SIMULATION AND ANALYSIS OF HARMONIC DETECTION AND MITIGATION SYSTEM USING ACTIVE FILTER

Miza Binti Belia

Bachelor of Engineering (Hons)
Electrical and Electronics Engineering
2019

UNIVERSITI MALAYSIA SARAWAK

Grade: A-

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Final Year Project Report ☑

Masters ☐

PhD ☐

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SIMULATION AND ANALYSIS OF HARMONIC DETECTION AND MITIGATION SYSTEM USING ACTIVE FILTER

MIZA BINTI BELIA

A dissertation submitted in partial fulfilment

of the requirement for the degree of

Bachelor of Engineering (Hons)

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Faculty of Engineering

Universiti Malaysia Sarawak

2019

To my beloved family and friends.

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ABSTRACT

The most frequent problems in power system is known as harmonics. This harmonic distortion causes by non-linear loads such as computers, printers, non-incandescent lighting, variable speed drives and programmable logic controllers (PLCs). In this era of technology, many electronics devices used in the residential area and industrial area contribute to the power quality issue, which is harmonics. Therefore, analysis of harmonic detection using Fast Fourier Transform (FFT) is one of the initiatives for power quality monitoring. The main objective for this study is to analyse the harmonics components in AC power system using Fast Fourier Transforms (FFT) algorithm. Other than that, the objective is also to design and develop the harmonic detection system for power quality of AC power system. In addition, this objective of this paper is to study of method of harmonics mitigation using the designed active filter to obtain better quality of signal in power system. This analysis is mainly to analyse the quality of power signal for power data collection, processing and analysis. A method to mitigate the harmonic distortion in power system are studied so that any low-quality power system issue can be improved from time to time.

ABSTRAK

Masalah yang paling kerap dalam sistem kuasa dikenali sebagai harmonik. Gangguan harmonik ini disebabkan oleh beban bukan linear seperti komputer, pencetak, pencahayaan tanpa pijar, pemacu laju berubah-ubah dan pengawal logik boleh diprogram (PLC). Dalam era teknologi ini, banyak peranti elektronik yang digunakan di kawasan kediaman dan kawasan perindustrian menyumbang kepada isu kualiti kuasa, iaitu harmonik. Oleh itu, analisis pengesanan harmonik menggunakan Fast Fourier Transform (FFT) adalah salah satu inisiatif untuk pemantauan kualiti kuasa. Objektif utama kajian ini adalah untuk menganalisis komponen harmonik dalam sistem kuasa AC menggunakan algoritma Fast Fourier Transforms (FFT). Selain itu, objektifnya juga untuk mereka bentuk dan membangunkan sistem pengesanan harmonik untuk kualiti tenaga sistem kuasa AC. Di samping itu, matlamat ini adalah untuk mengkaji kaedah mitigasi harmonik menggunakan penapis aktif direka bentuk untuk mendapatkan isyarat kualiti yang lebih baik dalam sistem kuasa. Analisis ini adalah terutamanya untuk menganalisis kualiti isyarat kuasa untuk pengumpulan, pemprosesan dan analisis data kuasa. Kaedah untuk mengurangkan penyelarasan harmonik dalam sistem kuasa dikaji supaya sebarang isu sistem kuasa rendah yang berkualiti dapat diperbaiki dari semasa ke semasa.

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LIST OF SYMBOLS

$f(t)$	-	Time domain function
n	-	Odd harmonic number
A_n	-	Amplitude of nth harmonic component
T	-	Length of one cycle in seconds
h	-	Harmonics order
f_1	-	Fundamental frequency
f_i	-	Frequency of harmonics components
%	-	Percent
°	-	Degree
Hz	-	Hertz
A	-	Ampere
V	-	Volt
Vpeak	-	Peak voltage
Vrms	-	Root-mean-square voltage

LIST OF ABBREVIATIONS

PLC	-	Programmable Logic Controllers
THD	-	Total Harmonic Distortion
FFT	-	Fast Fourier Transform
AC	-	Alternating Current
DC	-	Direct Current
DFT	-	Discrete Fourier Transform
SMPS	-	Switched Mode Power Supplies
UPS	-	Uninterruptible Power Supplies
CLF	-	Compact Fluorescent Lamps
OHC	-	Overall Harmonic Compensation
SHC	-	Selected Harmonic Compensation
ADC	-	Analog-to-Digital Converter
DSP	-	Digital Signal Processing
HM	-	Harmonic Modelling
MIMO	-	Multi-input multi-output
APF	-	Active Power Filter
PCC	-	Point of Common Coupling
SRF	-	Synchronous d-q reference frame method
PWM	-	Pulse-width-modulation
RMS	-	Root mean square

CHAPTER 1

INTRODUCTION

1.1 Project Background

Harmonics are one of the most frequent problems in power system. Generally, harmonic is the sinusoidal waveform of the current or voltage that distorted because of the non-linear load [1]. Practically, nonlinear load is the load that their response to voltage is not a straight line whereby the relationship between voltage and current is not easily predictable [2]. For instance, the non-linear loads can be computers, printers, non-incandescent lighting, variable speed drives, programmable logic controllers (PLCs) and many other peripherals.

The analysis of harmonics of three-phase power system with two non-linear loads which are six-pulse rectifier and twelve-pulse rectifier is one of the initiatives for monitoring the power quality. This analysis is mainly to analyse the quality of power signal for power data collection, processing and analysis. One of the methods to reduce the harmonic distortion in the three-phase power system is studied and applied to the power system so that any low-quality power system issue can be improved from time to time. The source and loads waveform are recorded. In addition to that, the harmonic components and Total Harmonic Distortion (THD) are also analysed.

Generally, this study involves the simulation and analysis of power quality signal in the power system that involves software-based simulation by using the MATLAB and Simulink. Fast Fourier Transform (FFT) analysis tool is used to estimate the signal by transforming a function of time into a function of frequency.

The software program in MATLAB performs the FFT calculation to simulate the amplitude of fundamental frequency, harmonic components and total harmonic distortion percentages. The outputs are displayed by using the graph simulation in MATLAB software.

In this study, the quality of a three-phase system connected to the non-linear loads can be detected, monitored and analysed. Any low-quality of the signal can be detected earlier before the power quality problems lead to a failure in the system. The quality issues in the power system can be solved by mitigating the harmonics using the designed active filter. Hence, the power quality of the power system can be maintained and improved so that a stable supply of electricity is obtained.

1.2 Problem Statements

There are many effects caused by harmonics of voltage and current such as reducing the performance on energy generation, transport and usage systems, the premature ageing of insulation on grid components that lead to energy reduction. The potential of some harmonics is due to parallel or series resonance and the poor functioning of the system. Some of the components in power system may get effected. These components are the conductors, neutral conductors, capacitors, transformers as shown in Figure 1.1, motors, power generating set and control as well as measurement system. The power quality problem like harmonics cannot be avoided in power system, as there is no such thing of a perfect system. However, the harmonic problems are seriously needed to reduce to improve the performance of power system.

Figure 1.1 Transformers Structure [3]

For example, harmonics in conductors may increase the issues in current ratings, resistance and may lead to the thermal losses. These problems may create effects to the conductor such as cable heating and tripping of protection system. Therefore, the quality of the power system will be degraded and unreliable. The power system wave form is shown in Figure 1.2. Harmonics will be causing the perfect sinusoidal waveform with constant frequency and amplitude distorted.

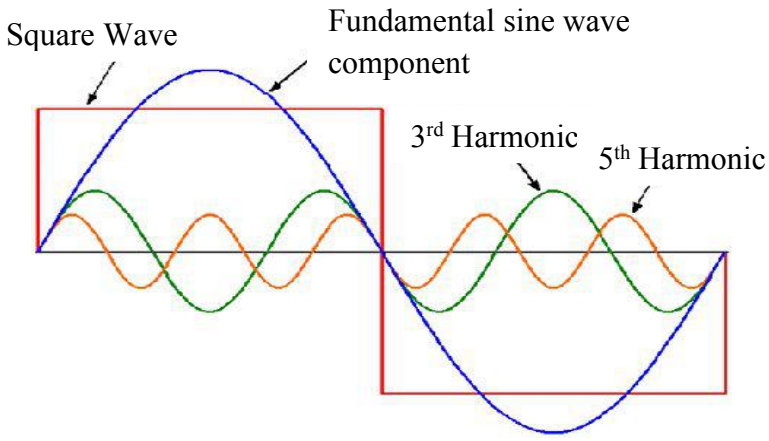

Figure 1.2 Waveforms in Power System

In power system, the quality must be controlled, measured and monitored to make sure that the power system can run smoothly. Analysing the components harmonic in the voltage or current waveforms is an important part of an electrical system. Determining and analysing the harmonic distortion is the foundation to

choose the right power filter for that system. Therefore, this study is going to focus on the analysing of harmonic signal in alternating current (AC) power system and a method to mitigate the harmonics.

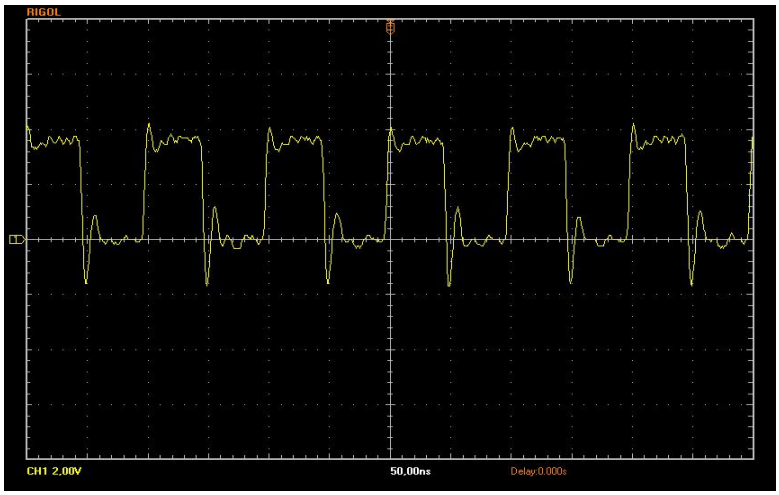

Figure 1.3 Waveform Distortion shown from Oscilloscope [4]

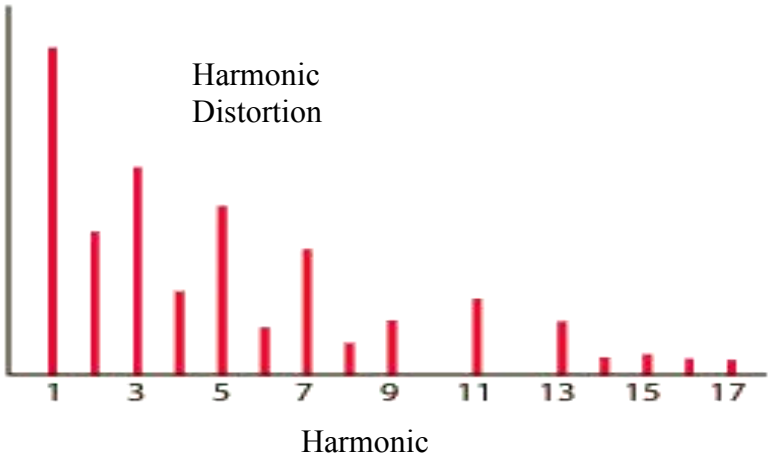

Figure 1.4 Harmonics Distortion [4]

1.3 Project Objectives

The following objectives are going to achieve in this project:

1) To study the harmonics components in AC power system.
2) To design the harmonic detection and mitigation technique for AC power system.
3) To evaluate the performance of the designed active filter using MATLAB Simulink.

1.4 Scope of Project

The goal of this study is to analyse the power quality problem and to study the methods of harmonics mitigation for the AC power supply system considering the three-phase power system. The harmonic detection will be applied in the three-phase power system to detect and analyse harmonic components. In addition, harmonic mitigation is applied and connected to the grid of the three-phase system parallel with non-linear load. A three-phase power system with two non-linear loads circuit is considered, designed and simulated using the MATLAB Simulink. The simulation of the signal will be analysed which includes the source current, loads current and the harmonic components. Shunt active harmonic filter will be applied to the system in order to determine the solution of mitigating the harmonics to get a better quality of power system.

1.5 Organization of the Dissertation

Chapter 1 describes the project background, problem statements, project objectives, scope of project and conclusion of the chapter. Chapter 2 presents the literature review which describes the harmonics and its concept, harmonics compensation method and also the most related works related to harmonic analysis and mitigation technique. Chapter 3 presents the methodology of this study that includes introduction of chapter, algorithm for harmonic detection, harmonic mitigation method and chapter summary. Chapter 4 is the results and discussion section. This section includes the introduction of chapter, results, discussions related to study, conclusion and also chapter summary. Chapter 5 presents the conclusion chapter, which includes the overview, summary of project, limitations and future recommendations for the study.

1.6 Chapter Summary

A power quality issue which includes total harmonic distortion will be analysed for power system quality monitoring. The analysis tool should be able to measure and perform the calculation of the harmonics percentage in AC power system. Furthermore, the mitigation method by using shunt active harmonic filter should be able to reduce the harmonic distortion in the system. The main projected advantage is to monitor the

power quality problem and to apply the method of harmonics mitigation in power system to get more efficient power system.

This chapter discusses the overview of the harmonics distortion analysis AC power system. This chapter also highlights the problem statement and its significance, scope, objectives and the outcome of this study. The next chapter is going to discuss the literature review.