UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AN ANALYSIS OF HARMONICS CONTRIBUTION OF VARIABLE FREQUENCY DRIVE IN POWER DISTRIBUTION SYSTEM

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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SESI PENGAJIAN: **2014/15 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

……

En.Mustafa Bin Manap

(Project Supervisor)

ABSTRAK

Harmonik adalah salah satu isu kualiti kuasa yang biasa berlaku dan penyongsang tiga fasa adalah salah satu sumber harmonik. Kajian ini membentangkan analisis mengenai sumbangan harmonik yang dihasilkan oleh penyongsang beban tiga fasa. Model penyongsang tiga fasa disimulasikan dengan menggunakan Matlab / Simulink. Seterusnya, sumbangan harmonik penyongsang tiga fasa dikaji menggunakan kaedah Fast Fourier Transform (FFT). Hasilnya menunjukkan bahawa sumbangan harmonik semasa keadaan beban penuh adalah lebih besar daripada keadaan tiada beban. Ini membuktikan bahawa, beban bukan linear menghasilkan penyelewengan harmonik. Selain itu, perbandingan hasil simulasi dengan jelas menunjukkan bahawa suis IGBT menhasilkan jumlah gangguan harmonik yang kurang apabila dibandingkan dengan MOSFET, jadi ini membuktikan suis IGBT adalah suis terbaik untuk penyongsang tiga fasa berbanding dengan suis MOSFET.

ABSTRACT

Harmonic is one of the common power quality issues happen and three phase inverter is one of the common source of harmonic. This research present an analysis on harmonic contribution that been produced by three phase inverter loads. The model of three phase inverter is simulate by using Matlab / Simulink. Next, the harmonic contribution of three phase inverter is analyze using Fast Fourier Transform (FFT) method. The result indicates that, harmonic contribution during full load condition is greater than no load condition. This prove that, non-linear load create harmonic distortion. Besides, comparison of simulation results evidently reveals that IGBT Switch provides less total harmonic distortion current when compared to MOSFET, so considering IGBT switches is the best switch for three phase inverter as compare to MOSFET.

DEDICATION

To my beloved parents,
Rohanizah Binti Mohammad and Mohd Ridzuan Bin Abdul Aziz

Siblings,
Nur Hanis, Nur Haslina and Lukman Hakim

Supervisor,
En. Mustafa Bin Manap

Lecturers, teachers and friends;

Who educated me and enabled me to reach at this level.
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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

FFT	-	Fast Fourier Transform
THD	-	Total Harmonic Distortion
PWM	-	Pulse Width Modulation
IGBT	-	Insulated Gate Bipolar Transistor
MOSFET	-	Metal Oxide Semiconductor Field
IEEE Std.	-	Institute of Electrical Electronics Engineering Standard
GTO	-	Gate Turn Off
s	-	Second
V	-	Volt
A	-	Ampere

CHAPTER 1

INTRODUCTION

1.1 Background

In variable speed AC motor drive applications three phase inverters are widely used as they deliver variable frequency and variable voltage output over pulse width modulation control. However, three phase inverter is one of the factors that cause harmonic and affect to the power quality.

In power system engineering, power quality is an important branch. It assume as a vital part to guarantee the quality of power being delivered to the industry customer. A single power quality event such as voltage swell, voltage sag, flicker, harmonic and others may cost the affected industries up to millions of monetary losses.

In order to improve the power quality, it is necessary to understand, detect and also analyze the harmonic contribution. This research introduces an analysis on harmonic contribution that been produced by three phase inverter loads in power system using Fast Fourier Transform (FFT) method.

Besides, Harmonic Analysis is performed by simulating the model of three phase inverter by using MATLAB/SIMULINK.

1.2 Problem Statements

Harmonic is one of the common power quality issues happen and three phase inverter is of the common source of harmonic. This harmonic voltage and current distortion may affect negative impact such as overheating of transformers, capacitor explosion, reduce motor life and more.

1.3 Objectives

The objectives of this research are:

I. To detect harmonic contribution of three-phase inverter in power distribution system by simulating model using MATLAB/SIMULINK.

II. To analyze harmonic contribution of three-phase inverter in power distribution using Fast Fourier Transform (FFT) method.

III. To calculate the total harmonic distortion produced by the harmonic for the future reference.

1.4 Scope of Work

This research will study on harmonic contribution of three-phase PWM inverter. In this research, the main focus is on the signal analysis using THD detection. Based on the signal faults parameters obtained from the analysis, the harmonic are detected, simulated and analyzed. By using MATLAB software, the analysis is done. The MATLAB system is developed by using visual basic 2016 and the signal of harmonics is analyze by using Fast Fourier Transform (FFT) method.

According to the IEEE STD 519-2014, voltage harmonics below 1kV whose frequencies are integer multiples of the power frequency for individual harmonic is 5% and THD is 8.0%. The Nyquist theorem states that the sampling frequency used in the analysis must be at least double the size of the measured frequency. Thus, according to IEEE Standard 1159-2009, the measurement frequency of harmonic is 0Hz-9Hz. Therefore, the sampling frequency of the system is set to 12,000 Hz.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a summary of an analysis harmonic contribution of three phase PWM inverter in power distribution system. In power distribution system, since three phase inverter provide variable frequency and variable voltage output over pulse width modulation control, so they are widely used in variable speed AC motor drive applications (Manivannan et al. 2014). Pulse width modulated (PWM) inverters are among the most used power-electronic circuits in practical applications (Converters n.d.).

However, three phase pulse width modulated (PWM) inverter is one of the factors that cause harmonic and affect to the power quality (Studies 2014). Besides, harmonics are major problems in PWM drives, in this research a study of harmonics and total harmonic distortion of a 3 phase PWM drive has been studied (Anon 2015).

2.2 Theory of Power Quality

In power system engineering, power quality is an important branch. It assume as a vital part to guarantee the quality of power being delivered to the industry customer. A single power quality event such as voltage swell, voltage sag, flicker, harmonic and others may cost the affected industries up to millions of monetary losses (Mcgranaghan et al. 2002)

Power quality disturbances are categorized into transient, flicker, voltage notch, voltage swell, voltage sag, and harmonic. The research about power quality is the study of various phenomena that cause power quality disturbance to occur and the development of mitigation strategy. In order to develop the right mitigation strategy for the power quality problem, it is necessary to be fully understood about the power quality disturbance phenomenon and its source (By n.d.)

Categories of power quality sources include nonlinear loads, power system events, poor wiring and also grounding. Examples of power quality disturbances sources include adjustable speed drives, loose connections, and lightning.

2.3 Harmonics

Harmonics are sinusoidal voltages or currents having frequencies that are integer multiples of the frequency at which the supply system is designed to operate (termed the *fundamental frequency*; usually 50 Hz or 60 Hz) (Committee et al. 2009).

The major source of sine waveform distortion are harmonics (Primer n.d.). Due to increasing application of power electronics equipment, harmonic distortion has growing concern for many customers and for the overall power system (Committee et al. 2009).

To ensure good power quality of systems, harmonics is one of the most dominant attributes that need to be kept to a minimum level (Tengl & Lil n.d.).

In general, the most important parameter to indicate harmonics contents is called Total Harmonic Distortion, THD and defined as:

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} U_n^2}}{U_1} \times 100\%$$

Where U_1 represents the fundamental component of waveform and U_n denotes the harmonics components. All values are in root-mean-square (rms) quantities. Therefore, THD is commonly used as a standard to relate the harmonics contents in power system and circuits.

2.3.1 Cause of Harmonics

Arc furnaces, power electronic converters, inverters for distributed generation, ac phase controllers, cycloconverters, static VAR systems and ac-dc converters (rectifiers) commonly used in switched mode pulse width modulated (PWM) motor drives are the common sources of harmonic currents in power systems (Studies 2014).

Nonlinear loads and devices on the power system produce harmonics. There are a wide variety of devices that generate harmonics and they can be connected to the power system at any voltage level (Engineers & Avenue 2012).

Harmonic are usually caused by nonlinear loads like static UPS systems, electronic ballasts for fluorescent lighting, adjustable speed drives, solid-state heating controls, rectifiers, filters, switched-mode power supplies in computers, electronic office machines, and electronic and medical test equipment. Harmonics become more common because of the increased uses of nonlinear equipment. Nonlinear loads cause harmonic currents to transform from a sinusoidal current to became non-sinusoidal current by or interrupting the current during a cycle or drawing short bursts of current each cycle.

This causes the sinusoidal current waveform to become distorted. The combination of the fundamental 50-Hz sine wave and the various harmonics are the resulting non-sinusoidal wave shape.

2.3.2 Effect of Harmonics

Harmonic voltages and currents have a disadvantageous effect on utility and end-user equipment. As example, harmonic cause overheating of motors, transformers, and power cables. Harmonic voltages also cause increased iron losses in transformers. Table 1 below shows the effect of harmonics on various types of equipment. Besides harmonics can cause power quality problems on the end user or the utility serving the end user, harmonic can also cause problems on other end users (Primer n.d.).