COMPARISON BETWEEN ACTIVE AND PASSIVE POWER FILTERS IN HARMONIC REDUCTION

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DEDICATION

To my whole world, mama and abah.

This is for both of you.

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ABSTRACT

Harmonic distortion has become a serious problem that needs to be resolved. With the development of power electronics equipment, high technology nonlinear loads have increased rapidly. This alteration of the load structure resulting in an increase of the harmonic value present in the system resulting in a deterioration of the power quality. Without a filter, harmonics can damage equipment, increase electricity bills and reduce product quality and production output. This can lead to inefficiency and financial losses, particularly in industrial buildings. This project will study the harmonics and the nonlinear loads, design the Passive Power Filter (PPF) and the Active Power Filter (APF), model and simulate both the APF and the PPF. Next, a simulation of the three-phase circuit with PPF and APF will be conducted accordingly and the percentage of Total Harmonic Distortion (THD) will be compared in the simulation. At the end of this project, it has been shown that APF is the most efficient in terms of harmonic mitigation and presented the greatest improvement in the percentage of THD.

ABSTRAK

Herotan harmonik telah menjadi masalah serius yang perlu diselesaikan. Dengan perkembangan peralatan elektronik kuasa, beban bukan lelurus berteknologi tinggi telah meningkat dengan pesat. Perubahan struktur beban ini mengakibatkan peningkatan nilai harmonik yang ada di dalam sistem mengakibatkan penurunan kualiti daya. Tanpa penapis, harmonic dapat merosakkan peralatan, meningkatkan bil elektrik dan mengurangkan kualiti produk dan pengeluaran. Ini boleh menyebabkan ketidakcekapan dan kerugian dari segi kewangan, terutamanya di bangunan perindustrian. Projek ini akan mengkaji harmonik dan beban tak lelurus, merancang Penapis Kuasa Pasif (PPF) dan Penapis Kuasa Aktif (APF), memodelkan dan mensimulasikan kedua-dua APF dan PPF. Seterusnya, simulasi rangkaian tiga fasa dengan PPF dan APF akan dilakukan dengan sewajarnya dan peratusan Jumlah Herotan Harmonik (THD) akan dibandingkan dalam simulasi. Pada akhir projek ini, telah ditunjukkan bahawa APF adalah yang paling efisien dari segi mitigasi harmonik dan menunjukkan peningkatan terbesar dalam peratusan THD.

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LIST OF ABBREVIATIONS

APF	-	Active Power Filter
PPF	-	Passive Power Filter
THD	-	Total Harmonic Distortion
DC	-	Direct Current
IEEE	-	The Institute of Electrical and Electronics Engineers
STF	-	Single Tuned Filter
DTF	-	Double Tuned Filter
STATCOM	-	Static Synchronous Compensator
VFD	-	Variable Frequency Drive
IGBT	-	Insulated Gate Bipolar Transistor
GTO	-	Gate Turn Off
FFT	-	Fast Fourier Transform
HCC	-	Hysteresis Current Controller
AC	-	Alternating Current
ETAP	-	Electrical Transient Analysis Program
PSCAD	-	Power Computer Aided Design

LIST OF SYMBOLS

f_n	-	Fundamental frequency
H	-	Integer value
V_n	-	Harmonic voltage
V_1	-	Fundamental voltage
I_n	-	Harmonic current
I_1	-	Fundamental current
THDi	-	Total Harmonic Distortion (current)
THDv	-	Total Harmonic Distortion (voltage)
pf	-	power factor
S	-	Apparent power
P	-	Actual power
Q	-	Reactive power
V_S	-	Source voltage
L_S	-	Line inductance at source
R_S	-	Resistor at source
L_L	-	Line inductance at rectifier
R_L	-	Resistor at rectifier
R	-	Resistance
C	-	Capacitance
Q_C	-	Reactive power supplied by capacitor
X_c	-	Capacitor reactance
X_L	-	Inductor reactance
L	-	Inductance
Q	-	Quality factor
ω_s	-	Series resonance
ω_p	-	Parallel resonance
$I_{ripple,max}$	-	Maximum current ripple
f_{sw}	-	Switching frequency

CHAPTER 1

INTRODUCTION

1.1 Introduction

The problem in power quality of electricity is the disruption in capability of electrical instrumentation to use the energy supplied to it. One of the issues with the power quality problems is harmonic distortion. A harmonic is a current or voltage that is a numeral manifold of the fundamental frequency. The characteristics of non-linear loads resulting in non-sinusoidal waveform current causing harmonics to occur [1]. Figure 1.1 shows an example of a distorted non-sinusoidal waveform.

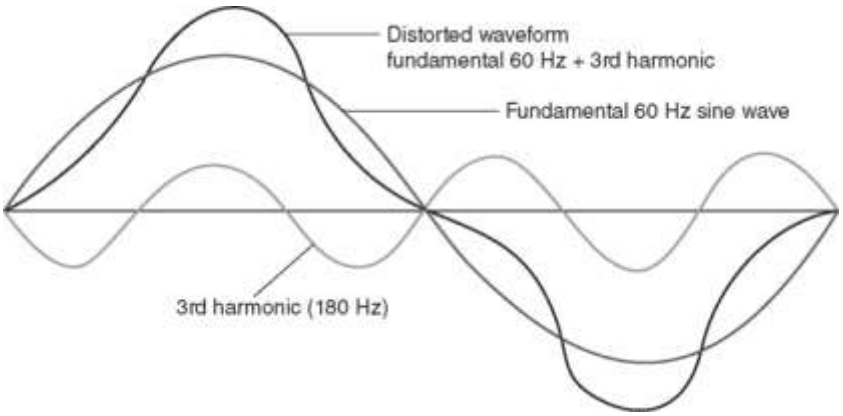

Figure 1.1 Harmonic Distortion Waveform [1]

Harmonics have a number of different effects on different devices. Harmonic currents increase the temperature of the engines, transformers and power cables and this can lead to overheating. Harmonics induces the capacitors to heat and causes them to be less able to dissipate heat and to fail. Harmonics in the power system result in overloading of neutral conductors, fuse tripping and disruption in the distribution of power.

Harmonic distortion is caused by nonlinear loads. It has become a severe problem that needs to be addressed. With the rapid increase of nonlinear loads in many residential, commercial, and industrial applications, this results in a deterioration in the quality of power. This calls for a solution to the harmonic mitigation process. There are many methods available to reduce harmonics in the system, such as Passive Power Filter (PPF), Active Power Filter (APF), DC Choke, Line Reactor, and Static Synchronous Compensator (STATCOM). Each method has its own advantages and disadvantages and the details will be further elaborated in Chapter 2. However, the filters chosen for this project are Active Power Filter and Passive Power Filter.

1.2 Problem Statement

With the development of power electronics equipment in 1970, high technology nonlinear loads were rapidly increasing [2]. This rise of electronic power systems in industry is due to high energy demand and the requirement for efficient energy management. This alteration of the load structure resulting in an increase of the harmonic value present in the system. The increase of the nonlinear loads in many residential, commercial, and industrial applications has led to a deterioration of power quality. These problems could lead to higher operating costs, particularly in industrial buildings, due to higher energy consumption, additional investment, higher maintenance and repair costs and reduced product quality and production output resulting in efficiency and financial losses. Harmonic filter is therefore required to solve this problem and remove the harmonics from the system.

1.3 Objectives

The objectives of the research are:

a) To design an Active Power Filter and Passive Power Filter for harmonic mitigation.
b) To model and simulate the Active and Passive Power Filter using MATLAB Simulink.
c) To compare the simulation result between the Active and Passive Power Filter.

1.4 Scope of Work

The scopes of the project according to the objectives are limited to:

(a) Modelling and simulation of the system using MATLAB Simulink.
(b) The type of filter chosen for APF is Shunt Active Power Filter.
(c) The type of filter chosen for PPF are Single Tuned Filter and Double Tuned Filter.

1.5 Report Outline

This report contains six chapters. Chapter 1 is the introduction, which includes the introduction, the problem statement, objectives, and scope of work. Introduction explains the harmonic and the method used to measure the level of harmonic distortion. The problem statement identifies the problem of harmonics and its effects on the power quality, while the objectives of this project are set out in the objectives. The scope of work is the scope on the methodology of this project.

Chapter 2 provides the literature review on related topics. This chapter also considered some papers on other methods of harmonic mitigation other than APF and PPF. The advantages and disadvantages of each method are also taken into account.

Chapter 3 describes the methodology of this project, which comprises of three phases of work. The first phase involves the process of developing the three-phase nonlinear load system, the next phase explains the simulation of the circuit followed by simulation with APF and PPF, and the last phase is a comparison of the THD level of both filters. This chapter also included the flow of the project.

Chapter 4 discusses the result obtained from this project, analysis and verification of the system, and overall performance.

Chapter 5 presents the conclusion of the project. This chapter sets out the overall achievement of this project in terms of project objectives, limitations and some recommendations for improvement in the future.

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