UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FACULTY OF ELECTRICAL ENGINEERING

FINAL YEAR PROJECT REPORT

Development and Analysis of Three Phase Seven Level Trinary DC Source Multilevel Inverter

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This report is submitted to Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka in partial fulfillment for Bachelor of Electrical Engineering

Faculty of Electrical Engineering
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(2014)

DECLARATION

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references"

Signature : ……..

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Date : 18/06/2014

DECLARATION

"I hereby declared that I have read through this report entitled 'Development and Analysis of Three Phase Seven Level Trinary Multilevel Inverter'"

Supervisor's Signature : ……..

Supervisor's Name : Musa bin Yusup Lada

Date : 18/06/2014

DEDICATION

Specially dedicated to my family

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First and foremost, thanks to Allah for giving me this healthy body that enables me to devoted to the community as well as gaining new knowledge, experience and able to finish this report in the frame of time. Nothing can be done except with the permission of Allah.

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ABSTRACT

Inverter is electronic equipment used to convert Direct Current (DC) supply to Alternating Current (AC). There are many types of inverter exists and among all, multilevel inverter produce less harmonic compared to the conventional two level inverter. Harmonic do no useful work and it degrades the power quality of the electrical system also sometimes can cause malfunction of equipment. By using multilevel inverter, total harmonic distortion can be reduced by increase the output voltage level. However, for multilevel inverter, increasing of output voltage level will cause additional components to the circuit. This will increase the implementation cost, the inverter will be more bulky and not practical to implement. In this research, analysis of Three Phase Trinary Multilevel Inverter is conducted. Trinary multilevel inverter has the ability to produce high output voltage level with minimum components usage. The analysis is conducted using MATLAB/Simulink simulation tools for Three Phase Square Inverter, Three Phase Quasi Inverter and Three, Five, Seven and Nine Level of Trinary Multilevel Inverter, meanwhile for analysis on hardware is only focus on Three Phase Seven Level DC Source MLI. Different types of load are connected to the inverter to analyze the output voltage and current characteristics for all inverter mentioned above. Data gathered from the simulation and hardware is compared in terms of total harmonic distortion. The comparison shows that, the voltage THD is decrease as the number of level is increase. Three Level Trinary MLI produce 31.08% of voltage THD meanwhile for Nine Level Trinary MLI, the voltage THD reduce to 15.12%. This proved that the output voltage level of Trinary MLI

is significantly affected to the voltage THD which is higher level of Trinary MLI will produce lower voltage THD. Hardware and simulation result also shows that for RL load, the current THD is less than using R load.

ABSTRAK

Penyongsang adalah sejenis peralatan elektronik yang digunakan untuk menukarkan bekalan Arus Terus (AT) kepada Arus Ulang Alik (AU). Terdapat banyak jenis penyongsang wujud dan diantaranya, penyongsang pelbagai peringkat menghasilkan kurang harmonik berbanding penyongsang konvensional dua peringkat. Harmonik tidak mendatangkan sebarang faedah dan ia menyebabkan kualiti kuasa dalam sistem elekrik menjadi rendah disamping kadang kala boleh menyebabkan kepada kerosakan peralatan. Dengan menggunakan penyongsang pelbagai peringkat, jumlah herotan harmonik boleh dikurangkan dengan menambah peringkat voltan keluaran. Walau bagaimanapun, bagi penyongsang pelbagai peringkat, meningkatkan tahap voltan keluaran akan menyebabkan komponen yang digunakan juga akan bertambah. Ini akan meningkatkan kos pelaksanaan dan menyebabkan penyongsang menjadi lebih besar dan tidak praktikal untuk dilaksanakan. Dalam kajian ini, analisis penyongsang pelbagai peringkat Trinary untuk tiga fasa dijalankan. Penyongsang pelbagai peringkat Trinary mempunyai keupayaan untuk menghasilkan peringkat voltan keluaran yang lebih tinggi dengan penggunaan komponen yang minimum. Analisis ini dijalankan menggunakan alat simulasi MATLAB/Simulink untuk Penyongsang Persegi tiga fasa, Penyongsang Separa tiga fasa dan Penyongsang Trinary berperingkat tiga, lima, tujuh dan sembilan. Manakala untuk analisis untuk perkakasan hanya difokuskan pada Penyongsang Trinary tiga fasa berperingkat tujuh. Pelbagai jenis beban disambungkan pada penyongsang untuk menganalisis ciri-ciri voltan dan arus keluaran penyongsang tersebut. Data yang

dikumpul dari simulasi dibandingkan dari segi jumlah herotan harmonik. Perbandingan ini menunjukkan bahawa jumlah herotan harmonik voltan berkurangan apabila tahap tingkatan penyongsang meningkat. Penyongsang Trinary berperingkat tiga menghasilkan 31.08 % jumlah herotan harmonik voltan sementara itu, bagi penyongsang Trinary berperingkat sembilan, jumlah herotan harmonik voltan berkurangan kepada 15.12 %. Ini membuktikan bahawa peringkat keluaran voltan penyongsang Trinary ketara mempengaruhi jumlah herotan harmonik voltan, dimana penyongsang Trinary berperingkat tinggi akan menghasilkan jumlah herotan harmonik yang lebih rendah. Keputusan perkakasan dan simulasi juga menunjukkan bahawa jumlah herotan harmonik arus untuk beban RL adalah lebih rendah berbanding beban R.

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AC	- Alternating Current
CHBMLI	- Cascaded H-Bridge Multilevel Inverter
CM	- Common Mode
DC	- Direct Current
EMI	- Electromagnetic Interference
FCMLI	- Flying Capacitor Multilevel Inverter
IEC	- International Electrotechnical Commission
IGBT	- Insulated Gate Bipolar Transistor
MLI	- Multilevel Inverter
NPCMLI	- Neutral Current Clamped Multilevel Inverter
OHS PWM	- Optimized Harmonic Stepped Pulse Width Modulation
PCB	- Printed Circuit Board
PQ	- Power Quality
PWM	- Pulse Width Modulation

RMS - Root Mean Square

SHE PWM - Selective Harmonic Eliminated Pulse Width Modulation

SPWM - Sinusoidal Pulse Width Modulation

THD - Total Harmonic Distortion

UPS - Uninterruptible Power Supply

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CHAPTER 1

INTRODUCTION

1.1 Overview

Inverter is an electrical power converter that changes Direct Current (DC) to Alternating Current (AC). The converted AC can be at any required voltage and frequency with the use of appropriate switching and control circuits. For example, the most common method to convert DC supply to AC supply for renewable energy is using inverter. There are several types of inverters exists and among them, multilevel inverters (MLI) produce less harmonic distortion compared to the conventional two level inverters. As the level of the inverter goes higher, the total harmonic distortion will lesser. The main problem of designing conventional MLI is the complexity of the circuit and used of component such as switching devices. As level of MLI getting higher, the usage of component will be increase. In this research, the seven level of MLI is implemented in the small scale. The concept of Cascaded H-Bridge MLI using Trinary DC Source is being used. The selection of this concept is based on their simplicity, easy to control and fewer components used which will reduce the implementation cost. The switching mode will be controlled by gate drivers which receive the command from microcontroller using simple modulation technique. MATLAB/Simulink will be used as simulation tools to generate the voltage and current harmonic distortion of the MLI to be compare with the hardware implementation of MLI.