Four switch three-phase Z-source rectifier with improved switching characteristics

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ABSTRACT

This paper describes four switch three-phase Z-source rectifier with improved switching characteristics. This configuration has some advantages switching loss and optimal drive circuit. The rectifier has buck-boost function by shoot-through state. Also, the rectifier has the advantage of decreasing inrush current in start-up and transient states. In order to reduce harmonics PWM modulation technique with a variable index has been suggested. Four switch three-phase Z-source rectifier with improved switching characteristics can output stable DC voltage at the same time decreasing the system's harmonic current. And also the paper presents an application of DCC method in Z-source rectifier. Principles and dynamics of the system are discussed in detail. After having viewed the results we can confirm that the proposed method is eligible and efficient.

1. INTRODUCTION

Switching is most important parameter of any power electronics device. Method of the switching impacts to the characteristics of the circuit by means waveform of output voltage and current, it is including duration of the transient period and creating undesired harmonics. Three-phase four-switch rectifiers, due to their high efficiency, good current quality and low EM1 emissions are widely used in industry. For switching this type of rectifier, various modulation techniques have been already developed and implemented.

In this paper, three phase four switch Z-source rectifier based on improved switch topology is presented. This z-network allows the z-source rectifier to buck or boost its output voltage. The four switch topology may be less costly. This configuration also simplifies the hardware structure and increases the converter reliability

2. THE PROPOSED METHOD

2.1 Three-phase four-switch Z-source rectifier

The main objective of three-phase rectifier is to generate three-phase sinusoidal input currents in phase with the input phase voltages and also DC stable voltage in output terminal. Fig.1 shows the four switch three-phase Z-source rectifier . One leg of the three-phase AC source is connected to the midpoint of a split capacitor, and the Z-impedance network is coupled between the front two phase leg's end and the second leg. When both the upper and lower devices of any one phase leg , or any two phase legs are shortened-through, the z-source rectifier has one extra zero state. This Z-network allows the Z-source rectifier to buck or boost its output voltage. For four-switch and six switch three-phase Z-source rectifier, their switching control and shoot-through time control are basically the same. According to the general six switch three-phase Z-source rectifier , we get

$$V_{dc} = \frac{1 - D_0}{M} \frac{2V_i}{\cos\phi} \quad (1)$$

Where V_{dc} is output DC voltage, V_i is input AC voltage, $\cos\phi$ is power factor, D_0 is shoot-through duty time and M is modulation index.

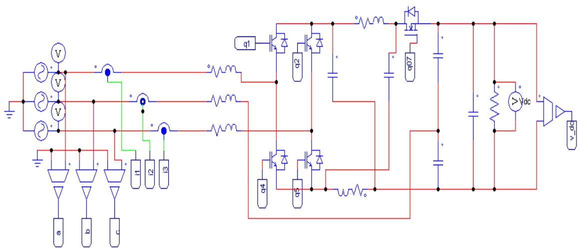

Fig. 1. Three phase four switch Z-source rectifier

2.2 The switching control method

Fig.2 shows the DCC (Direct Current Control) method which is to generate and complete SPWM control signal. The difference value of the reference DC voltage and the output DC voltage is through the PI control. This value and the unit voltage are multiplied to get the ideal active grid current. The reference values are obtained by subtracting the grid current from this value. Then the difference V_a-V_b and V_c-V_b will be multiplied with the value and $\sqrt{3}$. Then derived resultant is transmitted to the PWM to get switching signals.

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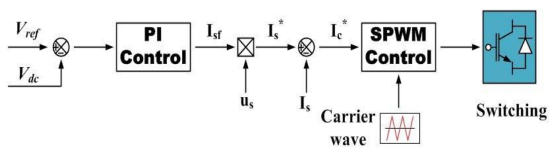

Fig. 2 Direct current control (DCC) method.

3. SIMULATION AND RESULTS

There are parameters of the circuit in Table 1. There is output DC voltage in Fig 3. It's shown that the rectifier has boost capability. The DC voltage has an insignificant harmonic, but it's clearable by regulating PI controller .Also it's seen in Fig. 4 that input current and voltages are in-phase, so the power factor is nearly unity.

Table 1 Per Unit values of the system parameters

RL1	0.2 ohm, 2 mH	C1 ,C2	1000 uF
RL2 , RL3	0.2 ohm, 1 mH	C3 ,C4	3300 uF
R1	100 ohm	C5	1000 uF
Peak value of input AC voltage		100 V	

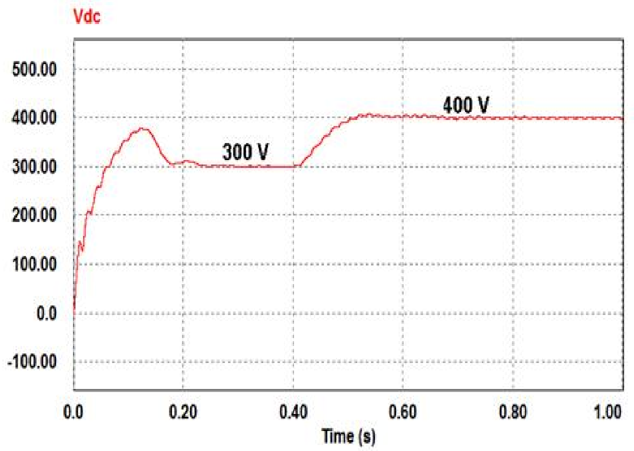

Fig 3. Output DC voltage waveform.

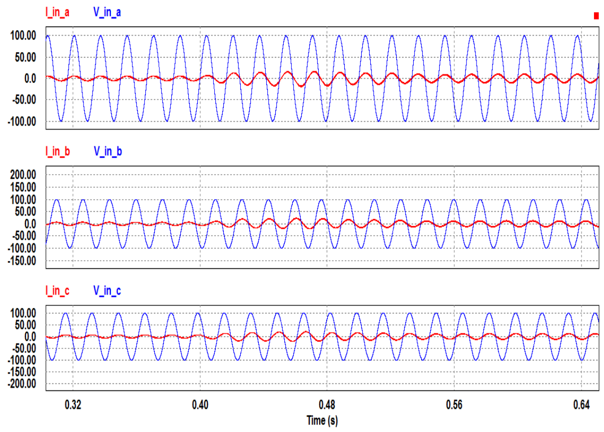

Fig 4. Input current and voltage waveform per phase.

4 . CONCLUSION

The goal of this paper is to improve the switching characteristics of the three-phase four switch Z-source PWM rectifier by using PI controller and DCC method. As it is seen from the results, the three-phase Z-source rectifier can buck or boost input voltage by using a shoot-through state. The output voltage value can be controlled by regulating the reference value.

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