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FACULTY OF ENGINEERING TECHNOLOGY

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SIMULATION OF MULTILEVEL INVERTER WITH MODIFIED CARRIER FOR POWER QUALITY MITIGATION APPLICATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

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FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Ekectrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

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ABSTRACT

Power system consists of generation, transmission, and distribution. Inverter is one of the crucial components in renewable energy to change a Direct Current (DC) supply to an Alternating Current (AC) supply. There are many problems with the application of inverters such as insufficient power, low-quality sine wave generation and harmonics issues. Thus, to encounter harmonics problem is to increase the performance of inverter. Triangular carrier which is the normally supplied as the carrier is changed to a modified carrier to overcome harmonics issue. Studies will be done to design a three phase cascaded H-bridge and flying capacitor multilevel inverter with modified carrier and the performance of the inverter will be observed by monitoring the THD and voltage output. The output THD of MPDPWM is 1% higher than PDPWM but are still under 5% which is acceptable under IEEE standard.

DEDICATION

To my beloved parents who build me up every single time I shattered apart, education community who hold the hopes of the future.

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First and foremost, I have to thank my research supervisor Encik Muhamad Faizal Bin Yaakub . Without his assistance and dedicated involvement in every step throughout the process, this paper would have never been accomplished. I would like to thank you very much for your support and understanding over these past 10 months.

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LIST OF SYMBOLS

A	-	Ampere
F	-	Farad
H	-	Henry
s	-	Seconds
V	-	Volt
Ω	-	Ohm

LIST OF ABBREVIATIONS

CHB	Cascaded H-Bridge
FC	Flying Capacitor
PD	Phase Disposition
MPD	Modified Phase Disposition
THI	Third Harmonic Injection
MTHI	Modified Third Harmonic Injection
THD	Total Harmonic Distortion

CHAPTER 1

INTRODUCTION

1.0 Background

Inverter denotes a class power conversion circuit that operates from DC voltage source or a DC current source and converts it into AC voltage or AC current. The inverter is the reverse of the AC to DC converter (Rodriguez, J. et al., 2002). Multilevel inverter was developed during the mid of 1970s were the first multilevel inverter is referring to 2-level inverters and was developed into various levels and topologies (Colak, I. et al., 2011). Multilevel inverter has various topologies and control techniques where each of them has their own advantages and disadvantages. Examples of multilevel inverter topologies are Neutral-point-clamped (Diode clamped), Flying capacitor (Capacitor clamped), and Cascaded H-bridge. Multiple combinations of these basic topologies are available which produced hybrid topologies that have been inverted to increase the performance of inverter.

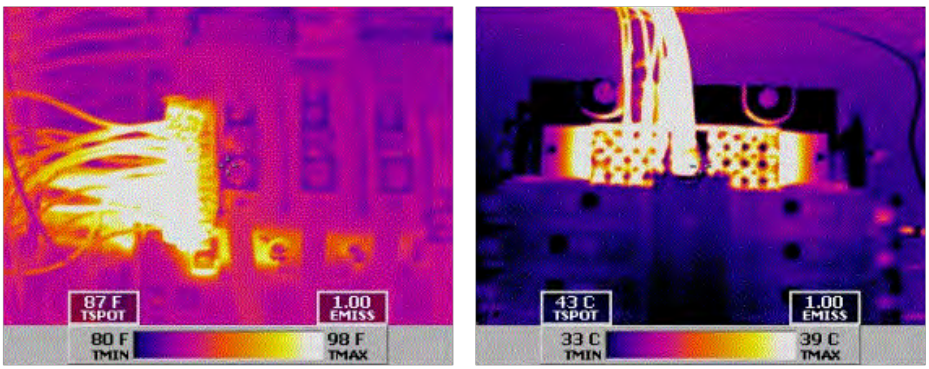
Space vector control, selective harmonics elimination, space vector PWM, and Sinusoidal PWM are the basic control techniques based of fundamental and high switching frequency (Chattopadhyay, S. K. and Chakraborty, C., 2014). There are numerous new topologies proposed with new techniques as methods to increase the performance of inverter (Shehu, G. S. et al., 2016).

Multilevel inverter consists of a few levels as it varies from the DC sources and numbers of switches. As the number of levels increased, a better output waveform will be produced due to the decreasing size of sampling which then produces a smoother output waveform. As the output waveform is smoother, the harmonics are reduced (Rajesh, B. and Manjesh, 2016).

A cascaded multilevel inverter consists of a few single phase H-bridge inverter units. An inverter's level using cascaded H-bridge topology consists of (levels-1)/2 number of cascaded H-bridge cells, where each of them has its' own DC source (Kalla, U.K, et al., 2016). Increasing the steps in output voltage value will decrease the THD that improves the power quality and produces a smoother output waveform by using a certain algorithm that is compatible with the cascaded H-bridge topology (Paikray, A. and Mohanty, B., 2014).

1.1 Problem Statement

Inverters can be used in various applications for renewable energy circuit design or as a motor driver. But there are problems arise as the inverter is implemented such as insufficient power supplied, low-quality sine wave generate and harmonics issues. High harmonics will cause high temperature of the device used as the figure below (Blackledge, J. et al., 2012).



Above thermal images show an overheated neutral bus bar caused by third order, zero sequence harmonic currents.

Figure 1.1: Overheated Neutral Bus Bar Caused by Harmonics Current (Blackledge, J. et al., 2012)

Normally, industrial and commercial institute use four wire for three-phase distribution system where the neutral conductor sizes are smaller than the live wires. Nevertheless, the triplen harmonics which is multiples of third order harmonics current from every phase total up in the neutral conductor with the increment of non-linear loads (Blackledge, J. et al., 2012). Thus harmonics problems should be encountered to reduce heating of equipment resulting longer equipment lifespan.

Harmonics is one of the crucial issues that would be encountered when improving the inverters' performance. Harmonics issue can be catered from the carrier injected into the inverter. Instead of supplying a normal triangular carrier, a modified carrier can be injected into the inverter to reduce harmonics occurrence in the output.

1.2 Objectives

The development of multilevel inverter with Modified Carrier PWM comes with 3 objectives as stated below:

- Construct and simulate a model of three phase cascaded H-bridge multilevel inverter with Modified Carriers Sinusoidal Pulse Width Modulation (MPD PWM)

- Construct and simulate a model of three phase Flying Capacitor multilevel inverter with Modified Carriers Sinusoidal Pulse Width Modulation (MPD PWM)
- Analyse the maximum voltage and total harmonic distortion (THD) of three phase cascaded H-bridge multilevel inverter with Flying Capacitor multilevel inverter.

1.3 Scope

This study focused on a three phase multilevel inverter. Aside of using triangular wave carrier, a U-shaped modified carrier sinusoidal pulse width modulation were also used and a sinusoidal wave was referred. The inverter used using cascaded H-bridge and flying capacitor topology due to the circuit's design simplicity which provides a focused study on the inverter's performance. Two different topologies were used to see the trend based on the control scheme applied. Each module consists of individual DC supply connected to a three phase full bridge inverter. A detailed study on the voltage output and total harmonics distortion will be done to monitor the inverter's performance. Then, a comparison of the inverter's performance were made between the application of Phase Disposition Pulse Width Modulation (PDPWM) and the application of Modified Carrier Phase Width Modulation (MPD PWM). Third Harmonics Injection Pulse Width Modulation (THIPWM) and Modified Third Harmonic Injection Pulse Width Modulation (MTHIPWM) were compared. All simulation and theoretical analysis were conducted by using the MATLAB software.