Design and Analysis Three-Phase Shunt Active Power Filter In Mitigate Harmonic

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DECLARATION

I declare that this thesis entitled "Design and Analysis Three-Phase Shunt Active Power Filter In Mitigate Harmonic" 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 : Nazri

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Date : 17 June 2021

APPROVAL

I hereby declare that I have checked this report entitled “Design and Analysis Three-Phase Shunt Active Power Filter In Mitigate Harmonic” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electric Engineering with Honours

Signature :

Supervisor Name : SYAHAR AZALIA BINTI AB SHUKOR

Date : 14 JUNE 2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Nowadays, the power electronic equipment is widely used by industrial, commercial, and residential consumers which inject harmonic current in the power system. This harmonic will reduce the power quality and creates power quality issues. This report will analyze the three-phase shunt active power filter (SAPF) to improve the power system and to reduce the current harmonic in nonlinear load. Besides, the MATLAB/Simulink will use to verified the shunt active power filter in harmonic mitigate. This project, the harmonic extraction based on the instantaneous power theory (PQ theory) and synchronous reference frame (DQ theory) method is being used to produce a reference current signal. Besides, the conventional proportional-integral (PI) controlled and fuzzy control-based SAFP is being used in the DC-link capacitor voltage regulator. Then, different between DC voltage which is error signal and DC reference voltage will generate. After that, the PI controlled will compensate for the error signal. The subtracts between line current and the harmonic signal from the controlled will be obtained the reference current. After that, the switching signal will be generated in current control algorithm and follow to the switching active power filter. The result for this project will be compared and analyzed. Based on the simulation of the MATLAB/Simulink result, this project confirmed the efficient use of this method to reduce the harmonics in power system.

ABSTRACT

Pada masa kini, peralatan elektronik kuasa banyak digunakan oleh pengguna industri, komersial, dan kediaman yang menyuntik arus harmonik dalam sistem kuasa. Harmonik ini akan mengurangkan kualiti kuasa dan menimbulkan masalah kualiti kuasa. Laporan ini akan menganalisis penapis daya aktif shunt tiga fasa (SAPF) untuk meningkatkan sistem kuasa dan mengurangkan harmonik semasa dalam beban tidak linear. Selain itu, MATLAB / Simulink akan digunakan untuk mengesahkan penuras kuasa aktif shunt dalam pengurangan harmonik. Projek ini, pengekstrakan harmonik berdasarkan teori daya sesaat (teori PQ) dan kaedah kerangka rujukan segerak (teori DQ) sedang digunakan untuk menghasilkan isyarat arus rujukan. Selain itu, SAFP berasaskan kawalan proporsional-integral (PI) dan kawalan kabur konvensional digunakan dalam pengatur voltan kapasitor pautan DC. Kemudian, perbezaan antara voltan DC yang merupakan isyarat ralat dan voltan rujukan DC akan dihasilkan. Selepas itu, PI yang dikawal akan mengimbangi isyarat kesalahan. Penolakan antara arus talian dan isyarat harmonik dari terkawal akan diperoleh arus rujukan. Selepas itu, isyarat beralih akan dihasilkan dalam algoritma kawalan semasa dan mengikuti penapis daya aktif beralih. Hasil untuk projek ini akan dibandingkan dan dianalisis. Berdasarkan simulasi hasil MATLAB / Simulink, projek ini mengesahkan penggunaan kaedah ini dengan berkesan untuk mengurangkan harmonik dalam sistem kuasa.

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ABBREVIATION	DESCRIPTION
THD	Total Harmonic Distortion
APF	Active power filter
SAPF	Shunt Active Power Filter
SRF	Synchronous Reference Frame
PQ	Instantaneous Power
PLL	Phase Locked Loop
DQ	Synchronous Reference Frame

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CHAPTER 1

INTRODUCTION

1.1 Motivation

As we can see, that the electronic device and other nonlinear loads in manufacturing, commercial and domestic users have shown that the power system voltage and the current waveform is degrading from time to time. Additionally, the current drawn by these loads contain harmonics, degrading the system's power quality. However, this will cause the problem and make power quality poor because of the harmonics in the system. After that, the harmonics will make voltage high, increase power loss, the level RMS supply current becomes high, and heating of equipment (N. A. Rahim,2015). The methods to reduce the harmonic can be either active or active power and passive filter. Traditionally, the passive filter has been used for harmonic mitigation purposes. However, this solution will present a few problems since the size is quite huge and the compensation properties are set, and the voltage distortion can fall into series impedance resonance to produce unwanted harmonic current flowing via a passive filter.

The shunt active power filter (SAPF) approach was utilised to reduce the harmonic current in the power system to a maximum of 5%, as described in IEEE 519-1992 "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems". This research aimed to increase the harmonic compensation for the three-phase model using a shunt active power filter. Finally, the result, which is harmonic value for a three-phase system from this project, will be shown by using MATLAB/Simulink software

1.2 Problem Statement

As we all know, we are surrounded by one of the most significant innovations of all time daily: power electronic devices. The power electronic device has many uses in our day-to-day life. It has also become a part of modern, and it has brought our lives to become better. This situation will increase the use of the power semiconductor switching devices in electronics such as television, computer, and the other microprocessor causes harmonics in the electric power system. High harmonics in electrical devices can create various difficulties and must be reduced to improve power quality.

The method to reduce harmonic can using either passive and active power filter. The passive filter is a capacitor and inductor combination that is adjusted to resonate at a single frequency. But passive filter is not very good for filter harmonic because the size is significant, and tuning cannot be changed. However, the tuned frequency and the system parameters its size cannot be changed easily. In fact, the active filter needs four control algorithms to improve the system to mitigate harmonic.

1.3 Objective

The objectives of this project are:

1. To verify the total harmonic (THD%) in 3 phase nonlinear load
2. To develop the three-phase shunt active power filter with nonlinear load

3. To verify of shunt active power filter to reduce harmonic
4. To applied DQ and PQ theory to generate reference current of Shunt Active Power Filter (SAPF)
5. To applied SPWM and hybrid hysterises/fuzzy on current control for PQ and DQ theory
6. To applied PI and fuzzy on voltage control for PQ and DQ theory

1.4 Research Scope

The research's primary objective is to develop and analyze a shunt active power filter by utilising mathematical equations based on DQ and PQ theory and simulate it using MATLAB/Simulink. The purpose of this research is primarily to investigate the control algorithm for a shunt active power filter. Additionally, the output behaviour of the percentage harmonic of a nonlinear load without and with the shunt active power filter will be studied

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

According to a literature review definition, "the literature" refers to the works studied to understand and examine the study subject. To begin, this chapter will explain shunt active power filters (SAPFs) and how they may be used to minimize harmonics in nonlinear loads. This is followed by a description of the four primary control algorithms applied to the shunt active power filter (SAPF) to enhance the system's harmonic mitigation capability.

2.2 Shunt Active Power Filter

This chapter reviews the development of shunt active power filter (SAPF) method in power system. However, the advantage of the active filtering method is a factor that many researches using the active power to enhance the power quality and their project application over passive filter method (Hirofumi Akagi,1994). The function such as harmonic termination, harmonic damping, harmonic isolation, harmonic compensation and voltage regulation is the function that provides by SAPF in power system (Hirofumi akagi,1996). The main purpose of the SAPF is to compensate current harmonic, improved power factor in their own harmonic-producing load, provide harmonic damping factor and also reduce harmonic voltage in power system (Hirofumi akagi,1996).

The application of the active power filter component that commonly used in electronic device is the shunt active power filter (SAPF) according to literature (M.A Chaudhari et al,2006; P. Rathika et al,2010; Zainal Salam et al,2006). According to Akagi (2005), the shunt active power filter (SAPF) is the most suitable to deal with harmonic current distortion. However, the shunt active power filter (SAPF) capable to improve power factor performance by reduce the reactive power burden on the system, while mitigate harmonic current (Ozdemir et al,2005; Chaoui et al 2015). According to Zainal salam et al (2006) said that the VSI based SAPF has been used widely today because its well-known topology and easier to implement in system.

Source: M.Sunitha et al,2013

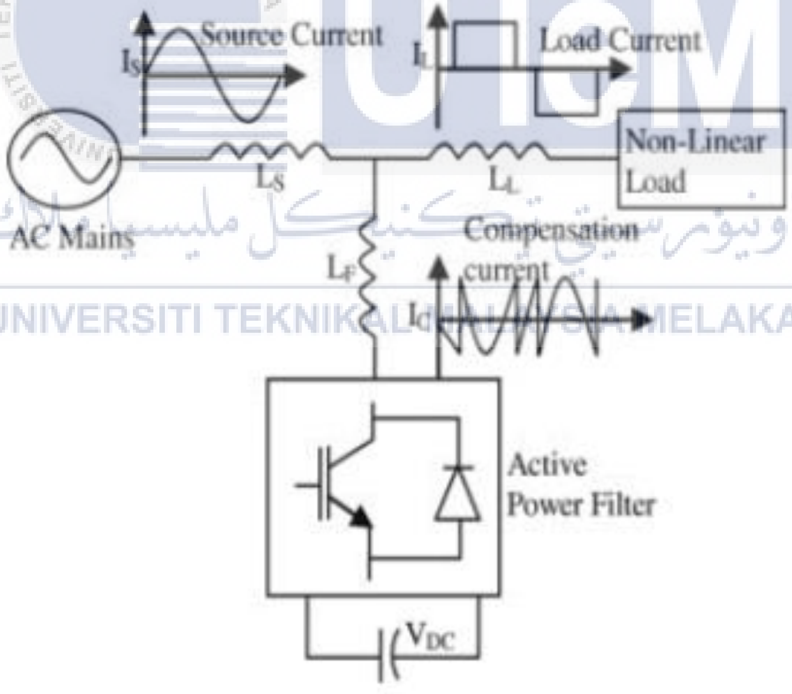

Figure 1: Voltage Source Inverter Based SAPF

Figure 2.1 show the circuit of voltage source inverter (VSI) based SAPF. The circuit consists of an inductor (L_F) and also the combination between power switching active filter and DC capacitor to become VSI. The SAPF works as a current source and compensates for the harmonic current signal from loads. However, the operation of SAPF is based on inject current signal which is equals with the harmonic signal to reduce the harmonic signal. The VSI switches used to generate compensation current, I_F .

In the shunt active power filter, the controller become an important parameter to mitigate harmonic in nonlinear load. The controller in SAPF can be divide into four main control algorithm which are:

I. Harmonic Extraction
II. Synchronizer Algorithm
III. Dc-Link Voltage Regulation
IV. Current Control Algorithm

Source: Yap Hooh et al,2017

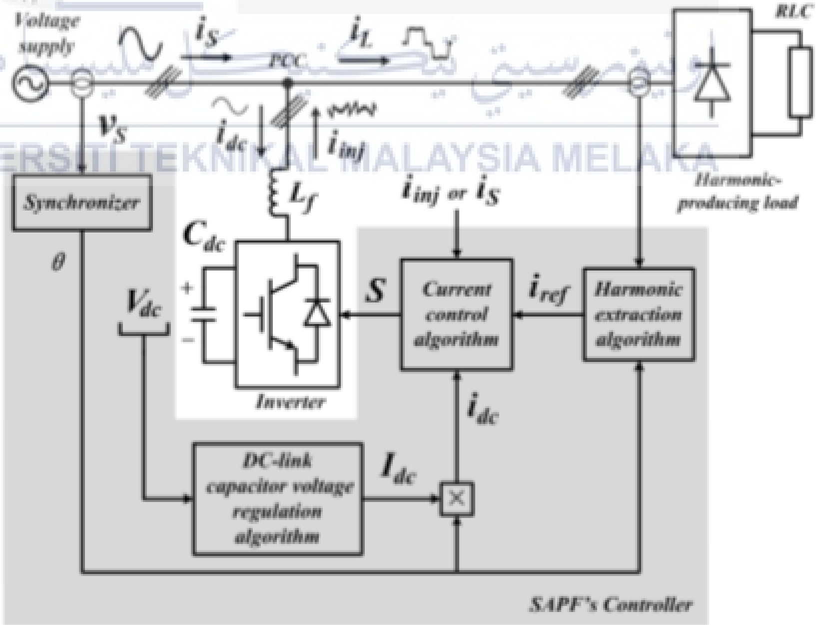

Figure 2: Circuit Connection Between SAPF and Control Algorithm

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2.3 Harmonic Extraction

In shunt active power filter, the harmonic extraction is one of important control algorithm. Another name of harmonic extraction is reference current generation. The purpose of the harmonic extraction is to generate a reference current signal, I_{ref} to become desired current injection, I_{inj} for reduce harmonic in the system. However, the harmonic extraction is the most important operation stage in SAPF that generate a reference current signal for the SAPF in system (Zainuri et al, 2016). According to Yap Hoon et al (2017), The harmonic algorithm will be taking distorted load current signal, I_L from harmonic polluted source load to provide a reference current signal, I_{ref} by isolating the harmonic current, I_H and fundamental current, I_I. Basically, the traditional reference current generation techniques and modern techniques is the group in the harmonic extraction. The traditional techniques can be categorized as time domains and frequency domains, and soft computing techniques are based on modern techniques (Harnek et al,2018).

Source: Harnek et al,2018

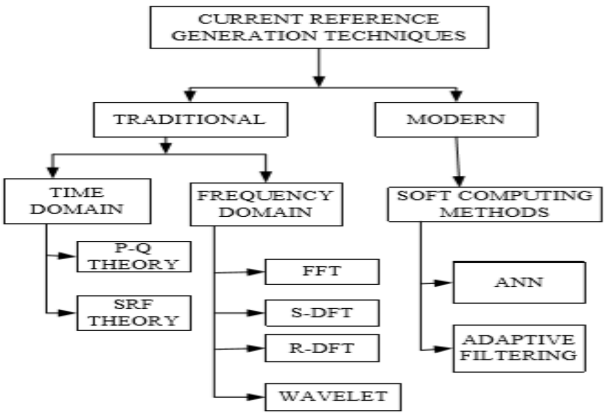

Figure 3: The Types of Harmonic Extraction Techniques

2.3.1 Traditional Reference Current Generation Techniques

2.3.1.1 Time Domain Approaches

Time-domain methods are more commonly used as they offer straightforward design functions with improved speed and decreased computational burden compared to their counterpart in the soft computing techniques and frequency domain. Basically, in time domain has two algorithm which is instantaneous power (pq) theory and theory synchronous reference frame (SRF) that widely applied in time domain (Hassan et al, 2016; Monfared et al,2013).

a) Synchoronous Reference Frame (SRF)

According to Y. Hoon et al (2006) the synchronous reference frame (SRF) algorithm also known as DQ theory is the best algorithm as it provides simple design structure with increased speed, reduced computational burden and also easier to implement. In this algorithm, the three-phase load current I_{abc} will convert into direct-quadrature-zero(dq0) frame by using Park transformation matrix. Then the d and q component of current are to fed to low pass filter to separate fundamental component and harmonic component (Jain et al,2014; Hoon et al, 2016). In the SRF algorithm, the Phase Locked Loop (PLL) synchronization system is using to automatically evaluate the phase angle of the fundamental positive sequence and the system frequency of the three-phase voltage source signal (Maria Isable,2007). Finally, the dq frame will inverse back to the three-phase load current, I_{abc} via inverse Park-transformation to generate desired reference current, I_{ref}.