SHUNT ACTIVE POWER FILTER PERFORMANCE BASED ON SYNCHRONOUS REFERENCE FRAME (SRF) FOR DIFFERENT LOAD CONDITION

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DECLARATION

I declare that this thesis entitled "SHUNT ACTIVE POWER FILTER PERFORMANCE BASED ON SYNCHRONOUS REFERENCE FRAME (SRF) FOR DIFFERENT LOAD CONDITION 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 : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "SHUNT ACTIVE POWER FILTER PERFORMANCE BASED ON SYNCHRONOUS REFERENCE FRAME (SRF) FOR DIFFERENT LOAD CONDITION" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

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ABSTRACT

The distorted waveforms due to highly uses of the non linear load, especially the current that is considered the main issues need to be addressed seriously. The issues of the distorted waveforms for the current have attracted many researchers to recover them in the electrical system. There are so many electronic devices that have been used in order to protect the waveform of the current from distorted as it is very dangerous and may cause the main supply to shut down or burnt. The main aims of this project is to design and develop a shunt active power filter for the purposes to mitigate the distorted of current waveform produced by the different types of non linear loads using the controller of the SRF. The software MATLAB/SIMULINK will be used to design and develop shunt active power filter and its controller. Finally the performance of the shunt active power filter and its controller at different types of non linear loads will be evaluated through the waveforms of the currents produced by different types of non linear loads and the Total Harmonic Distortion (THD) will be monitored and observed whether meets to the International Electrical Committee (IEC) standard or not.

Keywords: controller, non linear load, harmonics, shunt active power filter, SRF

ABSTRAK

Gelombang elektrik ubah bentuk disebabkan oleh penggunaan beban bukan linear, terutamanya aurs yang dianggap sebagai isu utama perlu ditangani dengan serius. Isu-isu bentuk gelombang yang terganggu untuk masa kini telah menarik ramai penyelidik untuk memulihkannya dalam sistem elektrik. Terdapat banyak alat elektronik yang telah digunakan untuk melindungi bentuk gelombang arus dari menyimpang kerana ia sangat berbahaya dan boleh menyebabkan bekalan utama ditutup atau dibakar. Matlamat utama projek ini adalah untuk merekabentuk dan membangunkan penapis kuasa aktif shunt untuk tujuan mengurangkan ubah bentuk gelombang arus yang dihasilkan oleh pelbagai jenis beban bukan linear menggunakan pengawal SRF. Perisian MATLAB / SIMULINK akan digunakan untuk merekabentuk dan membangunkan penapis kuasa aktif shunt dan pengawalnya. Akhirnya prestasi penuras kuasa aktif shunt dan pengawalnya pada pelbagai jenis beban bukan linear akan dinilai melalui bentuk gelombang arus yang dihasilkan oleh pelbagai jenis beban bukan linear dan Total Distortion Total Harmonic (THD) akan dipantau dan diperhatikan sama ada memenuhi standard Jawatankuasa Elektrik Antarabangsa (IEC) atau tidak.

Kata kunci: pengawal, beban bukan linear, harmonik, penapis kuasa aktif shunt, SRF

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LIST OF SYMBOLS AND ABBREVIATIONS

SAPF	-	Shunt Active Power Filter
SRF	-	Synchronous Reference Frame
THD	-	Total Harmonic Distortion
APF	-	Active Power Filter
SMPS	-	Switch Mode Power Supply

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the modern era, electricity is indispensable to everyone. Human use electronic devices in their daily life. Therefore, power quality is important as it will affect the electronic devices. However, the power quality is not perfect all the time. There are nine common power quality problems which include voltage sag, short interruptions, long interruptions, voltage spike, voltage swell, harmonic distortion, voltage fluctuation, noise, and unbalance voltage. Each of these power quality problems will bring damage to the power system. For harmonic distortion, the consequences are shortening the lifespan of equipment. Harmonic distortion will cause excessive heat and leads to malfunction in electronic devices [1].

In order to prevent the damage lead by harmonic distortion, standards has been set both internationally and nationally. According to IEEE-519, harmonic voltage distortion on power system 69kV and below is limited to 5.0% total harmonic distortion (THD) with each individual harmonic limited to 3%. Another standard set by IEC declared that for 400V power system, the total harmonic distortion is limited to 5%. For 6.6kV, 11kV and 20kV power system, the THD is limited to 4%. In Malaysia, TNB declared that the THD in 400V power system is limited to 5%, 4% for 11kV to 22kV power system, and 3% for 33kV and 132kV power system.

To overcome the power quality problem, passive power filters were introduced. Passive power filter is used to minimize the harmonic distortion in power system. However, there were many disadvantages such as the size of passive power filter is large, it will cause

resonance with the power system, and its fixed compensation characteristics [2]. To improve the power quality, active power filters (APF) was introduced to overcome the disadvantages of passive power filters. Active power filters can be classified into shunt active power filter and series active power filter. The function of shunt active power filter and series power filter are different. Shunt active power filter is used to reduce the current harmonics in power system.

1.2 Problem Statement

An important issue in the quality is that the distorted waveform of the current which are produced by the non-linear load. The distorted waveforms of the current is dangerous as it will cause the electrical equipments will damage or malfunction. They are so many electronic devices are used in order to protect the distorted current waveform among the popular device is called an active power filter. Actually the performance of the active power for mitigating the distorted waveform is totally depend on the controllers. As, there exist many controllers which are applied to the active power filtering, still, the SRF technique is widely accepted in the active power filter application. This controller is able to minimize the contains of the harmonics of the current waveform.. This work will concerned with the design and model of the active power filter with its controller using MATLAB/SIMULINK software for the aims of the harmonic minimization of the current waveform

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1.3 Objective

i) To study the operation of shunt active power filter and the controller applied in shunt active power filter.

ii) To design and model of shunt active power filter and its controller based on synchronous reference frame.

iii) To analyse the performance of shunt active power filter and its controller.

1.4 Scope

The scope of the project is to study, model, and analyse the function of shunt active power filter and its controller based on synchronous reference frame. This project will focus on the distortion of the waveform of the current. The overall system for this project comprises of the supply, loads and the active power filter and its controller. Normally the active power filter is installed between the supply and the load . The distorted current waveforms which are produced by the non-linear loads will be observed The performance of the active power filter with its controller will be analyse.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter included literature review, project background and the theory that needs to be studied related to the shunt active power filter based on synchronous reference frame (SRF) for different load condition.

An overview of this project and project background will be discussed in the first section of this chapter. The theory and working principle of shunt active power filter based on the synchronous reference frame will be presented. A summary of the literature review will be presented in the last section of this chapter.

2.2 Overview of Active Power Filter

In 1970s, active power filter was developed to diminish the harmonic currents in power system. Active power filter produces either harmonic currents or voltages in a way that retains the sinusoidal form of the current and voltage waves in the power system [5]. Without active power filter, harmonic distortion will occur when the power system is connected to non-linear load. Active power filter can be categorised as series active power filter or shunt active power filter based on their function. The function of series active filter is to lessen the voltage harmonics in power system. For shunt active filter, it is used to diminish the current harmonics in power system. Active power filter possess many advantages such as supply reactive currents, do not cause harmful power system resonances. The performance of active power filter is independent of the properties of the power system.

2.3 Shunt Active Power Filter

The function of shunt active power filter is to reduce the current harmonic in power system. To reduce the current harmonic, the shunt active power filter produces a same amplitude but 180° opposite phase current. The current produced by shunt active power filter will cancel out the current harmonic.

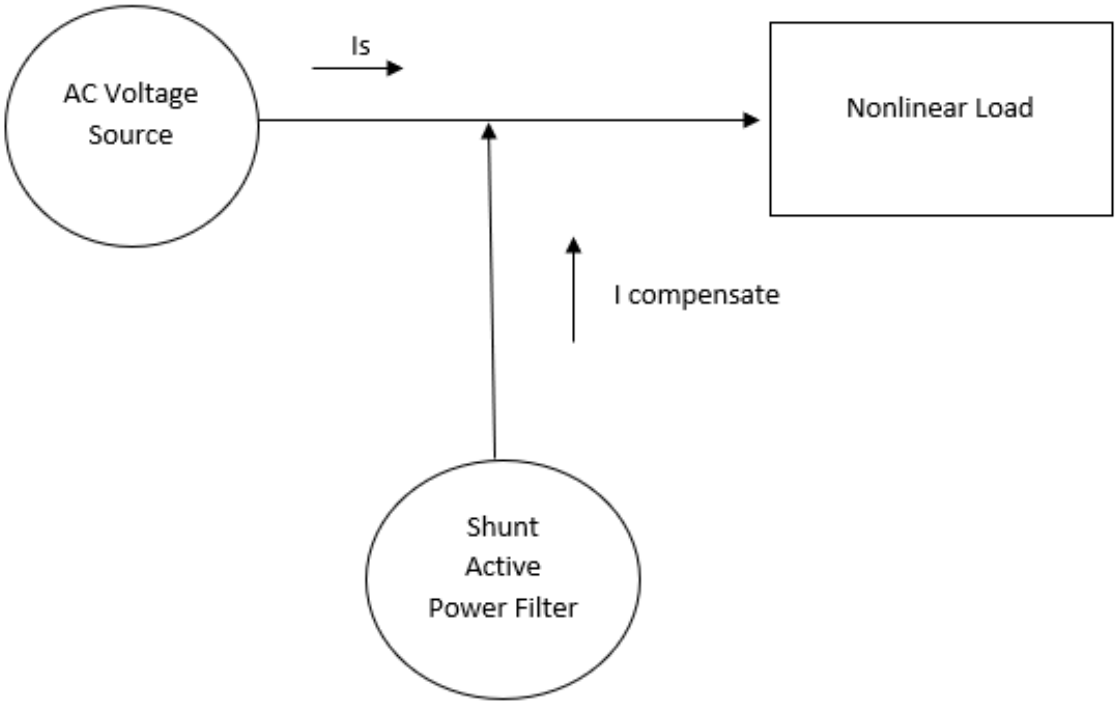

Figure 2-1 Basic scheme of shunt active power filter

Over the years, many control strategies were introduced to control shunt active power filter to generate current that responsible for reducing the current harmonic in power system. The performance of shunt active power filter varies with different control strategy.

2.4 Overview of Control Strategy for Shunt Active Power Filter

In recent year, many controllers is used to improve the performance of shunt active power filter.

In [9], hysteresis current control techniques is employed to control the magnitude and phase angle of the current injected by shunt active power filter. DSP TMS320LF2407 is

also implemented to control the shunt active filter. The author claimed that the THD of the source current improves from 11% to 4%. The author also claimed that the input power factor is enhanced from 0.91 to unity.

In the previous study by Arpit Shah and Nirav Vaghela [3], hysteresis current control and instantaneous reactive power theory is used to control the shunt active power filter. The author carried out the study using two different kind of loads which is resistive rectifier load and inductive rectifier load. The author claimed that for resistive rectifier load, THD of source current improved from 27.17% to 1.02%. The author also claimed that THD of source current improved from 25.82% to 2.46% for inductive rectifier load.

From the previous researches by Jarupula Somlal, Venu Gopala Rao.Mannam , Narsimha Rao. Vutlapalli [10], ANN based shunt active power filter is implemented in power system to boost its power quality. The author claimed that the %THD is reduced from 29.71% to 2.27%. Joao Afonso , Mauricio Aredes , Edson Watanabe , Julio Martins [11] had also studied shunt active filter to enhance power quality. The author used digital control in shunt active power filter to enable dynamic power factor correction. The digital control also permit harmonic current compensation and zero-sequence current compensation. The author used instantaneous power theory (p-q theory) to model shunt active power filter. The proposed shunt active power filter were employed using a standard 16 bits microcontroller. Somlal Jarupula et al. [12] has used fuzzy based hybrid active power filter in power systems to boost the power quality. The author claimed that the fuzzy based hybrid active power filter (FHAPF) is able to minimize harmonics and improve the power factor of a power system. In this design, the author used Generalized PI control unit and fuzzy adjustor unit as the controller of FHAPF. The author proposed generalized PI control unit to in order to achieve dividing frequency control. To create better adaptive potential and dynamic response, the

author had implemented fuzzy adjustor unit to adjust the parameters of the PI control unit. The author claimed that the power factor has been improved from 0.6 to 0.985 and the %THD is reduced to 0.78% from 21.34%.

C Nalini Kiran et al. [13] had carried out a study using instantaneous power theory for active power filter with PI and hysteresis current controller. The research is carried out under open loop system and closed loop system. The author claimed that the %THD for open loop with nonlinear load is 14.12%, 18.26% for open loop with composite load and 2.75% for closed loop with composite load.

From previous researches by A.Sakthivel et al. [14] , SRF based control algorithm is applied on three phase shunt active power filter. Synchronous Reference Frame (SRF) theory is used to calculate compensating currents. The author constructed a three-phase source that is feeding a highly non-linear load. The author claimed that the %THD in the source current is reduced to 2.58%.

From the previous researches by R.Sheba Rani et al. [15] ,PSPWM based Five-Level Shunt Active Filter is employed to power system network to enhance power quality. The author used Phase-Shifted carrier PWM technique to produce the gate drive signals of the inverter. The author claimed that the %THD in source current is maintained within nominal values of 3.27% with the balanced non-linear type of load. From the previous researches by Sanvog Dubey et al.[16], a three-phase four wire neutral clamped active power filter is employed to minimise the harmonics and reactive power created by non-linear balanced and unbalanced low power loads in steady state and in transients. From the previous researches by Niklesh Das et al. [17], a shunt active power filter is implemented to enhance the power quality of three phase system. The proposed shunt active power filter is based on the