Modified Z-Source Converter for PV Application

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ABSTRACT

There has been an increase development in renewable energy application, so a Z-source (ZS)-based network combines through switched-capacitor (SC) converters provide a straightforward design semiconductor apparatus to have voltage stress at its minimum, gain at voltage and steady input current. A voltage doubler circuit is integrated with z-source converter which helps in voltage boosting at output. This circuit helps to improve or double the output voltage. For a small input voltage an improved output voltage can be obtained. The power switch duty cycle is reduced in any way by the suggested converters, in contrast to several other ZS-based topologies that are already present in the literature. Hence voltage gain is improved and voltage stress across switch is reduced. These qualities make the suggested converters suitable choices for PV applications that require the interface of solar photovoltaic panel (PV) through a dc bus. For a load of 100W which provides efficient modified converter.

Keywords: Solar Photovoltaic (PV) cell, Switched Capacitor (SC) cell, Z-source (ZS).

1 Introduction

Recently, increasing focus have been placed on the technological growth of renewable energy with photovoltaic and wind energy. The solar powered apparatuses are used for their effortlessness in installation, low maintenance and effectiveness in supplying isolated power to rural locations. Solar-PV panel's output voltage and current can fluctuate randomly then it is dependent on solar radiation levels and the temperature settings for operation. One of the key problems through PV technology, the common approach to raising the voltage of the PV panels and to connect them in series. The PV panels' output power significantly declines as a result of partial shadowing and module mismatches. Parallel connection is more efficient than series but PV method have relatively low-slung voltage output.

Therefore, converters using high-voltage gains is should be improved. The Z-Source converter comprise of two inductor and capacitor connected in X-shape to converter with input DC voltage. This can produce constant output DC voltage with input voltage magnitude. This conventional converter has dc input source as battery, diode rectifiers, thyristor converters fuel cell and more. An old-style boost converter can deliver a voltage gain in high value, but it has to run at high duty cycle near to unity. For the reason that the power switches run for long period of time nearly to switching period that is working at high duty cycle, the converter is suffering maximum conduction loss. Also, the output diode drives only to operate under short duration, which results in a serious reverse recovery issue with the diode. Through regulating transformers turns ratio, attain high voltage gain for isolated converters, so they have high cost and also switches have large voltage spikes because of inductance leakage and dissipation of power damage efficiency overall. Efficiency and cost can be reduced by using non isolated type of converters as galvanic isolation are not used in PV application.

Voltage and current output of given panel are affected by external condition (irradiance, temperature) and thereby its non-linear. MPPT depends on array, seasonal load and climate. MPPT varies between current and voltage, varies with temperature and radiance and track this and adjust accordingly. To get maximum power used (MPPT)function as a device that essential for an input current that's having low ripple and

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maximum voltage gain having short and medium duty cycle, switches taking low voltage stress and low quantity of components with high efficiency. MPPT depends on array, seasonal load and climate. MPPT varies between current and voltage, varies with temperature and radiance and track this and adjust accordingly.

The increasing demand for renewable energy sources several converters has been developed. For high step-up applications, various non-isolated converters are depicted. They use voltage-boosting approaches like coupled inductors [1], switched-inductor (SL)/voltage-lift (VL) system [2]- [3], and switched-capacitor (SCs) [4]- [7]. Device with high stepup is formed by isolating their isolated counterparts [8]. Converters with high step-up values are provided via voltage-boosting methods. In demand to produce a buckboost voltage gain and solve the issues of shoot-through in addition with restricted voltage at output side in conventional voltage and current-feeding system, ZS and qZS topologies were initially developed. As a result, advancing over ZS and qZS networks was made applicable to these converters. Addition to reduce the voltage ripple of output, an inductor was used in place of the output diode. However, by substituting an inductor for its output voltage gain considered to be less than that of the standard ZS converter.

Associated to the traditional ZS converter, network capacitors. The ZS conventional system is modified as qZS with enhancements such as common input, output and reduced voltage strains happening with capacitors ground cable. Nevertheless, qZS converter has similar voltage gain by way of ZS converter. The family of ZS besides qZS converters with bipolar voltage output and four-quadrant operation features were introduced, using possible switching devices with other elements. The voltage improvement, however, was insufficient, introduces a high-voltage gain sixth-order qZS device that integrates the SC approach by qZS and has better voltage gain and lower stress on capacitor voltage than standard converters.

A fusion SC-SL approach was employed to create a qZS high-voltage gain network using a sizable quantity of inactive apparatuses. A high-voltage gain system is presented by integrating SL cells of two into the qZS system; yet quantity of submissive apparatuses besides the voltage stress transversely the devices remained significant but suffered with short duty cycle choice restricted with 22.5%. Theses converters are contrasted with other high step-up ZS-/qZS system. The information about this quantity of inactive and dynamic apparatuses, voltage gain along with duty cycle having maximum value, and standardized voltage stresses with semiconductor device, together with diode and switch.

One power switch control all of the chosen converters. Created with arranged voltage gain vs duty cycle, converters with different topologies are compared. The straightforward ZS and qZS consume lesser voltage gains than the high stepup converters, but they are limited in their duty cycle ranges. Meaning that the maximum duty cycle for converters is restricted to values like 33.3% and 25%, which were lower than the supreme permitted duty cycle.

2 Conventional Z-Source Network

2.1 Topology of Conventional Converter

By incorporating the (Switched capacitor) SC cells into the standard ZS network, a ZS-based DC converter is created that provides gain in voltage at its maximum along with low power consumption. This converter provides low number of components in addition with voltage stress at semiconductor devices. This topology does not place duty cycle restriction, in contrast to certain existing ZS/qZS converters that only allow for a value lower than 0.5. This circuit has two inductors (L_1 and L_2), Four diodes (D_1 - D_4), one switch, and five capacitors (C_1 - C_4, Co). This traditional ZS network, which contains capacitors (C_1 and C_2), inductors of two (L_1- L_2) and combined with two SC cells to create a new model known as the SC-ZS network. The system with symmetrical construction, reduces stress across switch in addition with diodes and increases its voltage gain of given below converter. The variables Vin and R stand for the voltage and resistance of the load, respectively, on the PV panel.

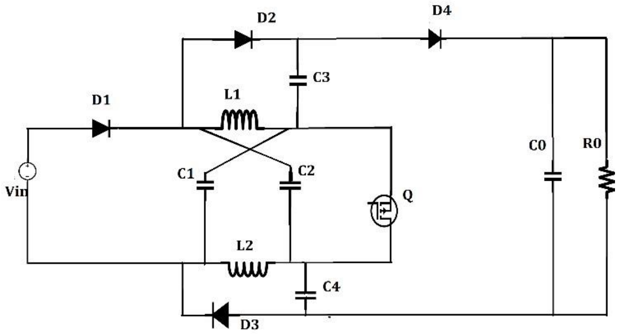

Figure 1: *Network topology of ZS system [1]*

2.2 Topology of S-SCZS Network

This topology is employed by SC cells integrated into the traditional ZS system to create the new ZS-based DC model, which offers maximum gain in voltage with short voltage stress, low number of components. Combined with a traditional Z-source network, switched capacitor creates a new converter. They are of two kinds.

i. Symmetrical Design
ii. Asymmetrical Design

A novel network with a traditional ZS converter is output diode and capacitor. A novel (Switched capacitor) SCZS (SCZS) network is suggested as a result of SC technique's integrated with traditional ZS. This topology consists of a capacitor (C in), an input inductor (Lin), diode (Din), a switch (Q), a SCZS, an output diode (Do) along with capacitor filter makes up the dc converters (Co). these systems greatly boost its voltage gain in addition decrease voltage strains on semiconductor as compared with traditional ZS. Additionally, the ZS networks and the SC cells capacitors all experience equal and low voltage pressures.

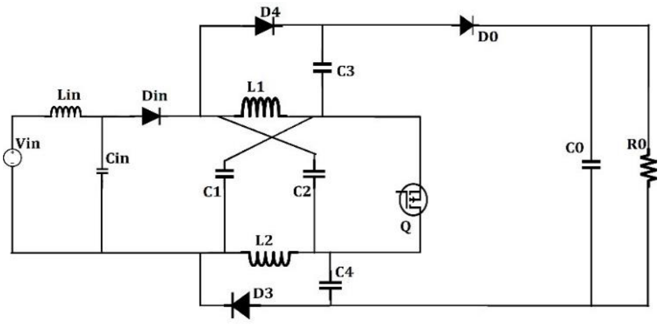

Figure 2: *The topology of S-SCZSC*

The subsequent expectations done to command the proposed (Symmetrical Switched capacitor Z-Source converter) SSCZSC: the capacitors are sufficiently large, and it is functioning at steady-state that all components are perfect. The input filter, which is made up of Lin and Cin, is constructed so Din its average current equating with input current. Here capacitor voltage is same as input voltage.

Due to the novel design of this system, the maximum output that is voltage measurement is produced by means of Switched capacitor impendence network with either C_1 or C_2. This converter produces an output voltage with the highest value of 455.3 V. The model was simulated with 33V input DC voltage. It indicates that voltage measurement that is output is amplified. The output current is 1.138A.

3 Modified S-SCZSC for PV Application

This paper introduces a new topology that is modified Switched Capacitor Z-Source Boost system consists of Z Source impedance system, load along with input source. The output side is integrated with a voltage doubler circuit. A total of eight capacitor, three inductor, six diode and a resistor are used. Here two capacitor and diode are added as a voltage doubler circuit. By using this method voltage is varied with respect to variation in current and maximum power can be tracked and delivered to the system. This voltage doubler circuit helps to boost output voltage.

When a voltage doubler circuit is integrated with SC-SZ network, the output is further increased. The SC-ZS network have capacitor that are switched in a specific sequence to transfer energy from input to output. This efficiently generate high output with low input voltage. The duty cycle is reduced and voltage stress across switch can be reduced. High duty cycle leads with problems in the system like overheating, reduced efficiency, increased voltage stress and more.

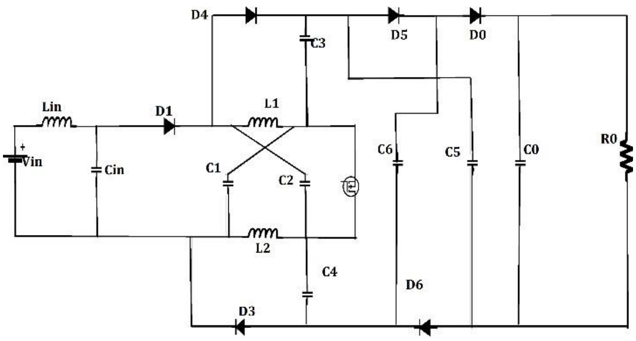

Figure 3: *The topology of modified S-SCZSC*

4 Simulation Results

Using MATLAB Simulink, the simulation has been done aimed at given Z-Source converter in addition modified Z Source converter. All the converters are designed with R-load of 400**Ω**. The modified topology is improved than the conventional converter as they have high voltage gain, minimum number if switch and components. The efficiency of the modified converter is better than conventional system.

4.1 S-SCZS Network

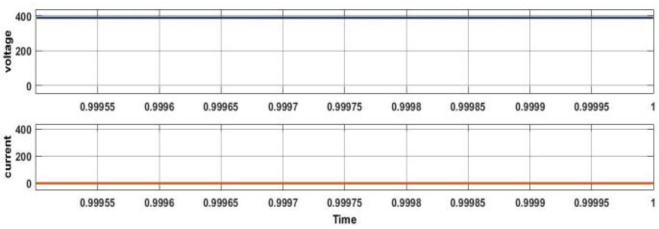

Figure 4: *Output voltage and current waveform*

Conventional system which simulated with 33V input dc voltage and 400Ω load resistance. The waveform characteristics changes with the change in load. Figure 4 represents the output voltage and current measurement. The voltage across input inductor is shown in Figure 5, voltage across capacitor is shown in Figure 6, voltage stress across switch is shown in Figure 7 and the voltage across output capacitor in Figure 8 is analysed and represented respectively.

It can be clearly identified that the voltage and current at output is 388V and 0.9A for an input of 33V.The voltage across input inductor, capacitor, voltage stress across switch and voltage across output capacitor is analysed and represented below.

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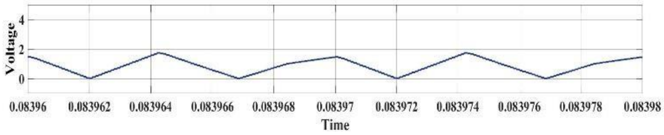

Figure 5: *Voltage waveform of input inductor*

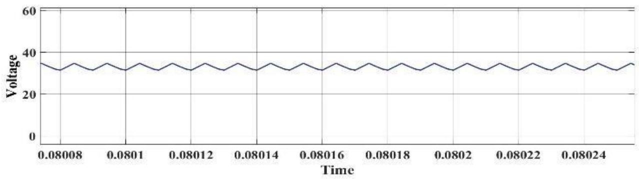

Figure 6: *Voltage waveform of S-SCZS Network*

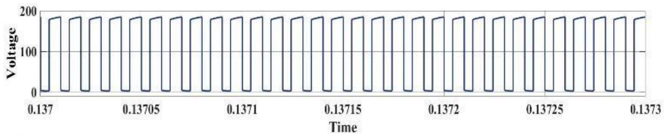

Figure 7: *Waveform of voltage stress across switch*

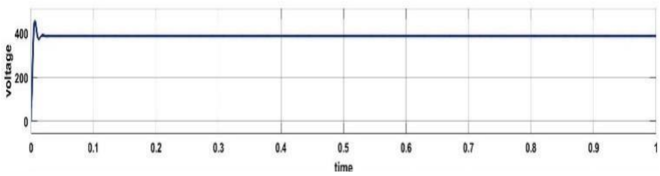

Figure 8: *Output voltage waveform of capacitor*

Table 1: *Simulation Parameters*

Items	Specification
Input voltage	33V
Input capacitor	20 μH
Capacitors C_1, C_2	$270\mu F$
Capacitors C_3, C_4, C_0	$30\mu F$
Input Inductor	20μH

The maximum output that is voltage measurement is produced by means of Switched capacitor impendence network with either C_1 or C_2. This converter produces an output voltage with the highest value of 388 V. The model was simulated with 33V input DC voltage. It indicates that voltage measurement that is output is amplified. The output current is 0.9A.

4.2 B. Modified S-SCZS Converter

Figure 9: *Waveform of Input Voltage across inductor*

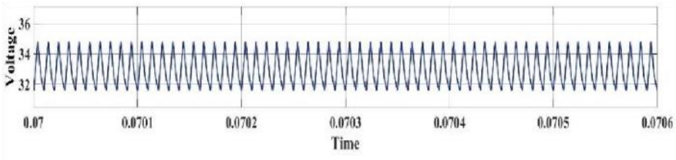

Figure 10: *Waveform of Input Voltage across capacitor*

The simulation result of modified converter is analysed, and waveforms are plotted. The waveform across voltage across input inductor, capacitor, voltage stress across switch and output voltage across the capacitor is done. The waveform across voltage across the input capacitor is shown in Figure 9, the voltage waveform of input inductor is in Figure 10, voltage stress across switch is in Figure 11 and output voltage across the capacitor is shown in Figure 12 capacitor.

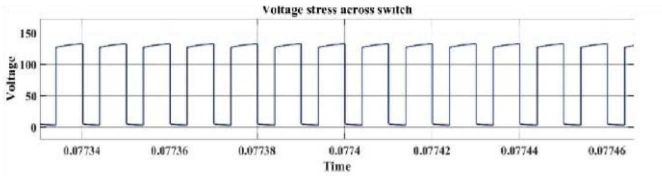

Figure 11: *Waveform of voltage stress across switch*

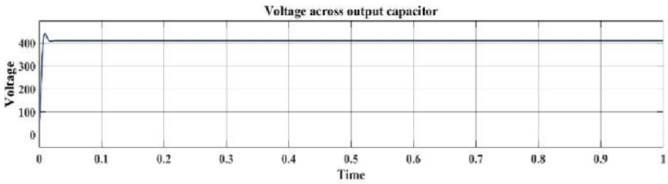

Figure 12: *Output voltage waveform of capacitor*

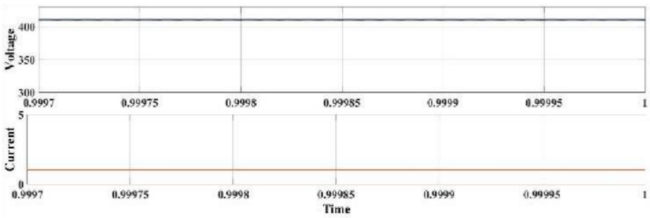

Figure 13: *Output waveform of voltage and current*

The output voltage and current waveform is inferred. When a voltage of 33V is provided as input, it can be determined that voltage is about 410V, and current is about 1.02A at the output. Here voltage stress across swich is reduced as 133V and voltage gain is improved as 12.42. As voltage stress reduced across the switch overheating of the device can be reduced, losses can be reduced as a result efficiency of overall system can be improved.

5 Comparative Study

The simulation of these two converters is described in this paper. Here voltage input (Vin), voltage at output (Vo), output current (Io), gain of voltage in addition voltage stress are compared. Table 2 presents the comparison table. This comparison table indicates that the modified converter has better performance than conventional system. Voltage gain is 12.4 and stress across voltage is 133V in this modified converter. For same input voltage of 33V an improved voltage and current output can be generated as of 410V, current about 1.02A.

Table 2: *Comparison Study of Conventional Z-Source Also Modified Network*

Converter	Vin	Vo	Io	Voltage Gain	Voltage Stress
S-SCZSC	33 V	388V	0.9A	11.7	184V
Modified converter	33V	410V	1.02A	12.4	133V

6 Conclusion

The usage of renewable energy has been improved drastically over a wide area of application. They can be used for domestical, and industrial applications DC system stand extensively used for several purpose like protection, improvement, and control voltage level. From simulation done and study conducted it can be said that the voltage gain is more about 12.42 in modified circuit rather than conventional circuit. Similarly, Voltage stress across MOSFET switch is reduced to 133V from 184V in conventional circuit. The conventional device takes low voltage and semiconductor devices face large stress compared with modified system. Modified Z-Source networks features a high voltage gain among the configurations. The method for boosting voltage of suggested network is created with help of integrating SC cells with ZS network. Modified boost converters can be used effectively. These circuits don't give any limitation on duty cycle. The integrated system enables tracking of maximum power to the system. This topology gives advantages of maximum output power, voltage gain, low stress happening with switching devices, smooth input current and duty cycle with 0% to 50%.

7 Publisher's Note

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