DESIGN AND DEVELOP A HARMONIC FILTER FOR MAGNETIC BALLAST FLUORESCENT LAMP

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(POWER ELECTRONIC AND DRIVE)

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"I hereby declare that I have read this report and in my opinion this report in term of content and quality requirement fulfils the purpose for the conferring of the Degree of Bachelor in Electrical Engineering."

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"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

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Date : MAY 2009

DEDICATION

Specially dedicated to my beloved family especially my mother (Fatimah binti Ahmad) and my late father (Allahyarham Hamid bin Puteh); whose very concern, understanding, supporting and patient. Thanks for everything. To All My Friends, thanks for everything. This work and success will never be achieved without all of you.

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Thank you.

ABSTRACT

The aim of this project is to design and develop harmonic filter circuit to control harmonic distortion in magnetic ballast. The harmonic filter circuit will attach between power supply and magnetic ballast. The entire characteristic and its performance will be study and analyze. To design the harmonic filter several passive components will be use. The purpose of the harmonic filter circuit is to reduce the selected component of harmonics distortion that happens in fluorescent lamp so that the distorted waveform can be reshaped to the ideal sinusoidal waveform. To prove the theory practically, the OrCAD software will be used to simulate the circuit. From the simulation, a useful graph such as voltage, current and harmonic distortion will produce. The result of the analysis will be used to design a prototype circuit to be tested. At the end of the project, a complete circuit of harmonic filter will be developed to improve power quality in term of harmonic in the fluorescent lamp.

ABSTRAK

Tujuan menjalankan projek ini adalah untuk merekacipta dan membangunkan penapis harmonik supaya dapat mengawal gangguan harmonik pada pengantap megnatik. Litar penapis harmonik akan dipasangkan di antara sumber kuasa dan pengantap megnatik. Mengkaji setiap sifat dan prestasi pengantap megnatik. Dalam menghasilkan pengantap megnatik, beberapa komponen pasif akan digunakan. Tujuan penapis haomonik ini adalah untuk mengurangkan pilihan komponen bagi gangguan harmonik di dalam lampu kalimantan. Selain itu, litar tersebut boleh mengubah bentuk gelombang dari yang telah di ganggu kepada gelombang sempurna. Untuk membuktikannya, perisian OrCAD akan digunakan untuk menganalisa litar. Daripada simulasi, graf yang berguna seperti voltan, arus dan gangguan harmonik akan diperolehi. Hasil daripada analisis tersebut akan digunakan untuk merekacipta litar prototaip untuk diuji. Di akhir projek ini, litar lengkap bagi penapis harmonik akan dibangunkan untuk memperbaiki kualiti kuasa (harmonik) dalam lampu kalimantan.

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THD – Total Harmonic Distortion

STF – Single Tuned Filter

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

The definition of visible lights is wavelengths of electromagnetic radiation that can be seen with the human eye. Isaac Newton proposes that light existed as *"CORPUSCLES"*. The discovery of electric power and the possibility of transmitting it in a simple manner facilitated the development of modern lamps. There are various types of lamps being manufactured which can divide into six categories: incandescent, fluorescent, high-pressure sodium (HPS), low-pressure sodium (LPS), mercury vapor and metal halide. The fluorescent lamp is the most familiar of the large class of lamps referred to as discharge lamps. In these lamps light is creating by an electrical discharge within gas or vapor.

When a fluorescent lamp in its running condition, there is an arc discharge along the length of the tube and the mercury vapor ionizes. The combination of the ionization itself and the excitation of the mercury atoms produce electromagnetic radiation. The major characteristics to be considered when choosing a lamp are its luminous efficacy, life, lumen depreciation and color rendering. Luminous efficacy is the measure of the lamp's ability to convert input electric power, in watts, into output luminous flux, in lumens, and is measured in lumens per watt (lm/w). The luminous flux of a light source is the electromagnetic radiation within the visible part of the electromagnetic spectrum multiplied by the sensitivity of man's eyes to that part of the light from the source.

The aim of ballast combination is ensure that the lamps operate safely, at maximum efficacy, and with long life. The lamps should also start quickly and the combined must not represent an undesirable load on the supply. Ideally the combination should provide some

regulation in the sense that changes in supply voltage should not be reflected in corresponding large changes in light output.

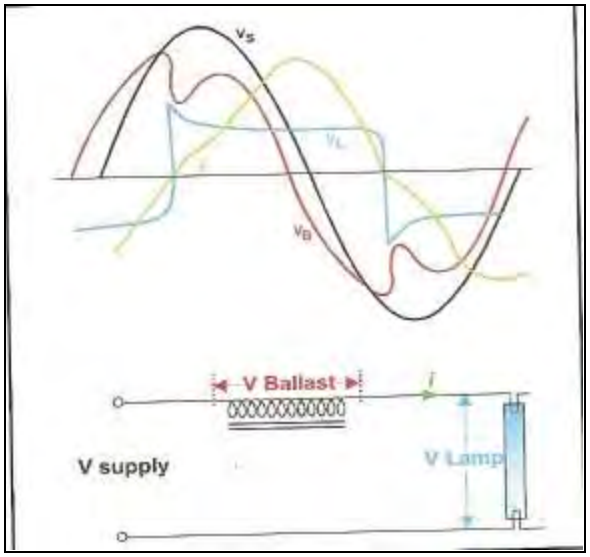

Figure 1.1: Current and voltage waveform for the simple reactor ballast circuit.

From figure 1.1 that simple reactor ballast provides a lamp voltage that is out of phase with the current. This is helpful as it ensure sufficient voltage for restrike at each half cycle. A resistive ballast would not only be wasteful, but would result in a significant discontinuity as the supply voltage change direction resulting in worse harmonic generation.

Harmonic distortion is voltage and current frequency riding top of the normal sinusoidal voltage and current waveform. It can be found in voltage and current waveform. Current distortion generated by non-linear loads. It creates voltage distortion according to ohm's law. Current distortion will affect power system and distribution equipment while voltage distortion will affect all load connect to particular bus or phase. Current distortion will directly or indirectly destruction of load loss of product.

Direct perspective for current distortion:

- Transformer will overheat and fail even through it not use fully load
- Conductor and conduit system also overheated and it leading to open circuit and downtime

Indirectly perspective for current distortion:

- Create resonant
- May excite resonant frequency in the system
- Resonant may cause extremely high harmonic voltage and also possibly damaging the equipment

1.2 Problem statements

Most of the magnetic ballast fluorescent lamp in the market had not provided power factor correction and harmonic filter. From the previous studies, a magnetic ballast of fluorescent lamp can produce 18-35% of harmonic distortion. A house can produce more than 35% of harmonic distortion depending on the number of fluorescent lamps installed. The problem cause by the harmonic is poor power factor and it can also damage the entire component of the fluorescent lamp in long term. Besides that, the lower value of power factor due to harmonic means the larger current will be drawn from the utility which will increase the power consumption. This means the electricity bill will be higher. Moreover, the existing harmonic filters in the market are only available for industrial use and they are expensive.

1.3 Project objectives

These are the objectives of this project:

1. To design and develop harmonic filter to get an improvement in term of power quality (harmonic) for a fluorescent lamp
2. To simulate and analyze the performance of magnetic ballast model (Newton ballast 32W for fluorescent lamp) based on design, power efficiency and harmonic filter.
3. To compare the resulting between the magnetic ballast without harmonic filter and magnetic ballast with harmonic filter.

1.4 Project scopes

The scope of this project is to analyze the harmonic produce in the model (Newton ballast 32W for fluorescent lamp). After analyze the model, a design of harmonic filter will be produce to reduce the available harmonic components. The targets of harmonic component are 3^{rd}, 5^{th} and 7^{th}. The harmonic filter design will use passive component as the based component in order to reduce the targeted harmonic components. A comparison between with and without harmonic filter will be analyze.

1.5 Thesis outline

The purpose of this project is to design a harmonic filter for 32W magnetic ballast fluorescent lamp. It will discuss in detail in five sections. It is introduction, literature review, methodology, results and discussions, and conclusion.

In chapter one (introduction and literature review), it discussed about the major characteristics to be considered when choosing a lamp. It also discuss about the magnetic ballast and harmonic filter as well. The problem statement, project objectives, scope and thesis outline are also included in this chapter. This chapter also discuss about the operation of fluorescent lamp, component in fluorescent lamp and harmonic distortion. Furthermore, it will discuss about harmonic filter that has being produce from previous studies.

In chapter two (methodology), it discussed about the techniques and consideration that applied during PSM1. In simulation part, OrCAD software is used to simulate the design circuit before it can proceed to the hardware part. The Fluke meter is used to do the analysis of the circuit operation of magnetic ballast. The calculation using Fourier analysis is done to determine the required filter.

In chapter three (results), the results are obtained using the methodology discussed in previous chapter. Then, OrCAD simulation is done to the design circuit to ensure it functions probably. This is determined by looking at the graph obtained during simulation.

Analysis on harmonic distortion also included. The measurement result from the laboratory is also show in this chapter.

In chapter four (discussions of result), all the measurement result will be compared in this chapter. An analysis will be performing to prove the calculation and measurement result according to expectation.

In chapter five (conclusion), brief summaries of this project are provided. Besides that, it also includes a recommendation of this project.

1.6 Literature Review

The article in [1] defined that fluorescent lamps are important and widely used in our places. The current waveforms of fluorescent lamps are non-sinusoidal because of luminous discharge mechanism. This article also stated that every fluorescent lamp was different value in producing harmonic current even the same type of lamp. The article added that if only the current waveform of every single device has been pre measured, the different harmonic source will becomes unpredictable. However, it is impossible to use this kind of method.

The article in [2] informs that, the 4 feet magnetic ballast fluorescent lamp is the most common lighting fixture Malaysia resident. The main reason is because it produces the highest lumens compare to other incandescent bulb and compact fluorescent lamp (CFL). From article [1] added that A CFL only produces up to 1600 lumen depending on the power of the CFL .A fluorescent tube can produces 3200 lumens. The fluorescent lamp is not an energy efficient lamp because the magnetic ballast commonly used in it.

The article in [3] shared one of the advantages of fluorescent lamps over incandescent lamps. First, it is 2 to 4 times more efficient. The power consumed is wasted in invisible infrared light because of the incandescent lamps. The fluorescent lamps are having longer lamp life compared to incandescent lamps. The ratio is 10 000–20 000 hours versus 1000 hours.

Article in [3] extended that fluorescent lamp also have several disadvantages. First, it must be properly disposed so that the mercury not going into the environment. The lamp life can be reduces by turning the lamps on and off. The process is called sputtering. The process occurs when reduction is cause from the mercury ions that collide with the electron that being release by the electrode.

The article also stated physically, compare to the warm incandescent lamp the fluorescent lamps color sometimes is cooler and less pleasing. Although, this issues is already solved by designing a new model that generate higher harmonics the ballast in fluorescent. The Lamps with higher harmonic distortions will reduce the light power intensity. So the lamp will flickering, and will give problems to other devices that connected to the electrical network. Furthermore, additional lamps that installed in a building, bigger harmonic will generate because of the total building load.

1.7 Fluorescent Lamp

The fluorescent lamp was the most advance technology to be a commercial success in small scale lighting since the tungsten incandescent bulb. Its greatly increased efficiency resulted in cool (temperature wise) brightly lit workplaces (offices and factories) as well as home kitchens and baths. Fluorescent lamps are a type of gas discharge tube similar to neon signs and mercury or sodium vapor street or yard lights. A pair of electrodes, one at each end - are sealed along with a drop of mercury and some inert gases (usually argon) at very low pressure inside a glass tube. The inside of the tube is coated with a phosphor which produces visible light when excited with ultra-violet (UV) radiation. The electrodes are in the form of filaments which for preheat and rapid or warm start fixtures are heated during the starting process to decrease the voltage requirements and remain hot during normal operation as a result of the gas discharge.

The internal phosphor coating very efficiently converts most of the UV to visible light. The mix of the phosphor(s) is used to tailor the light spectrum to the intended application. Thus, there are cool white, warm white, colored, and black light fluorescent (long wave UV) lamps. There are also lamps intended for medical or industrial uses with a special envelope such as quartz that passes short wave UV radiation. Some have an