Cockcroft Voltage Multiplier Converter Based Three-Phase Inverter for High Power Applications

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Abstract: The dc-dc converter converts the low dc input voltage to high voltage without using a step-up transformer. The typical dc-dc converter generates high voltage using a high duty cycle, but the suggested converter generates high voltage using a low duty cycle. The Cockcroft voltage multiplier uses the diode and capacitor to increase the potential at the output of the converter and gain high DC voltage. The proposed converter is connected to the three-phase inverter and feed into the ac application. The capacitor is utilized to boost the voltage and operate as a transformer since the switch in the converter is turned off. The capacitor discharges the power, adding to the supply side voltage. The pulse width modulation is used to control and regulate the voltage and current of the inverter. The voltage and current of three-phase inverter simulation are verified using the Matlab / Simulink software.

Keywords: Cockcroft Walton, High DC Voltage, Pulse Width Modulation, Three Phase Inverter, AC Application.

1. Introduction

The conventional dc-dc converter produces a high voltage by giving a high duty cycle, but the proposed converter has high voltage [1]. The pulse generator is fed to the converter and the passive component is used to improve the gain of the voltage [2]. Presently, various converters produce a high gain and reduce the ripple across the passive element. The constant dc supply is fed into the Cockcroft Walton voltage multiplier circuit based on the three-phase inverter for AC application [3]. The voltage increases and has a steady output at the dc voltage, and the harmonics will be reduced compared to the conventional converter [4]. A high D.C. voltage is generated by using a Cockcroft-Walton cascade rectifier without a transformer to produce a high dc voltage output from a low dc voltage input. It provides constant input current to the load while minimizing ripple, voltage, and current. [5]. The high dc voltage is attained by installing a boost converter with a multistage Cockcroft Walton voltage multiplier that also functions in continuous conduction mode, reducing voltage stress between the switches and improving the converter's performance with decreased ripples [6]. The topological optimization of three proposed bipolar design strategies for 220 V and 50 Hz AC input to generate more than 3.5 kV DC output in short time periods is demonstrated here.

In addition to Cockcroft–Walton multipliers [7]. Not only does the suggested converter achieve nearly unity power factor and sinusoidal input currents with little distortion, but it also achieves significant voltage gain at the output end [8]. A single switch architecture of the DC-DC multilevel buck-boost converter with an extremely high voltage gain ratio is a blend of the buck-boost converter and Cockcroft-Walton voltage multiplier in the proposed model converter design. The key advantage of the proposed topology is that the output voltage may be increased without interfering with the main circuit by increasing the number of capacitors and diodes on the output side [9]. A detailed investigation of three alternative topologies for low-power PV applications based on the well-known Cockcroft–Walton (CW) voltage multiplier [10]. A high DC voltage circuit based on the Cockcroft Walton Voltage Multiplier circuit is given, and the digital controller is created utilizing Complex Programmable Logic Devices (CPLD). As an input source, the suggested system makes use of a single-phase alternating current (AC). The multiple-pulse PWM switching technique is used to regulate the power switching devices in the controlled bridge to avoid the occurrence of low order harmonics on the converter system's AC side [11].

The results of comparative research on various voltage multipliers were given. Topology properties have been compared using models and experimental prototypes [12]. A high step-up DC-DC converter does not require a step-up transformer and is based on the Cockcroft-Walton voltage multiplier. The boost inductor (Ls) boosts the low input DC voltage in the DC-DC converter, and the recommended circuit performs the inverter function [13]. An n-stage Cockcroft Walton voltage multiplier, as proposed, can provide a sufficient DC source for an n+1 level multilevel inverter[14]. The input voltage from the photovoltaic source is low, while the output voltage produced by the CWVM DC-DC converter is higher. The suggested converter's output voltage provides continuous current to the circuit's switches and diode, a low voltage ripple, and a high voltage gain. The proposed approach consists of three phases, each with a 270V output [15]. In this article, the proposed topology, results and discussion and conclusion are explained in detail.

2. Proposed Topology

The proposed converter has designed by the parallel connection of two diodes, and the capacitor is added in between them. The capacitor is used to increase the voltage, and it will act as the transformer because the switch in the converter turns off, and the capacitor discharges the power, adding to the supply side voltage. The output voltage of the inverter has generated a high voltage gain. The block diagram of the proposed circuit is shown in Figure 1 and Figure 2.

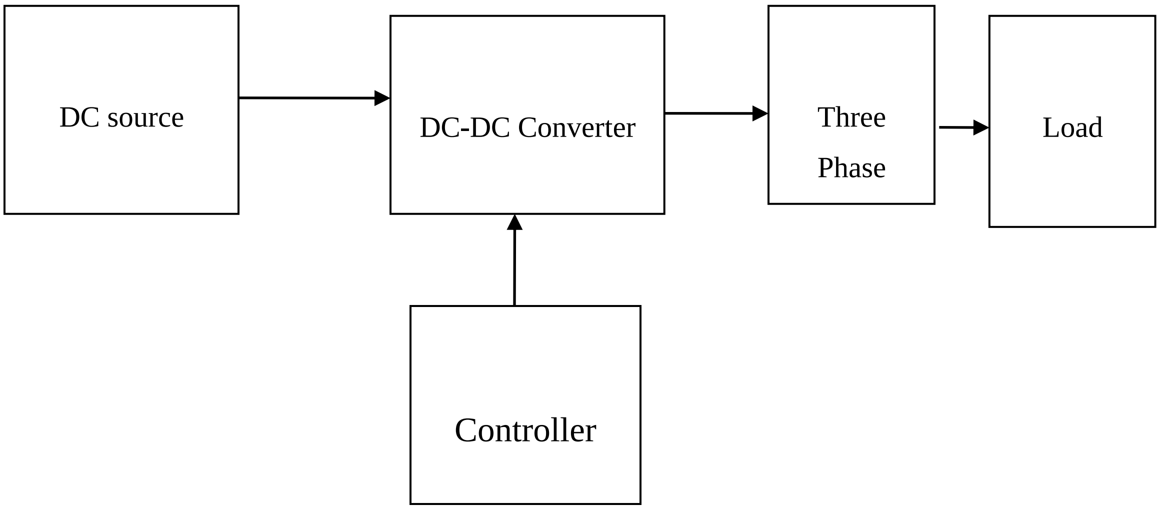

Figure 1: Block diagram of the proposed circuit

The proposed converter operated in various modes.

Mode 1: During this mode, none of the diodes are conducted, and the capacitors C6, C4, and C2 are supplied to load while the remaining capacitors are floating.

Mode 2: During this mode, the diode D6 is conducting, and the capacitors C6, C4, and C2 are charged, and the remaining capacitors are discharged through the diode.

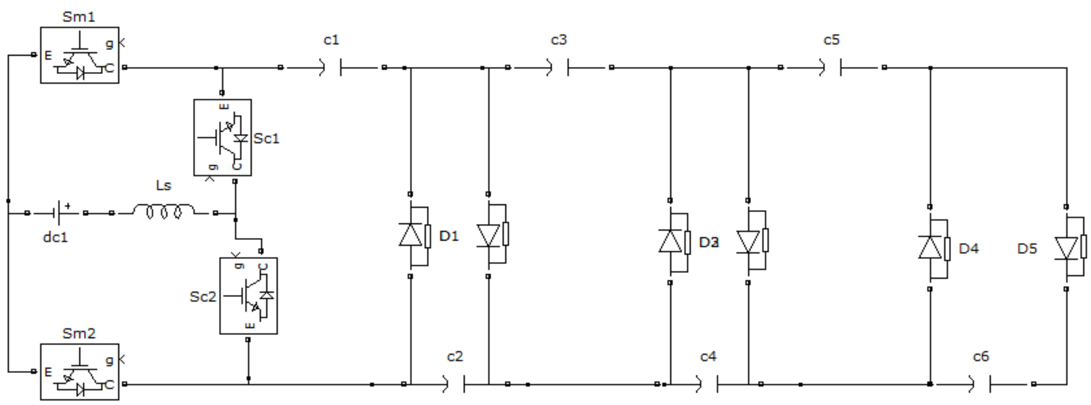

Figure 2: Proposed DC-DC converter

Mode 3: In this state, the diode D4 is conducting, the capacitors C4 and C2 are charged, and the capacitors C1 and C3 are discharged.

Mode 4: During this mode, the diode D2 is conducting, the capacitor C2 is charged, and the C3 and C4 are supplied to the load current.

3. Simulation Results

The overall simulation diagram is shown in Figure 3, which is consists of Cockcroft voltage multiplier converter-based inverter for ac applications. The proposed converter can be supplied by the DC source 24V. Then the proposed converter can be connected to the inverter which is controlled by PWM. Finally, the inverter can be connect to AC load. The system is designed and implemented using MATLAB/Simulink software.

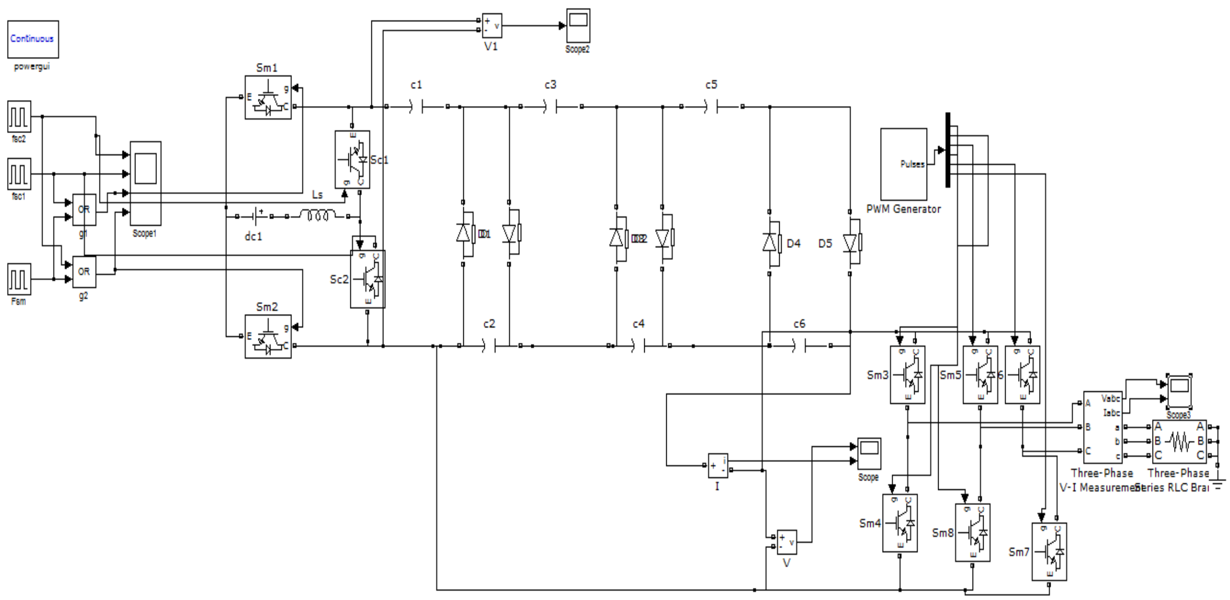

Figure 3: Proposed simulation circuit

Further the Simulink diagram can be presents in Figure 3. The DC source can be provide to the proposed converter, the source can be given using step response block to provide the supply with respect to time. However, the inverter is connect with the converter, PWM is used to control the signal which is also used to convert the DC –AC. Then the controlled inverter signal can be provide to the loads. Here we designed the three phase R load with 100Ω. The results are visualized by the scope block. Then the system can be compiling with the help of power GUI.

After that the system can be validate through the simulated waveforms, which is illustrates below,

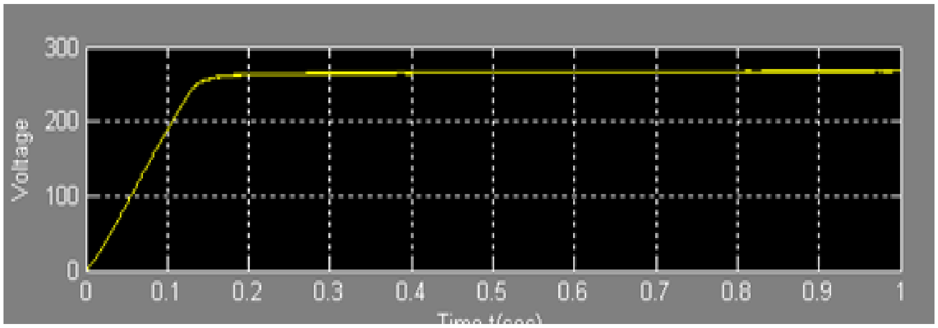

Figure 4: Output Voltage Waveforms for Converter

The voltage across the dc-dc converter is shown in Figure 4. Which is considered the proposed converter of Cockcroft converter's output voltage is 280V. This waveform represents that the source DC voltage is 24V this source voltage can be gained by the proposed converter. The proposed converter can initially at 0V, due to that operating conditions the converter voltage gradually increasing upto 280V at 0.15 sec. and further the output voltage of the proposed converter can be saturated.

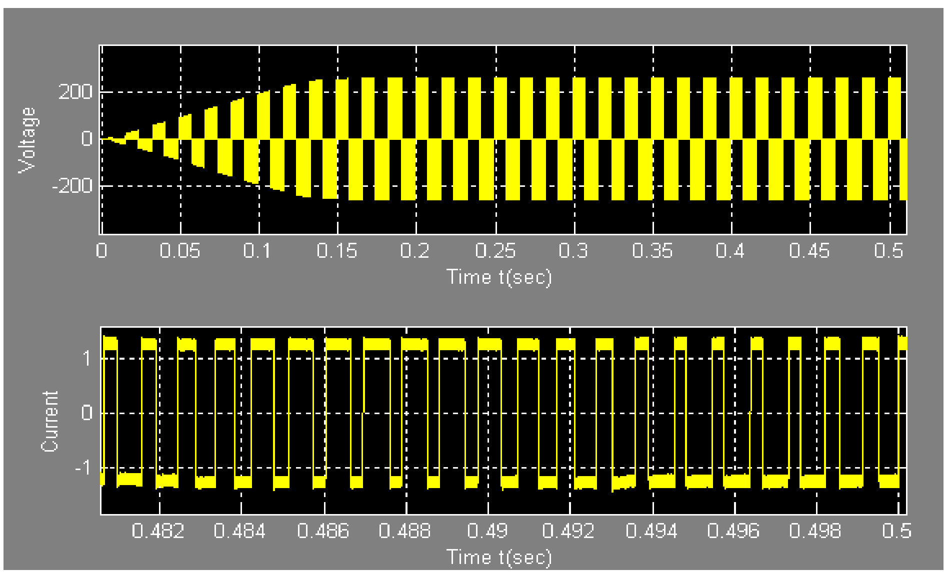

Figure 5: Output Voltage and Current Waveform for R Load Condition

Then the Figure 5 illustrates that output voltage and output current of the three phase R load. The output voltage is 280V and the output current is 1A. Whereas, the waveform represents the same amount of the converter's output voltage can exists in the overall output voltage. This proposed system can also illustrates as the no losses occur between converter and inverter to the loads. This ensures that the proposed system can be able to use in high power applications.

4. Conclusion

The high gain CW voltage multiplier has been analyzed in the proposed method. The dc-dc converter transforms a low dc input voltage to a high voltage without a step-up transformer. Still, the recommended converter uses a low duty cycle to generate high voltage. The proposed converter has three stages for ac load application. Every voltage multiplier stage has maintained the same potential and produces ripple-less output and continuous current at the output. Moreover, the proposed converter can be operated at various modes by connecting two diodes in parallel and adding a capacitor. The capacitor is utilized to boost the voltage and operate as a transformer. The switch in the converter is turned off, and the capacitor discharges the power, adding to the supply side voltage. The inverter's voltage and current are controlled and regulated via pulse width modulation. MATLAB/Simulink software is used to validate the voltage and current of a three-phase inverter simulation.

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