Four Switch Three-Phase Z-Source Active Power Filter

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ABSTRACT

This paper describes the four switch three phase Z source active power filter. This novel configuration has many advantages like reduction of cost, switching loss and smaller drive circuit. The paper presents an application of direct current control(DCC) method in a three phase parallel Z source active power filter to reduce the harmonics generated by the nonlinear load. The compensation principles and dynamics of the system are discussed in detail. The results show that the proposed control strategy is feasible and efficient.

1. INTRODUCTION

Harmonics are one of the most parameters power quality. Harmonics have many destructive impacts in power system, it is including creating heat losses in electrical machines and transformers. Power filter is used for eliminating or reducing harmonics which it is including two general types of passive filters and active filters. Active filters have been successfully developed, and are available as commercial products. It can solve the harmonic pollution and compensate the reactive power simultaneously.

In this paper, a shunt three phase Z source active power filter based on a reduced four switch topology is presented[1]. 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. Harmonic compensation algorithm is used. For harmonics compensation, four switch three phase Z source PWM rectifier is controlled.

2. THE PROPOSED METHOD

2.1 Four Switch Three-Phase Z-Source Rectifier

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.

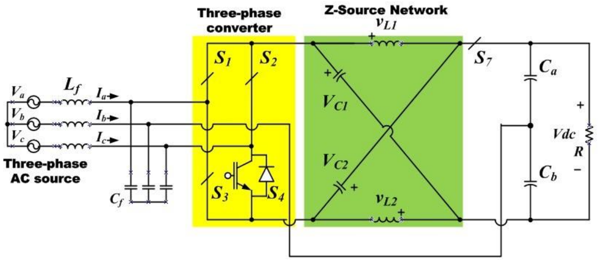

Fig.1 Four switch three-phase Z-source rectifier

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 literature[2], we get

$$V_{dc} = \frac{1-D_0}{M}\frac{2V_i}{\cos\psi} = \frac{B}{M}\frac{2V_i}{\cos\psi} \qquad (1)$$

where, V_{dc} is the DC output voltage, D_0 is the duty cycle, M is the modulation index, V_i is the peak phase ac input voltage, B is the buck factor.

In order to balance four switch three voltage signals produced by the last stage(V_a,V_b,V_c) are converted to two voltage signals so that balance is established. So, for four switch three phase Z source rectifier, Vi which is in the above equation is the peak value of two signals (V_a V_b), (V_c V_b).

2.2 The Active Power Filter

The voltage of DC link's side can always keep higher than the grid voltage and compensate the grid current. The Z source active power filter can output stable DC voltage from the DC link side and compensate the harmonics at the same time. Fig.2 is the system's complete circuit.

The source current(I_S) can be expressed by the nonlinear load current(I_L) and the compensating current(I_C) such as the equation(2).

$$I_S(t) = I_L(t) + I_C(t) \qquad (2)$$

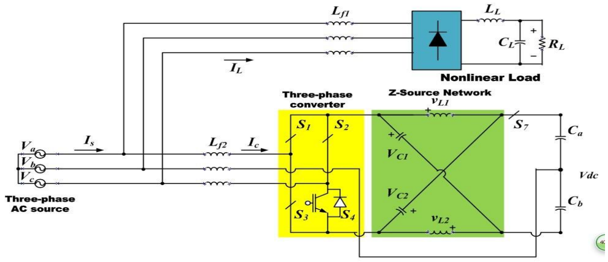

Fig.2 The proposed four switch three-phase Z-source active power filter

In this paper, we use the direct current control(DCC) method to complete SPWM control. Fig.3 shows the DCC method. The difference between the reference DC voltage and the actual DC voltage is through the PI control as one value. This value and the unit voltage vector are multiplied to get the ideal sinusoidal waveform of the active grid current. The reference compensating is obtained by subtracting the grid current. If we get the reference compensating current, the compensation can be realized by the SPWM.

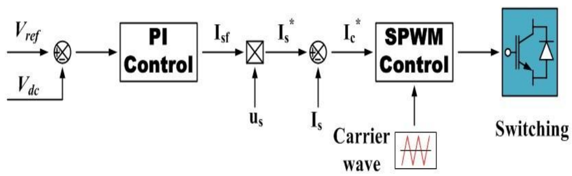

Fig.3 Direct current control method

3. SIMULATION AND DISCUSSION

The simulation parameters are as follows:

Table 1 System Parameters

Input voltage	$100V_{peak}/60Hz$	
Four switch Z source PWM rectifier	Lf2	3mH
	Ca=Cb	3,300uF
	L1=L2	1.5mH
	C1=C2	1000uF
Nolinear Load	Lf1	1.5mH
	LL	3mH
	CL	1000uF
	RL	40Ω
Switching frequency	10kHz	

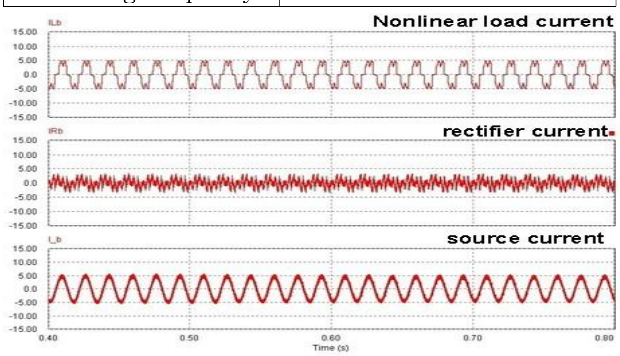

Fig.4 The currents waveform of the four switch three-phase Z-source active power filter.

Fig.4 shows the currents waveform of the four switch three phase Z source active power filter. From the figure, we can see that the nonlinear load current exits the harmonics. Though compensating current from the grid current of four switch Z source rectifier becomes sine wave.

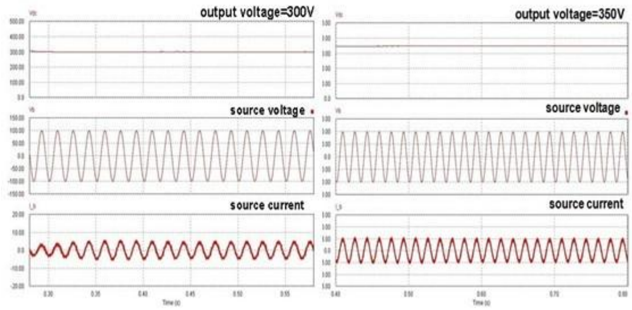

Fig.5 The different rectifier output voltage, the source voltage and current's waveform.

Fig.5 shows the rectifier output voltage, the source voltage and current. According to relevant knowledge, 300V is smaller than the minimum output voltage(340V) of the four switch three phase rectifier. However, 350V is the boost output voltage. Z network can buck or boost output voltage. From the source and current waveform, it shows that the power factor is nearly unity.

4. CONCLUSIONS

In this paper, the goal is to use four switch three phase Z source rectifier to eliminate harmonics generated by the nonlinear load. From the results, the three phase Z source rectifier can buck or boost output voltage. It has many advantages such as reduction of cost, switching loss, and circuit for pulse generation, but lead to happen unbalance in the system. By the proposed method, harmonic and reactive currents can be compensated effectively. After, we will further verify the effectiveness of the proposed method by the experiment.

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