COMPARATIVE ANALYSIS OF DIFFERENT HARMONICS MITIGATION TECHNIQUES

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Dedicate, in thankful appreciation for motivate, encourage and supporting

To

My supervisor Dr Dalila Binti Md Said,

My beloved family and friends

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In the name of Allah, The Most Loving and the Most Compassionate. I express my gratitude to Dr. Dalila binti Md Said as my supervisor, who has provided guidance in completing my master's degree project. Do not forget also to my family and friends who gave a lot of encouragement and support. Thank you

ABSTRACT

Electronic equipments have a great potential in contributing to the harmonic problems. With the widespread use of these equipments, the harmonic problems can become a major distortion to the power system if it's not treating properly. Today, various techniques to mitigate the harmonic problems are available. But, not all techniques are superior to solve the problems. Many factors are contributing in selection of the mitigation techniques such as types of harmonic sources, the salient order of harmonic, location installation of the technique and cost factors. Thus, the analysis on the system must be done properly before introduced or installed any mitigation technique, otherwise, another problems (e.g resonance phenomenon) may arise. The harmonic analysis focused on this study is at networks that consist of battery charger and UPS as the main contribution to the harmonic problems. Four harmonic mitigation techniques are proposed to solve the problems, single tuned filter tuned at 5^{th} order, 5^{th} and 7^{th} order tuned filter, 3^{rd} order C-type filter and phase shift transformer. After all the parameters regarding to respective techniques are determined, the proposed techniques are then performed using ETAP software for harmonic analysis purposes. IEEE-519 1992 limits standard is used as a guideline in this study. The results obtained shows that, all mitigation techniques are able to suppress the THDI below the limits but at some individual harmonic number and power factor resultant, not satisfied the limits. In term of electrical and cost benefits, the 5^{th} and 7^{th} order tuned filter is chosen as a best technique to mitigate harmonic problems in this study. This method manage to reduced the THDI almost 83% (from 26.7% to 4.55% of THDI) and correct the power factor up to 0.98.

ABSTRAK

Peralatan elektronik mempunyai potensi yang besar dalam menyumbang kepada masalah harmonik. Hari ini, pelbagai teknik untuk mengurangkan masalah harmonik boleh didapati. Tetapi, tidak semua teknik adalah lebih untuk menyelesaikan masalah. Banyak faktor yang menyumbang dalam pemilihan teknik-teknik mitigasi seperti jenis sumber harmonik , perintah yang utama harmonik , pemasangan lokasi faktor teknik dan kos. Oleh itu , analisis pada sistem mesti dilakukan dengan betul sebelum diperkenalkan atau dipasang apa-apa teknik mengurangkan. Analisis harmonik memberi tumpuan kepada kajian ini adalah pada rangkaian yang terdiri daripada pengecas bateri dan UPS sebagai sumbangan utama kepada masalah-masalah harmonik. Empat teknik pengurangan harmonik dicadangkan untuk menyelesaikan masalah-masalah , penapis tunggal ditala ditala pada tahap 5 , perintah -5 dan ke-7 penapis ditala , perintah ke-3 C-jenis penapis dan fasa peralihan pengubah. Selepas semua parameter mengenai teknik masing-masing ditentukan, teknik yang dicadangkan kemudiannya dilakukan dengan menggunakan perisian ETAP bagi tujuan analisis harmonik. IEEE- 519 1992 had standard digunakan sebagai panduan dalam kajian ini. Keputusan yang diperolehi menunjukkan bahawa , semua teknik pengurangan dapat menyekat THDI bawah had tetapi beberapa individu nombor harmonik dan faktor kuasa paduan , tidak berpuas hati batas. Dari segi faedah dan kos elektrik , perintah ditala penapis ke-5 dan ke-7 dipilih sebagai teknik terbaik untuk mengurangkan masalah harmonik dalam kajian ini. Kaedah ini berjaya mengurangkan hampir 83 THDI % (daripada 26.7 % kepada 4.55 % daripada THDI) dan membetulkan faktor kuasa sehingga 0.98.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Harmonics are always present in the power system due to extensive use of power electronics systems that result in increased their magnitude. They draw current is in the form of nature as correction / reversal phenomenon of their operations. Harmonic comes generally from devices with non-linear characteristics of the load as adjustable speed drives, electronic ballasted lamp and power supply each computer, copier, and fax machines and telecom equipment is used in a lot of modern offices. Interference can be considered a form of pollution that the electrical system can cause problems if the total harmonic current exceeds a certain limit set by the standards of IEC and IEEE 519 standard. High levels of harmonic distortion in the power system increases different risk of inconvenience and unwelcome effects. For example, some of the serious problems associated with the harmonic is overheating and damage to the neutral conductor, overheating and damage to the panel board feeders, line voltage irregularities, and the failure of overheating and premature distribution transformers. Then, in most cases, consumers with major distorting load have been asked to install a harmonic filter,

which prevents excessive harmonic interference from entering the supply system. The uniqueness of this new harmonic condition raises serious doubts and concerns regarding the effectiveness of the existing standards and practices for managing and reducing the harmonic distortions in the present distribution systems. As a result, studies on advanced and efficient harmonic mitigating method that can be properly planned in line with the new features of modern harmonic source is obviously required. There are plenty of ways to reduce the harmonic distortions in power system depends on financial allocation for the installation and type of load used by the consumer. Among the most commonly utilized are line reactor, passive filters, active filters, and phase shifting transformer. But among these techniques are not all the harmonic reduction is a suitable solution for every application. Basically depending on the type of load, the location of the filter should be installed and the cost of the filter.

1.2 Problem Statement

The elimination or attenuation of harmonics can be accomplished through a variety of techniques that currently available in the market such as line reactor, isolation transformers, k-factor transformers, tuned harmonic filters, IGBT, based fast switched harmonic filters, low pass harmonic filter, 12 & 18 pulse rectifier, phase shifting transformers and active harmonic filters. Among these technique, there is no single solution for mitigate harmonic that is universally superior. Therefore, the most economical and electrical benefits of different harmonic mitigation techniques need to be investigated.

1.3 Objective

This project has several objectives, the objective are

1. To study various harmonic problems and comprehend the different techniques used to solve the problems
2. To analyze and compare various types of harmonic mitigation techniques and,
3. To suggest a single or multiple techniques of harmonic mitigation as solutions of the harmonic problems

1.4 Scope of Work

This study will be focused on commercial and industry sector, which is involved low and medium types of single phase voltages. The available harmonic mitigation technique will be applied and compare so that the most economical and electrical benefits can be identified.

1.5 Thesis outline

This thesis completed of 5 chapters. Chapter one will describe the background of this study and followed by the problem statement of study. Besides that, objectives and scope of the study is also stated in this chapter.

The next chapter is about literature review. In this chapter, the harmonic phenomenon such as disturbances of harmonic, harmonic effects and harmonic mitigation solutions are explain in details. Standard for harmonic distortion is also included in this chapter.

Earlier in chapter 3, network under study is analyzed by using ETAP software. In the analysis, the parameters such as THDI, THDV, power factor and load current is obtained. After that, the steps to sizing each harmonic mitigation techniques are shown in details that based on the information obtained from base case system analysis.

Chapter 4 present the results obtained after all mitigation techniques are performed using ETAP software. The analysis of the results includes the reduction of harmonic distortion and power factor improvement. The best solution between the proposed techniques is identified.

Conclusion and recommendation of future works for further analysis are stated in chapter 5.

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