A Study On the Output Voltage and Power Factor of the Three-Phase Four Switches Z-Source PWM Rectifier

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3상 4 스위치 Z-소스 PWM정류기의 출력전압과 역률에 관한 연구

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ABSTRACT

In this paper, the four switches three phase Z source rectifier is studied. The conventional three phase four switches rectifier can only either perform buck or boost operation, distortion and unbalance of the input current are serious. Therefore, we proposed the four switches three phase Z source rectifier which can realize buck function simply by applying the Z impedance network. We will verify characteristics of Z network by the simulation and experiment.

1. INTRODUCTION

Nowadays, in some low power range applications, the reduced switch technologies are considered by both users and vendors to reduce volume and cost. In order to achieve this goal, four switches three phase rectifier was proposed[1]. It has some limitations as traditional six switches VSR(Voltage Source Rectifier) that it can either boost or buck. It is possible to obtain the desired output voltage only with the 2 stage configuration of a buck boost converter used. Besides, it is very vulnerable to EMI noise. So as to overcome those limitations, we studied the four switches three phase rectifier where the Z network is applied[2]. Because of the unique Z network, the circuit would have a shoot through state where the switches in the same arm are shorted. Due to this extra shoot through state, the rectifier can output desired output DC voltage, greater or smaller than the line AC voltage and increase the reliability of the circuit and the size of the circuit is reduced.

2. THE PROPOSED SYSTEM

2.1 Three-Phase Four Switches Z-Source Rectifier

The structure of the three phase four switches Z source rectifier is shown in Fig.1. Unlike the Z source rectifier with 6 switches, one leg of the three phase AC source is connected to the midpoint of a split capacitor, and the Z network is coupled between the front of the end of two phase leg and the third leg.

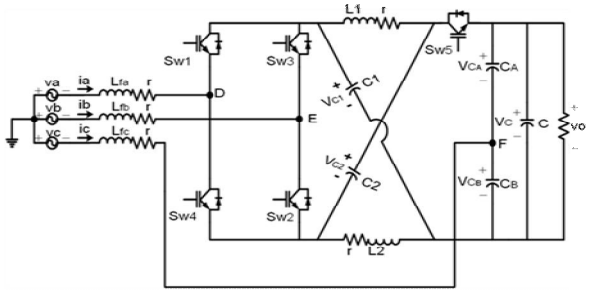

Fig.1 Circuit structure of the three phase four switches Z source PWM rectifier

From the relevant literature[3] and the basic rectifier's knowledge, we can know:

$$V_0 = \frac{1-2D}{M} V_i = BV_i \qquad (1)$$

Where, V_0 is the output DC voltage, V_i is the input voltage of Z network, D is the duty value, and M is modulation index.

2.2 The Switching Control Method

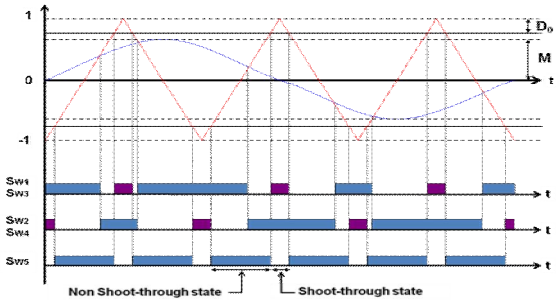

Fig.2 Switching control method for the three phase four switches Z source rectifier

The switching control method for the three phase four switches Z source rectifier is shown in Fig.2. The switches in each arm is turned on or off by comparing the reference with the triangular carrier similar with the basic SPWM

method. But in the proposed three phase four switches Z source rectifier, in the unique shoot through state period determined by the D ratio the upper and lower switch of same arm are turned on simultaneously.

3. SIMULATION AND EXPERIMENT

The simulation and experiment parameters are as follow;

Table 1 System Parameters

		Conventional rectifier	Z source rectifier
Input voltage		$30V_{peak}$	$30V_{peak}$
Input inductor(L_f)		1.5mH	1.5mH
Z network	Inductor(L_1, L_2)		2mH
	Capacitor(C_1 ,C_2)		1000μF
Split capacitor(C_A,C_B)		3300μF	3300μF
output capacitor		1000μF	1000μF

Fig 3 shows the simulation results in the case of the output DC voltage is in buck region. Three phase four switches Z source rectifier can buck voltage to 80V. In addition, it can generate DC voltage with balanced input three phase current and fine power factor control.

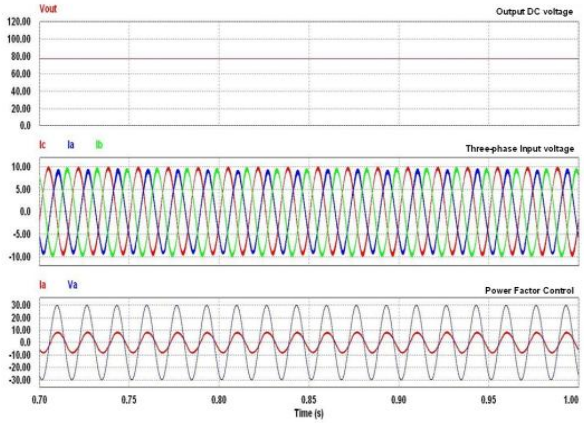

Fig.3 The output DC voltage, three phase input current and power factor control of the Z source rectifier

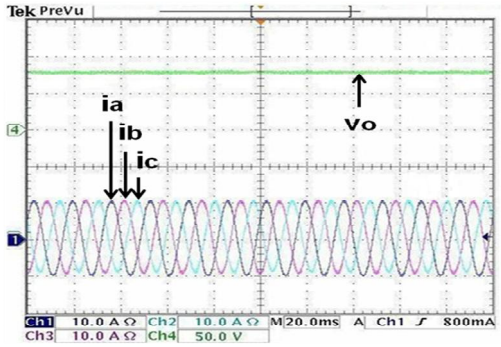

Fig.4 Experiment results of the Z source rectifier under V_{out}=80V.

Fig.4 shows the experimental result of the output DC voltage and three phase input currents. It is shown that the DC output voltage is bucked to 80V, the three phase input currents is with less distortion and the unbalance is highly reduced.

Fig.5 shows the excellent power factor control with using the three phase four switches Z source rectifier where there is barely no phase difference between the input voltage and input current waveform.

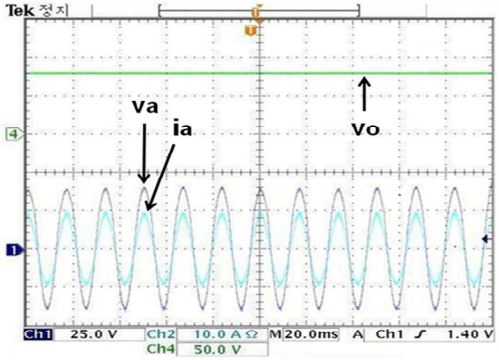

Fig.5 Experimental results of the factor power control between input voltage and input current under V_{out}=80V

4. CONCLUSIONS

A three phase four switches Z source rectifier is studied in this paper where the structure and operating principle and features are discussed. The three phase four switches Z source rectifier can realize the buck function through using a unique Z network. We verify its characteristics by simulation and experiment. The three phase four switches Z source rectifier with simple switching control can also improve unbalance of the input current waveform, eliminate distortion of the input current, keep excellent power factor control and increase efficiency.

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