the output voltage obtained is 141V,so that the gain of the converter is around 12 for a duty ratio of 69%. The drop in voltage from the design value of 144V is due to the diode forward drop.

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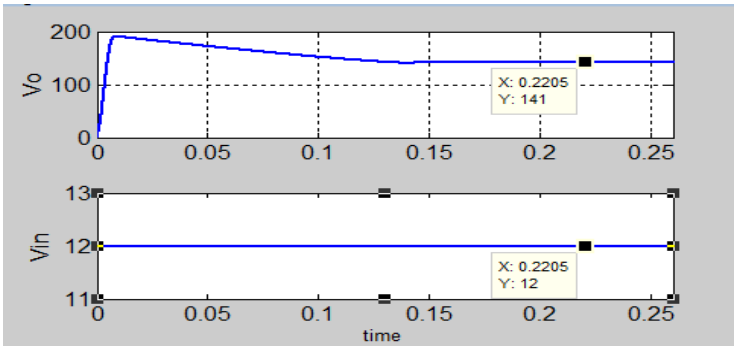


Fig .10 Output voltage(Vo) waveform of High Gain DC-DC Converter with Voltage Multiplier (Vin=12V,Ro=5861Ω)

The voltage waveform across all the semiconductor devices of High Gain DC-DC Converter with Voltage Multiplier are shown in Fig .11.The maximum reverse voltage(Vs) across the switch (S) is 76.68 Vand it is around one half of the output voltage. The reverse voltage drop across input diodes Di1and Di2(ie;VDi1 and VDi2 ) are 38.19V and it is 1/4$^{th}$of output voltage..The reverse voltage across Do1, Do2 and Dc(VDo1 , VDo2 and VDc) are equal to one half of the output voltage.

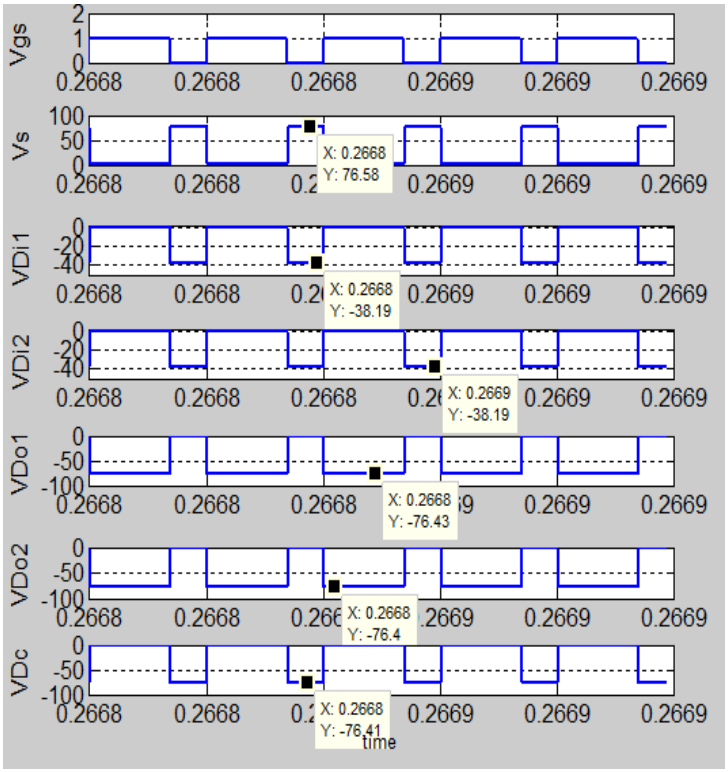


Fig .11Voltage across semiconductor devices of High Gain DC-DC Converter with Voltage Multiplier (Vin=12V,Ro=5861Ω)

Table-2 provides the comparison of Relift converter and High Gain DC-DC Converter with Voltage Multiplier in terms of simulation results and number of components.

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| Parameters | Relift converter(Converter I) | Converter with Voltage Multiplier(Converter II) |
|---|---|---|
| Output voltage(Vo) | 76.62V | 141v |
| Voltage gain | 6.38V | 11.75V |
| Maximum switch voltage stress(Vs) | 76.76V | 76.58V |
| Peak reverse voltage across Di1 &Di2(VDi1,VDi2) | 38.3V | 38.19V |
| Peak reverse voltage across Do Do1,Do2 | 76.6V | 76.43V |
| Peak reverse voltage across Dc | 76.6V | 76.4V |
| Number of components | 11 | 12 |

From table-2 it is clear that with the addition of one capacitor and diode the gain of the High Gain DC-DC Converter with Voltage Multiplier becomes double that of the Relift converter. Since the reverse voltage across the MOSFET switch is around half of the output voltage it is possible to use a low R_DSon MOSFET for the same power rating in the case of High Gain DC-DC Converter with Voltage Multiplier .So that the efficiency will be higher than that of Relift conveter

## VI.CONCLUSION

The paper presents the comparison of two single switch high gain DC-DC converter using MATLAB simulation. The simulation result magnifies the advantages of a voltage multiplier cell in high step up converter. The behaviour of both the converters are explained with relevant circuit diagrams. The simulation result reveals the advantage of using Converter II over Converter I for high voltage and high power application.

## REFERENCES

[1] B. Axelrod, Y. Berkovich, and A. Ioinovici, "Switched-capacitor/switched-inductor structures for getting transformerless hybrid DC–DC PWMconverters," IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 55, no. 2, pp. 687–697, Mar. 2008.
[2] M. Prudente, L. L. Pfitscher, G. Emmenderfer, E. F. Romaneli, andR. Gules, "Voltage multiplier cells applied to non-isolated DC–DC converters,"*IEEE Trans. Power Electron.*, vol. 23, no. 2, pp. 871–887,Mar. 2008.
[3] F. L. Luo and H. Ye, "Ultra-lift Luo-converter," *IEE Proc., Electr. PowerAppl.*, vol. 152, no. 1, pp. 27–32, Jan. 2005.
[4] X. Chen, F. L. Luo, and H. Ye, "Modified positive output Luo converters,"in *Conf. Rec. IEEE Int. Conf. PEDS*, 1999 , vol. 1, pp. 450–455.
[5] Abbas A. Fardoun,Esam H. Ismail,"Ultra Step-Up DC-DC Converter With Reduced Switch Stress", IEEE Trans. Ind. Appl., vol. 46, no. 4, Sep./Oct. 2010