Modified Dickson Charge Pump Voltage Multiplier Using High Voltage Gain Converter

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Abstract: ***A high voltage gain converter along with the inverter is introduced in this paper. The input side consist of two phase interleaved boost converter and the output side consist of the Dickson charge pump based Voltage Multiplier(VM). A continuous input current is achieved which makes the system to be more feasible such that it could be integrated with the various renewable energy sources such as solar. Integration of the solar panel with a 400-V dc bus is also possible. In the this system either a one or two independent sources can be used as input. Reduction in size is possible as the voltage multiplier provides the capacitors with a low voltage rating. To verify the proposed system,the computer based simulation model is developed using using MATLAB/Simulink.***

Keywords: High-voltage-gain power electronic Converter, modified Dickson charge pump, voltage multiplier (VM)

1. Introduction

Increasing use of renewable energy sources and its applications has increased the need of high voltage gain converters . The more efficient the design of the system is, the more output would be achieved. They can be interfaced with the low voltage sources like fuel cells, photovoltaic (PV) panels, batteries, etc., to the dc micro grid system of 400-V. we also find applications in various types of electronic equipment such as high-intensity-discharge lamps for automobile headlamps, X-ray power generators, servo-motor drives, power supplies for computer peripherals and uninterruptible power supplies.

When compared to ac systems,dc system have an improved power quality at low cost. The integrating of power electronics converter with renewable source has been a great challenge faced by the researchers. To Stepping up the voltage range from a solar panel of 20 V to 400 V dc uses boost and buck–boost converters which results in low efficiency and more stress in the component. A typical choice would be using two cascaded converters, resulting in inefficient operation, reduced performance, increased volume, and problems of stability issues. Isolated designs like fly back, forward, half-bridge, full-bridge, and push–pull converters requies large sized input capacitors for discontinuous input currents.

High voltage gain converter proposed by the researchers have been compared and their features are listed in the table below. The number of capacitors, number of inductors, number of diodes, voltage gain and the nature of input current has been studied. In [1] converter proposed is a second-order hybrid boosting converter which provides a low voltage gain compared with the Voltage multiplier converters.It produces a large input current ripple with is proportional to the average current.

Table I: High-Voltage-Gain Converters Using Boost Stage And Vm Circuits

Topology	No.of switches	No. of inductors	No. of capacitors	No of diodes	Vout/Vin
Interleaved Boost Converter	1	1	4	4	(3-d)/(1-d)
Switched Capacitor	1	1	3	3	2/(1-d)
Switched Capacitor Based Active Network	2	2	3	3	(3+d)/(1-d)
Transformer Less High Gain Converter	2	2	3	4	1/d(1-d)

In [4] transformer-less high gain boost converter, a high continuous output current is available. The drawback is that it would undergo a high voltage strain handling two to three percent of its output voltage. In [2] converter using a single inductor energy storage cell based on the switched capacitors, the High Step-up Converter.The disadvantage is that at a desired switching duty cycle, they did not offer voltage gain as high enough to raise the 20 V to 400 V. Based on the switched capacitor, the multiple energy storage cell provides a relative low voltage gain in proportion to the number of components.

In the above existing methods from the literature review the conventional converter the design is complicated as the leakage inductance increased when higher voltage gains are intended. The converter would encounter significant voltage spikes in the proposed circuits and would require a clamping circuit. The voltage spike on the switches is greatly reduced when clamping circuitry is included in the circuit. However, these clamping circuits adversely affect the voltage gain of the converters

In [5] it was suggested that a high voltage dc-dc converter be generated from the Dickson charge pump which is shown in the Fig 1. The voltage rating of the capacitors that is proposed in each cell is twice as that of the previous cell capacitor.

Voltage Doubler is a circuit with a voltage multiplication factor of two. So that the voltage get multiplied by the multiplier circuit. When even number of voltage Multiplier cells are used the current stresses experienced by each of the switches and inductors are different.

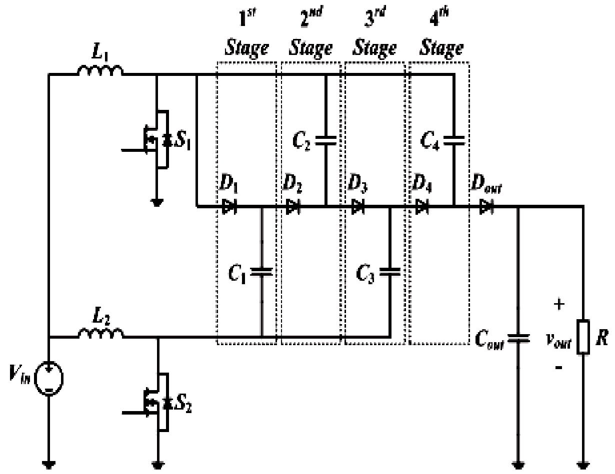

Figure 1: High-voltage-gain dc–dc converter

A high voltage gain converter that is based on the modified Dickson charge pump Voltage Multiplier circuit along with the inverter is introduced in the paper. This converter is capable of rising voltages from 20 V to 400 V together with the inverter. Initially the voltage from the solar panel is converted to high voltage dc and again it is inverted to ac such that it could be used in various ac applications as well.

The converter has the potential to step up the voltage and it also offers a high continuous input current and low voltage stress. The stress is reduced drastically such that it is one-fourth of the output voltage stress on the switch. The input to the converter could be from a single of multiple sources while having continuous input currents, which makes it suitable for applications like solar panels.[7] The main advantage of this proposed system is that it requires low voltage rating capacitors for its voltage multiplier circuit and one less diode when compared to the other method. The inductors and switches experience identical current stresses, making the component selection process for the converter simpler.

2. Modified Dickson Charge Pump Voltage Multiplier

The Dickson charge pump voltage multiplier circuit that is proposed in [6] shown in Fig. 2(a), offers a boosted dc output voltage by charging and discharging its capacitors. The input voltage VAB is a modified square wave voltage.

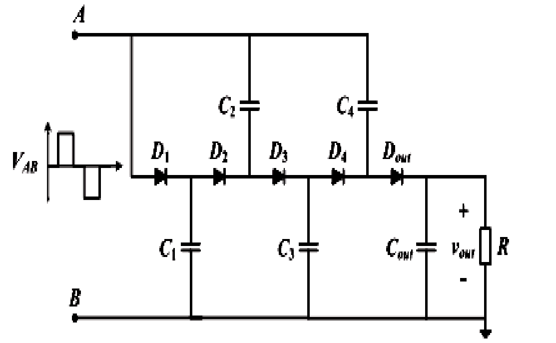

Figure 2 (a): Dickson Charge Oump Voltage Multiplier

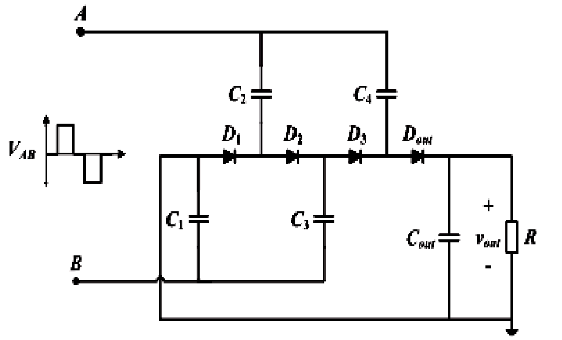

Figure 2 (b): modified Dickson charge pump.

The voltages of the capacitors in the Dickson charge pump double at each stage as one traverses from the input-side capacitor C1 to the load-side capacitor C4. For an output voltage of Vout = 400 V, the voltages of capacitors C1, C2, C3, and C4 are 80, 160, 240, and 320 V, respectively.

3. Modified Dickson Charge Pump Voltage Multiplier with Inverter

The proposed system contains inverter along with the converter so that it could be used for AC applications as well.

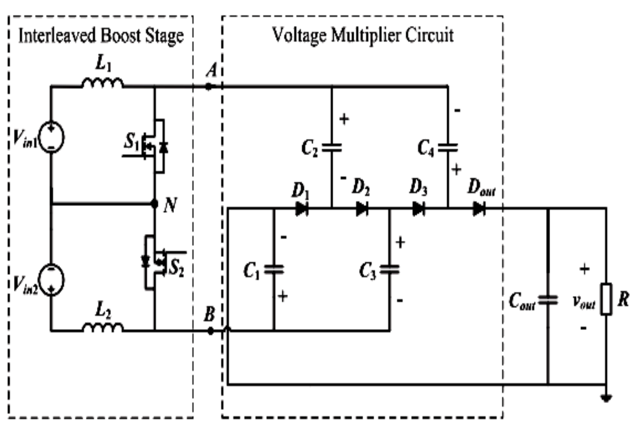

Figure 8: Proposed high-voltage-gain dc–dc converter

In this paper we make modifications to the Charge pump that is proposed in Fig. 2(b). For a same output voltage, the voltages of all the capacitors in the modified Dickson charge pump are smaller than the voltage of capacitor C2 in the Dickson charge pump. For an output voltage of Vout = 400 V, the voltages of capacitors C1 , C2 , C3 , and C4 are only 150, 50, 50, and 150 V, respectively. Therefore, the volume of the capacitors used in the proposed modified Dickson charge pump VM circuit is potentially less compared to the Dickson charge pump.

4. Modes of Operation

The two switches S_1 and S_2 as shown in the Fig 3. should have an overlap time when both the switches are ON and one of the switches must be ON at a particular point of time. This can be achieved by using duty ratios of greater than 50% for both the switches and having them operate at 180° out of phase from each other.[6]

4.1 Mode I

In this mode of operation shown in see Fig. 4 , switches S_1 and S_2 of the boost converter are ON. The inputs will charge the inductors L_1 and L_2 by which the current increases linearly for both the inductors L_1 andL_2. Now all the diodes of the VM circuit remains in reverse bias condition and the capacitors remain same. Therefore the output diode is also reverse biased and the output capacitor will supply the load[6].

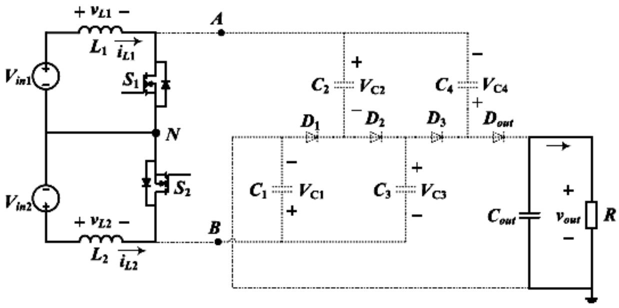

Figure 4: Proposed converter operation in mode I.

4.2 Mode II

In this mode of operation shown in see Fig. 5, switch S_2 is ON and the switch S_1 is in OFF condition. The diodes D_2 and D_{out} are forward biased and they are in ON condition. The diodes D_1 and D_3 are reverse biased and they are in OFF condition. The capacitors C_2 and C_3 are charged by a part of inductor current i_{L1}. The capacitor C_{out} is charged by the remaining current flowing through the capacitors C_4 and C_1. The load is supplied by output capacitor C_{out}. [6]

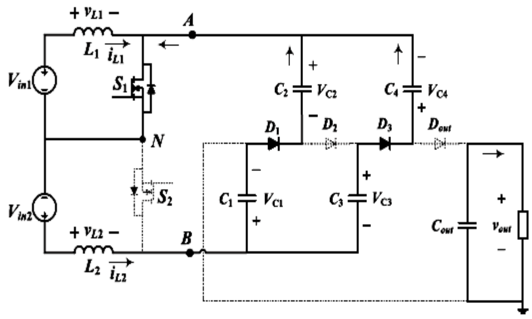

Figure 5: Proposed converter operation in mode II.

4.3 Mode III

In this mode of operation shown in see Fig. 6, the switch S_1 is ON and S_2 is in OFF condition. The diodes D_1 and D_3 are forward biased and they are in ON condition. The diodes D_2 and Dout are reverse biased and they are in OFF condition. The inductor current iL2 flows through all the capacitors C_1, C_2, C_3 and C_4 in VM cell. In this the capacitors C_1 and C_4 are charged while discharging capacitors C_2 and C_3. The load is supplied by output capacitor C_{out}. [6]

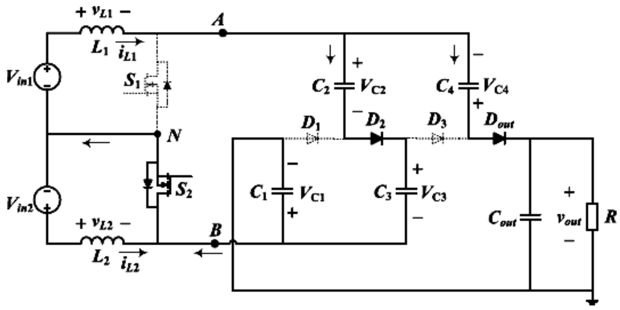

Figure 6: Proposed converter operation in mode III

5. Proposed System & Its Simulation Result Discussion

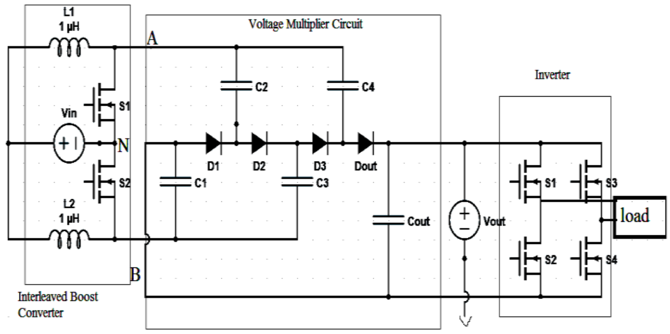

Figure 7: Proposed System

When the connected load is AC, inverter circuit could be connected and when in case of only DC load inverter circuit could be disconnected. By using inverter circuit the application of the proposed system is increased.

The Mat lab output is obtained for the above circuit when input voltage of 20V Dc is given to the system and the obtained output is around 400V AC which is been inverted using the inverter that is connected along with the High voltage Dc-Dc converter.

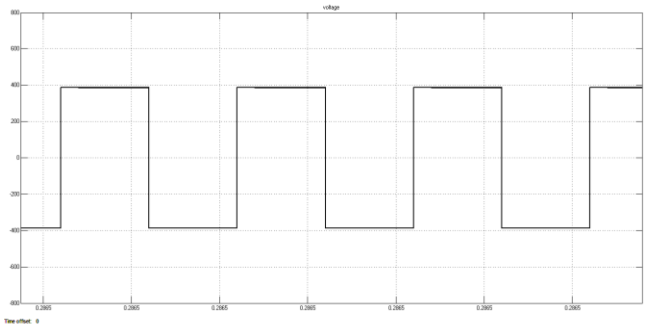

Figure 8: Mat lab Output

6. Conclusion

In this paper, a new approach of improving the classical Dickson Charge Pump is presented. A a high-voltage-gain dc–dc converter is introduced that can offer a voltage

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gain of 20, i.e., to step up a 20 V input to 400 V output. The main three components are two-phase interleaved boost, the modified Dickson charge pump VM circuit and Inverter. [6] A continuous input current is achieved which makes the system to be more feasible such that it could be integrated with the various renewable energy sources such as solar. Integration of the solar panel with a 400-V dc bus is also possible. The converter finds its application in integration of individual solar panels onto the 400 V distribution bus in datacenters, telecom centers, dc buildings, and, microgrids.

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