출력전압과 입력직류전압 검출에 의한 3상 Z-소스 인버터의 출력전압 PID 제어

오연준*, 정영국**, 임영철*
전남대학교*, 대불대학교**

Output voltage PID control of three-phase Z-source inverter by detection of output voltage and input DC voltage

WU Yan Jun*, Young Gook Jung**, Young Cheol Lim*
Chonnam National University*, Daebul University**

ABSTRACT

The paper proposes a close loop control algorithm for Z source inverter. The algorithm is realized by PWM duty ratio control in order to improve the output voltage to it's desired level. The controller consist of the output voltage PID controller and DC input voltage P controller. Using the DQ coordinate transformation simplify the controller design. The PSIM simulation results verify the validity by means of comparing the system with or without compensation and estimating if the system has output consistency function when ZSI's load and input voltage value changing.

1. INTRODUCTION

The Z source inverter (ZSI) was introduced as a new kind of inverter topology and it has overcome some limitations of the conventional ones.

For example: ZSI can perform buck boost functions without transformer or chopper. as a result, Z source inverter has been used extensively in fuel cell application, wind power generation and photovoltaic generation. there is a same characteristic in this kind of power generating systems. DC power source is nonlinear and unstable, but the AC output power supply need to be stabled. So it is necessary to design a close loop control for the Z source inverter to steady the system because the open loop control is difficult to achieve this requirement.

2. THE PROPOSED METHOD

2.1 ZSI topology

Traditional Z source inverter (ZSI) shown as Fig. 1 was proposed by Professor Peng in 2003 [1 3].

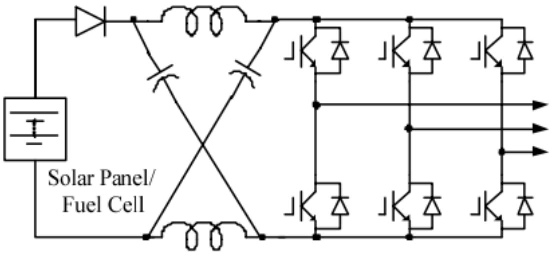

Fig. 1 3-phase ZSI topolpgy

The ZSI operates have symmetrical L C lattice network which consists of two inductors L1, L2 and two capacitors C1, C2 and utilize the shoot through of the inverter bridge to boost voltage without dead time. To make shoot through states, several pulse width modulation (PWM) methods [4 6] have been developed with the attempt of increasing the voltage gain in the Z source.

The relationship between the DC source voltage and peak dc link voltage can be described as:

$$\frac{T_0}{T} = \frac{2\pi - 3\sqrt{3M}}{2\pi} \tag{1}$$

$$B = \frac{1}{1-2\dfrac{T_0}{T}} = \frac{\pi}{3\sqrt{3M-\pi}} \tag{2}$$

$$T_{pn} = B \times V_{dc} \tag{3}$$

where 'Tpn' is the peak dc link voltage (PDV) of Z network. 'Vdc' is DC source voltage value. 'B' is boost factor. 'T' is the half period of the carrier waveform. 'T_0' is shoot through time in 'T'.

2.2 Close Loop Control

From the given formulas, we knew the boost factor is determined by the shoot through duty cycle in a half working period of ZSI.

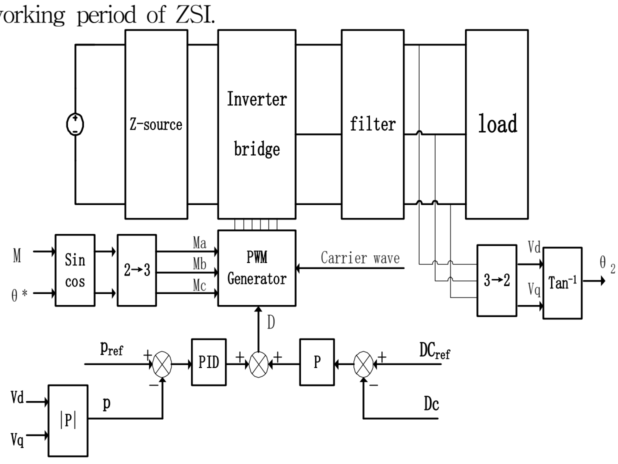

Fig. 2 control block diagram

So we can achieve the desired control effect by varying shoot through duty cycle D_0. The control block diagram in shown in Fig. 4. the loop is used to direct the AC output value and DC source variable quantity through the DQ transform and compared with the reference singal. The errors would be sent to the P and PID controller. Made the output of controllers feedback to the PWM generator to affect on the original D_0 to achieve the aim of improving system property.

3. SIMULATION AND DISCUSS

In order to verify the controller algorithms, the Z source inverter structure have been simulated in PSIM. The parameters used are:

Table 1 Per unit values of the system parameters

Input voltage:	$V_{dc}=311[V]$
Z source network:	$L_1=L_2=300[\mu H]$ $C_1=C_2=2000[\mu F]$
Full Load:	$R=15[\Omega]$
Heavy load:	$R=7.5[\Omega]$
Heavy load:	$L_f=3000[\mu H]$, $C_f=20[\mu F]$
Switching frequency:	$f_{sw}=20[kHz]$
modulation index:	M=0.6

Fig. 3. shows the output voltage waveform between system with or with out compensation under DQ coordinate. The nonlinear DC source model is aim to simulate a actual renewable energy power generation. and load will change from full load to heavy load in T=0.2s. DQ coordinate made the controller design from 3 phase to signal phase from alternating signal to direct signal so it has brought convenience to the controller design.

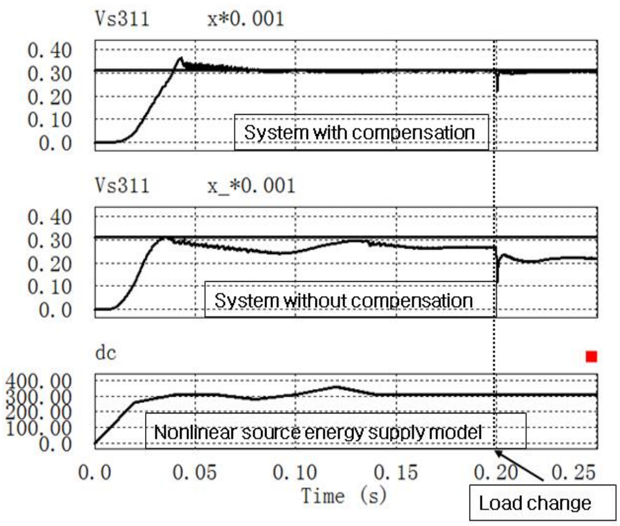

Fig. 3 system comparing under DQ coordinate

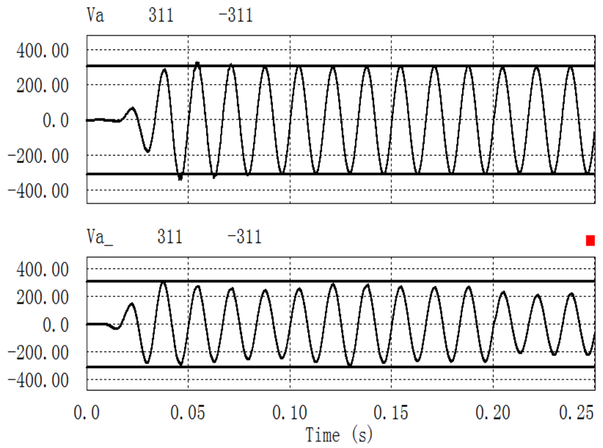

Fig. 4. 3-phase output voltage value comparing (only phase-a)

4. CONCLUSIONS

In this paper, the goal is to control the DC voltage boost and AC output voltage of a 3 phase Z source inverter power system using both P and PID controller. The PSIM simulation result showed its comparative advantages of Z source inverter with PID control. Compensator was also designed to reduce the overshoot period. Also, simulation results showed that the system with PID control have good function in case of the disturbance happened by load variations or Input changes. comparing to the uncompensated system.

이 논문 또는 저서는 2011년 교육과학기술부(지역거점연구단육성사업/바이오하우징연구사업단)와 바이오하우징연구소 및 "지식경제부", "한국산업기술진흥원", "호남광역경제권 선도산업지원단 "의 "광역경제권 선도산업 육성사업"으로 수행된 연구결과입니다.

References

[1] F. Z. Peng, "Z source inverter, IEEE Trans. Industry Applicat.,", Vol. 39, No. 2, pp.504 510, 2003.

[2] M. S. Shen, J. Wang, A. Joseph, et al, "Constant boost control of the Z source inverter to minimize current ripple and voltage stress", IEEE Trans. Industry Applicat., 2006, Vol. 42, No.3, pp.770 777, 2006.

[3] P. C. Loh, D. M. Vilathgamuwa, Y. S. Lai , et al, "Pulse width modulation of Z source inverters", IEEE Trans. Power Electron., Vol.20, No.6, pp.1346 1355, 2005.

[4] Miaosen Shen, "Z source inverter design, analysis, and its application in fuel cell vehicles", PhD thesis, Michigan State University, 2006

[5] F. Z. Peng, M. Shen, and Z. Qian, "Maximum boost control of the Z source inverter", IEEE Trans. Power Electron., Vol. 20, No. 4, pp. 833 838, 2004.

[6] Miaosen Shen, Jin Wang, Joseph, A., Fang Zheng Peng, Tolbert, L.M., and Adams, D.J., "Constant boost control of the Z source inverter to minimize current ripple and voltage stress", IEEE Trans Industry Applicat.,Vol. 42, No. 3, pp. 770 778, 2006.