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High Step-Up Dc to Dc Converter with Switched Capacitor Technique

S.Anu Ishwarya , S.Kannadasan

***Abstract*—** The voltage gain of Conventional boost converter is limited due to the high current ripple, high voltage stress across active switch and diode, and low efficiency associated with large duty ratio operation. High voltage gain is required in applications, such as the renewable energy power systems with low input voltage. A high step-up voltage gain active-network converter with switched capacitor technique is proposed in this project. The proposed converter can achieve high voltage gain without extremely high duty ratio. In addition, the voltage stress of the active switches and output diodes is low. Therefore, low voltage components can be adopted to reduce the conduction loss and cost. The operating principle and steady-state analysis are discussed in detail. Based on the concept of switched-inductor and switched- capacitor, this project proposes a novel switched-capacitor-based active-network converter (SC-ANC) for high step-up con- version, which has the following advantages: high voltage- conversion ratio, low voltage stress across switches and diodes, and self-voltage balancing across the output capacitors. The operating principle and steady-state analysis are discussed in detail. The simulation results are given to verify the analysis and advantages of the proposed converter.

Index terms: Switched capacitor active network converter (SC-ANC),Discontinous conduction mode (DCM), continuous conduction mode (CCM).

I. INTRODUCTION

High step-up dc–dc converter is a class of converters which can boost a low voltage to a relatively high voltage. As we known, the output voltage of fuel cell stacks, single PV module, battery sources, or the super capacitors is relatively low; it should be boosted to a high voltage to feed the ac grid or other applications like uninterruptible power supplies, new energy vehicles, and so on. High step-up dc–dc power conversion has become one of the key technologies in these fields. As a matter of fact, when the output voltage is high, it is important to reduce the voltage stress on the active switch and output diode; otherwise, it will cause high conduction loss and expensive cost.

Due to the existence of parasitic parameters such as the inductor's equivalent series resistance (ESR), traditional boost converters cannot provide a high voltage gain.

The extremely narrow turn-off time will bring large peak current and considerable conduction and switching losses. Lots of research works have been done to provide a high step-up without an extremely high duty ratio. The isolated converters can boost the voltage ratio by increasing the turns ratio of the high-frequency transformer. However, the leakage inductor should be handled carefully; otherwise, it will cause voltage spike across the power switches or diodes. Moreover, isolated dc/dc converters have the shortages in system volume and efficiency due to multistage dc–ac–dc conversion. Based on the concept of switched-inductor and switched capacitor, this paper proposes a novel switched-capacitor-based active-network converter (SC-ANC) for high step-up conversion, which has the following advantages: high voltage conversion ratio, low voltage stress across switches and diodes, and self-voltage balancing across the output capacitors. The operating principle and steady-state analysis are discussed in detail, and the experimental results are given to verify the analysis.

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A. Block Diagram And Description

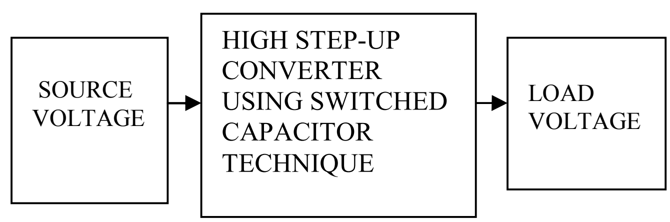

Fig 1: Block Diagram of Proposed Converter

The above block diagram represents the working of a switched capacitor-based active network converter with high step-up voltage gain. The source voltage is 20 v. Using the proposed converter high step-up voltage of 200 v is obtained based on the switched capacitor technique.

II. CIRCUIT DIAGRAM

High step-up dc–dc converter is a class of converters which can boost a low voltage to a relatively high voltage. As we known, the output voltage of fuel cell stacks, single PV module, battery sources, or the super capacitors is relatively low; it should be boosted to a high voltage to feed the ac grid or other applications like uninterruptible power supplies, new energy vehicles, and so on. High step-up dc–dc power conversion has become one of the key technologies in these fields. As a matter of fact, when the output voltage is high, it is important to reduce the voltage stress on the active switch andoutput diode; otherwise, it will cause high conduction loss and expensive cost. Due to the existence of parasitic parameters such as the inductor's equivalent series resistance

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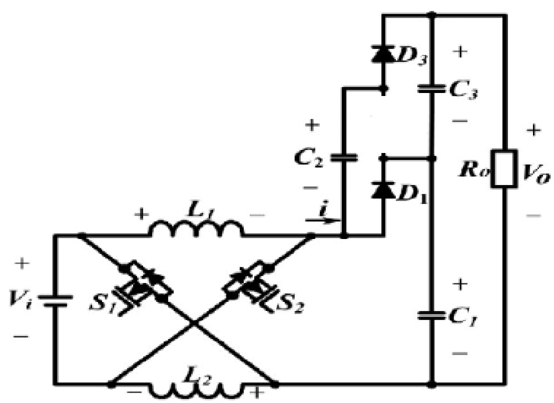

Fig.1 A Switched-Capacitor-Based Active-Network Converter

III. Modes of Operation

A) Ccm Operation

The operating modes in CCM condition are the Mode 1 and Mode 2.

1)Mode 1 [t_0, t_1]: during this time interval, switches *S*1 and *S*2 are turned ON. The equivalent circuit is shown in Fig. 4(a). Inductors *L*1 and *L*2 are charged in parallel from the dc source, the capacitor *C*2 is charged, and the energy stored inthe capacitors *C*1, *C*3 is released to the load. Thus,the voltages across *L*1 and L2

$$V_{L1} = V_{L2} = V_i$$

$$V_i + V_{c1} = V_{c2}$$

2) Mode 2 [t_1, t_2]: *S*1 and *S*2 are turned OFF. The equivalentcircuit is shown in Fig. 4(b). *C*2 is discharged and *C*1 is charged.At the time of *t*2 , the current through inductors decreases to zero.

We can derive,

$$V_{c2} = V_{c3}$$

$$V_{c1} + V_{c3} = V_0$$

The voltage of the capacitors can besderived as follows:

$$V_{c1} = \frac{Vo - Vi}{2}$$

$$V_{c1} = \frac{Vo - Vi}{2}$$

$$V_{c2} = V_{c3} = \frac{Vo + Vi}{2}$$

According to the KVL rule, the voltages across *L*1 and *L*2 can be derived as follows:

$$V_{L1} = V_{L2} = Vi$$

$$V_{L1} = V_{L2} = \frac{Vi - Vc1}{2} = \frac{3}{4} V_i \frac{1}{4} V_o$$

By using the volt–second balance principle on *L*1 and *L*2, the following equation can be obtained:

$$D.2V_i + (1\text{-}D).2\left(\frac{3}{4}V_i - \frac{1}{4}V_o\right) = 0$$

The Voltage Gain can be thus obtained as,

$$G_{CCM} = \frac{Vo}{Vi} = \frac{3+D}{1-D}$$

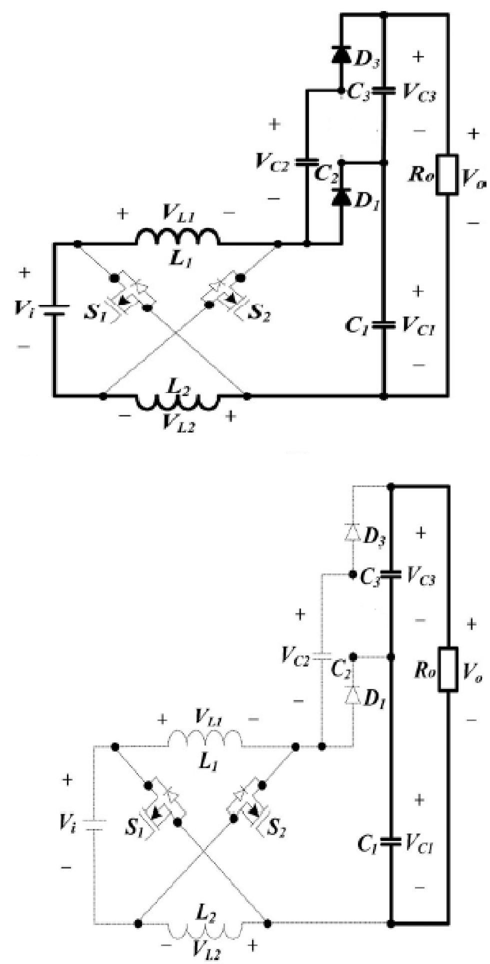

Fig.2 Equivalent circuits in CCM and DCM operation.

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B) Dcm Operation

Three modes exist in DCM condition.

1) Mode 1 [t_0, t_1]: during this time interval, the operational principle is the same as the mode 1 of CCM. The peak currents

of $L1$, $L2$ are derived as follows:

$$I_{L1p} = I_{L2p} = \frac{V_i}{L} . DT_S$$

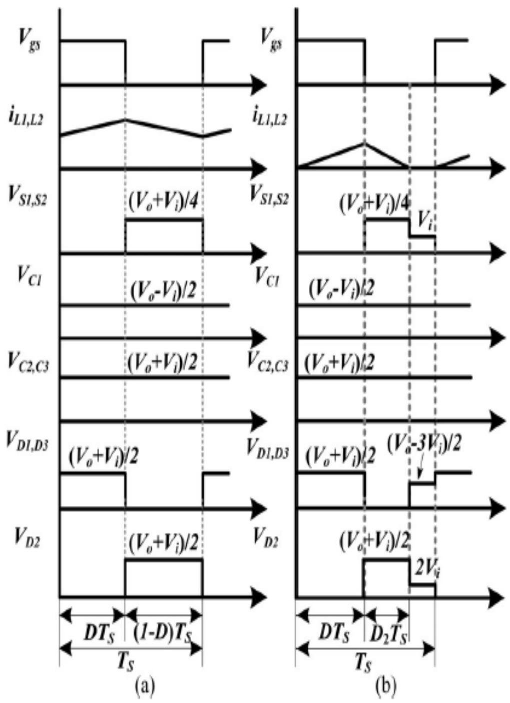

Fig. Key waveforms for the network, a) CCM, b) DCM.

2) Mode 2 [$t1$, $t2$]: $S1$ and $S2$ are turned OFF. The equivalent circuit is shown in Fig. 4(b). $C2$ is discharged and $C1$ is charged. At the time of $t2$, the current through inductors decreases to zero. We can derive as,

$$I_{L1p} = I_{L2p} = \frac{V_i - V_{c1}}{2L} D_2 .Ts = \frac{V_o - 3V_i}{4L} . D_2 .Ts$$

According to the KCL rule, the average current of the diode can be deduced

$$I_{D1} = I_{D2} = I_{D3} = I = I_o$$

The normalized inductor time constant is,

$$T = \frac{Lfs}{R}$$

The output voltage is given by,

$$V_o = \frac{3 + \sqrt{9 + \frac{4D^2}{T}}}{2} . V_i$$

IV. SIMULATION OF THE PROPOSED CONVERTER

The following diagram represents the simulation of the proposed converter in the MATLAB simulink.The following output results were obtained after the simulation process. The input parameters were initially set and after the simulation the expected output was obtained.The input or the

source voltage was set up as 20V and then the proposed switched capacitor based active network converter will produce the output of 200V.

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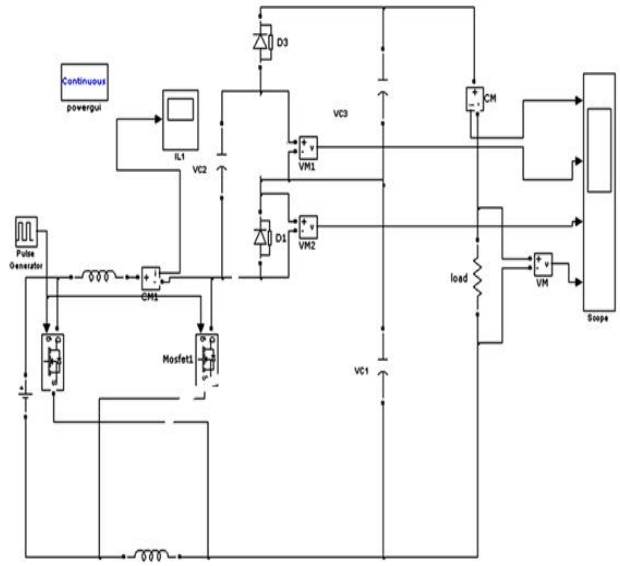

Fig.3 MATLAB Simulation of the converter

V. SIMULATION RESULTS

The results thus obtained after the Simulation are listed below,

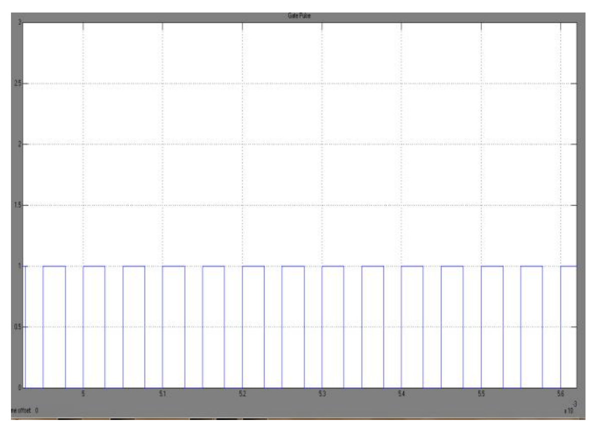

Fig.4 Gate Pulse waveform

The above figure shows the corresponding Gate pulse provided to the switching device.The switching device used is a MOSFET.The above figure represents the output voltage waveform.The output voltage obtained is 200v.The voltage is represented in the X-axis and the time period is represented in the Y-axis.

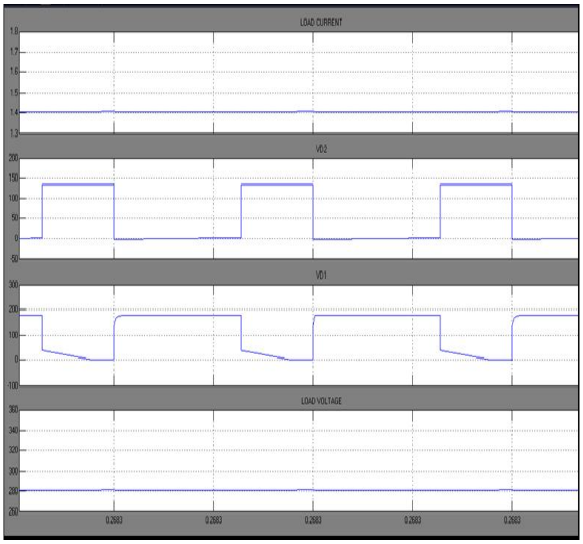

Fig.5 Voltage across the diodes and load voltage

The figure 4.4 represents the voltages across the diodes used in the proposed converter.There are two diodes used in the circuit.The diodes and the capacitors together form the voltage multiplier or the voltage doubler circuit, thus producing an output of 200v.

VI. CONCLUSION

This proposed work is a switched capacitor-based active network converter with high step-up voltage gain. The operating principles of the proposed converter in CCM and DCM have been discussed in detail. The voltage stress on active switches and diodes is low, which is beneficial to the system efficiency and cost. The voltage gain of the proposed converter is higher, the voltage across the power devices is lower; the inductor current is smaller. Simulation results have been given to verify the analysis and merits of the converter.

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