Faculty of Electrical Engineering

SIMULATION OF SHE-PWM FOR MULTILEVEL INVERTER

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SIMULATION OF SHE-PWM FOR MULTILEVEL INVERTER

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DECLARATION

I declare that this thesis entitled “Simulation of SHEPWM for Multilevel Inverter” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

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Date : ……

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfilment of Bachelor Degree of Electrical Engineering (Power Electronics and Drives).

Signature : …….…….

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ABSTRACT

Multilevel inverters have been receiving increasing attention in power system nowadays. The major problem for inverter is the harmonic distortion that will affect the performance and contribute in power losses. Thus, there are a variety of control techniques for inverters are introduced but less of the techniques can used to reduce the harmonic at low frequency. The harmonic at low frequency must be reduced due to some equipments are sensitive to the low frequency harmonic. Selective harmonic elimination pulse-width modulation (SHE-PWM) is a technique that can be used to eliminate the harmonic at low frequency which difficult to reduce by using passive filter. SHE-PWM is a low switching frequency strategy that uses Fourier Series and Newton-Raphson analysis to calculate the switching angles for elimination of harmonic. In this research, the main objective is to study the control technique for multilevel inverter and simulate the SHE-PWM for multilevel inverter. The performance of output waveform and total harmonic distortion (THD) for multilevel inverter are analysed and discussed. MATLAB program is important in this research. It is use to calculate the angle of PWM and simulate the SHE-PWM for multilevel inverter. The result shows that the percentage of harmonic at low harmonic order for SHE-PWM had been eliminated compare with other methods. In conclusion, the SHE-PWM technique can eliminate the selected harmonic at lower harmonic order.

ABSTRAK

Penyongsang berperingkat semakin mendapat perhatian dalam bidang sistem kuasa pada masa kini. Masalah utama bagi penyongsang adalah herotan harmonik yang memberi kesan kepada prestasi peralatan dan menyumbang kepada kehilangan kuasa. Oleh itu, pelbagai teknik kawalan penyonsang wujud akan tetapi teknik-teknik yang boleh digunakan untuk mengurangkan harmonik pada frekuensi yang rendah amat kurang. Harmonik pada frekuensi rendah perlu di kurangkan kerana beberapa peralatan akan sensitive terhadap harmonic di peringkat rendah. Penghapusan Harmonik Terpilih Pemodulatan Denyut Lebar (HT-PDL) merupakan satu teknik yang boleh dgunakan untuk menghapuskan harmonic pada frekuensi rendah yang mana sukar untuk dikurangkan dengan menggunakan penapis pasif. HT-PDL adalah satu strategi penukaran frekuensi rendah yang menggunakan analisis Siri Fourier dan Newton-Rapson untuk mengira sudut beralih untuk penghapusan harmonik. Dalam kajian ini, objektif utama adalah untuk mengkaji teknik kawalan penyongsang berperingkat dan simulasi untuk HT-PDL untuk penyongsang berperingkat. Prestasi gelombang keluaran dan jumlah herotan harmonik (JHH) untuk penyongsang berperingkat dianalisa dan dibincangkan. MATLAB amat penting dalam kajian ini. MATLAB digunakan untuk mengira sudut PDL dan mensimulasi penyongsang berperingkat menggunakan HT-PDL. Hasilan kajian ini menunjukkan bahawa peratusan harmonic pada susunan harmonic yang rendah. Kesimpulanya, SHE-PWM boleh menghapuskan harmonik yang terpilih pada peringkat harmonik yang rendah.

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NOMECLATURE

AC	-	Alternating Current
AM	-	Amplitude Modulation
APOD	-	Alternative Position Opposition Disposition
DC	-	Direct Current
FFT	-	Fast Fourier Transform
IEEE	-	Institute of Electrical and Electronic Engineers
MATLAB	-	Matrix Laboratory
MOSFET	-	Metal-Oxide Semiconductor Field Effect Transistor
POD	-	Phase Opposition Disposition
PWM	-	Pulse-Width Modulation
R	-	Resistance
RC	-	Resistance-Capacitor
RL	-	Resistance-Inductance
SHE	-	Selective Harmonic Elimination
SPWM	-	Sinusoidal Pulse-Width Modulation
SVC	-	Space Vector Control

SVM	-	Space Vector Modulation
THD	-	Total Harmonic Distortion
THDi	-	Total Harmonic Distortion of Current
THDv	-	Total Harmonic Distortion of Voltage

CHAPTER 1

INTRODUCTION

1.1 Background

Multilevel inverters are mostly used nowadays to generate an Alternating Current (AC) voltage from Direct Current (DC) voltage. The concept of a multilevel inverter is several voltage levels are added to each other to create a smoother stepped waveform with lower harmonic distortion. Moreover, multilevel inverters synthesize an AC voltage into a staircase which approximately to a desired sinusoidal waveform by divided the main DC voltage supply into several small DC sources. The multilevel inverters can yield operating characteristics likes high voltages, high power levels and high efficiency using multiple levels. They can operate without the use of transformer. Hence, multilevel inverters are mostly used in high power system. There are three main types of multilevel inverters such as diode-clamped, capacitor-clamped and cascade H-bridges. Cascade H-bridges is chosen due to its features such as its battery management capability, redundant inverter operation and scalability. Furthermore, it has the least components for given number of levels. Harmonic minimization is important to get the smoother waveform for multilevel inverter. There are several techniques have been introduced but the most popular technique is selective harmonic elimination pulse width modulation (SHE-PWM). It is one of the effective techniques to reduce the harmonic in lower switching frequency. In theoretical, SHE-PWM technique can provide the highest quality among the PWM techniques. Typically, this method is selected due to a system may be developed which can be solved for the switching angle that eliminate

selected harmonic. The advantages of SHE-PWM technique include that it produced the desired fundamental sinusoidal voltage while at the same time certain order harmonics are eliminated.

1.2 Research Motivation

In high power applications, multilevel voltage source inverters (VSI) have been receiving increasing attention in the recent years. These inverters are suitable in high voltage and high power applications due to their ability to synthesize waveforms with better harmonic spectrum and attain higher voltages without increasing the switching frequency and decreasing the inverter output power. There are three types of multilevel inverter topologies which are cascade inverter, flying capacitor and diode clamped. The cascade multilevel inverter is chosen in this study because it requires less circuit elements from the others. The number of output voltage levels can be easily adjusted by adding or removing the full bridge cells. However, the performances of multilevel inverter in some applications will be affected by the lower harmonic frequency. A key issue in designing the effective multilevel inverter is to ensure total harmonic distortion (THD) in the voltage output is low enough. Moreover, the harmonic at lower frequency are difficult to reduce or eliminate which not same as the harmonic at higher frequency that can be easily reduced by passive filter. Several techniques are introduced to reduce the harmonic at low frequency such as active power filter. The disadvantages of active power filter are it has complex circuit, costly and difficult to control compared to SHE-PWM technique. Thus, SHE-PWM technique had been introduced for elimination of harmonic at low frequency. One of the advantages of the SHE-PWM technique is its ability to operate in low switching frequency that makes it suitable for high power applications. This SHE-PWM technique can be used to synthesize output waveform of both half-bridge and full-bridge inverter.

1.3 Objective

The objectives of this research are

1. To study the control technique for multilevel inverter.
2. To simulate the selective harmonic elimination (SHE-PWM) for multilevel inverter.
3. To analyse and investigate the performance of multilevel inverter using SHE-PWM using Newton-Raphson technique.

1.4 Scope

The scope of project in this research is to analyse and investigate the performance of three phase multilevel inverter using SHE-PWM. It will also focus on the three phase seven-level inverter for several loads which are resistance (R), resistance-inductance (RL) and resistance-capacitance (RC) and the simulation of SHE-PWM. Besides that, the calculation of switching angles in SHE-PWM technique is discussed and shown in this research. The switching angle will determined using Newton-Raphson method in m-file or MATLAB and the value of angle is use to turn ON or OFF switching drive in simulink or MATLAB. Lastly, it covers also the THD of current and voltage for single phase of different type techniques for R, RL and RC load. A comparison is made to show the different between these topologies such as SHE-PWM, unipolar, bipolar and square wave.

1.5 Project Outline

A brief outline of the contents of the project report is organised as following:

Chapter 1 introduces the project background and the problem statement of thus project. It also covers the objective and scope for this project.

Chapter 2 briefly review the multilevel inverter with its topologies and applications. The modulation and PWM techniques are also discussed in this chapter. Lastly, it also discuss about the definition and effects of harmonic in power system.