ELECTRONICS BALLAST
WITH POWER FACTOR CORRECTION
AND HARMONICS FILTER

HARRY ANAK JAMES

JULAI 2009

© Universiti Teknikal Malaysia Melaka

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronic and Drive)."

Signature : ……

Supervisor‟s Name : EN. MD HAIRUL NIZAM BIN TALIB

Date : ……..

© Universiti Teknikal Malaysia Melaka

ELECTRONIC BALLAST WITH POWER FACTOR CORRECTION AND HARMONICS FILTER

HARRY ANAK JAMES

This Report is submitted in Partial Fulfillment of Requirements for The Degree of Bachelor in Electrical Engineering (Power Electronic and Drive)

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

JULAI 2009

© Universiti Teknikal Malaysia Melaka

"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."

Signature : ……

Name : HARRY ANAK JAMES

Date : ……

© Universiti Teknikal Malaysia Melaka

Dedicated especially to my father
and my beloved mother

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

First and foremost, I thank to God the Almighty for blessing me to complete my Final Year Project 2. I would like to enlarge my appreciation to Mr. Md Hairul Nizam bin Talib because of the kindness heart to accept me as one of the student under his supervision. Special thanks also dedicated to him for all comments, idea and a guideline begin from the first day I start this project.

This appreciation also goes to my friend that always gives support, opinion and advices for me to complete this report.

To my beloved family, I would like to forward my obliged to them for their continuous support during my study, their patience and benevolence. Lastly, I would like to thank to everyone who has contributed during my Final Year Project 2. Your kindness and cooperation in completion of my paper work is much appreciated.

THANK YOU.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

This project will focus on power factor correction and harmonic filter circuit designed for electronic ballast fluorescent lamp. The selected electronic ballast fluorescent lamp with high harmonic and low power factor is improved by added the valley fill passive power factor correction circuit after the fully control bridge rectifier. Valley fill circuit is used because it is due to low cost, high efficiency and simple circuit design. The power factor can be increase 35%, current total harmonics distortion reduced 41.8% and voltage 25.6%. This valley fill passive power factor correction circuit is suitable for increasing the power factor and reducing the harmonic.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Projek ini dilaksanakan untuk merekabentuk dalam meningkatkan pembetulan faktor kuasa dan gangguan harmonik pada pengatap elektronik lampu pendarfluor. Pengatap elektronik lampu pendarfluor yang mempunyai faktor kuasa yang rendah dan gangguan harmonik yang tinggi dipilih dan diubahsuai dengan menambah litar *"Valley-Fill Passive Power Factor Correction"* selepas diod tertimbang. Litar "Valley-Fill" dipilih kerana ia hanya memerlukan cost yang rendah, berkecekapan tinggi dan litarnya adalah ringkas. Faktor kuasa dapat ditingkatkan sebanyak 35%, gangguan arus harmonik dikurangkan sebanyak 41.8% dan voltan kurang 25.6%. Litar *"Valley-Fill Passive Power Factor Correction"* adalah sesuai digunakan untuk meningkatkan faktor kuasa dan mengurangkan gangguan harmonik.

© Universiti Teknikal Malaysia Melaka

CONTENTS

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATION

HPS	-	high-pressure sodium
LPS	-	low-pressure sodium
CFLs	-	Compact fluorescent lamps
CFL	-	Compact fluorescent lamp
FYP	-	Final Year Project
OrCAD	-	reflecting The Software's Origins Oregon + CAD
THD	-	Total Harmonic Distortion
RMS/rms	-	rotation minute per second
AC	-	Alternative Current
DC	-	Direct Current
Vac	-	Voltage alternative current
Hz	-	Hertz
IIR	-	infinite impulse response
FIR	-	finite impulse response
R	-	Resistor
L	-	Inductors
C	-	Capacitors
Q	-	Quality Unit SI
CPU	-	Computer Program Unit
VFPPFC	-	Valley-Fill Passive Power Factor Correction
MVF	-	Modified Valley fill

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Introduction

Electronic ballast has been widely used as saving energy lighting fixture in the household. Now days, there have many types of electronic ballast fluorescent lamp in the market with a different designs and shapes. There are compact electronic ballast, 2 feet or 4 feet electronic ballast and rounded shape of electronic ballast fluorescent lamp. The rapid development of electronic ballast has been showed by producing a lot of type fluorescent lamps. Year after year, the electric and electronic engineers find a new kind of discovery of fluorescent lamp in order to improve the electrical consumption.

There have a lot of type electronic ballast sells in the market with variation of electronic design as well as prices. However, some of this electronic ballast still has high of total harmonic distortion (THD) and low power factor. Because of this condition, this project comes with a new design of electronic ballast in way to improve the power factor and reduce the current harmonic on the selected electronic ballast. The improvement of this electronic ballast, are important to reduce the power consumption of electrical energy so it can save the cost and energy.

The basic design of electronic ballast are consists of four combination main parts of circuit. The four main parts are AC/DC rectifier, DC/AC inverter, harmonic filter and power factor correction circuit. The AC/DC rectifier is powered by 4 controlled diodes which is used to convert the alternating current (AC) to direct current (DC), DC/AC inverter used to convert the direct current (DC) to alternating current (AC), while filter including capacitor and inductor

© Universiti Teknikal Malaysia Melaka

used to cut out the voltage and current disturbance occur in the circuit [1,2]. Then power factor correction circuit consists of capacitor, used to increase the power factor of the circuit nearly to 1.0 power factor.

The output voltage of these four combination main parts is important because it is used by transformer, switching circuit and control circuit to switch ON the fluorescent lamp tube. The simple electronic ballast block diagram is as shown in Figure 1.1.

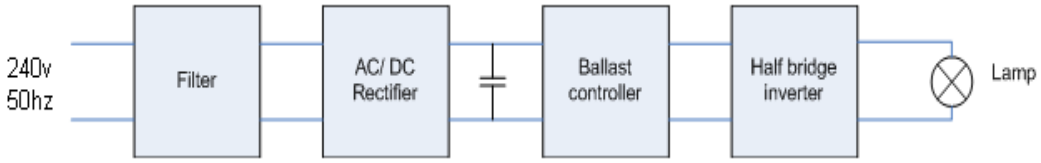

Figure 1.1: Electronic ballast block diagram.

The others important parts that has been discussed on this electronic ballast are harmonic filter and power factor correction circuit. It is important because these two parts used, to make sure the output of the current and voltage of this electronic ballast is under the harmonic and power factor standard rated value according to specified by Public Works Department. The standard value of the harmonic of the circuit is 25%. [3]

This project focuses on design the harmonic filter and power factor correction of the electronic ballast type RFO T8-36W 4 feet. This general electronic ballast is using a basic electronic ballast circuit as it mentions early. The electronic ballast circuit of this fluorescent lamp showed in figure 1.2 below.

Figure 1.2 Electronic Ballast Circuit

© Universiti Teknikal Malaysia Melaka

This circuit needs to be improved by increase the power factor and reduce the current/voltage harmonic. To fulfill this improvement, the Valley-Fill Passive Power Factor Correction circuit in order to improve the power factor while reduced the voltage and current total harmonic distortion.

While there are a lot of technique can be use to increase the power factor and reduced the total harmonic distortion of the electronic ballast. By considering the cost value, valley-fill type suitable because these circuit quite easy and simple to design. This valley fill circuit are consists of 2 electrolytic capacitor and 3 diode. It is connected after full bridge controlled rectifier circuit. The valley-fill passive factor correction circuit is shown in figure 1.3.

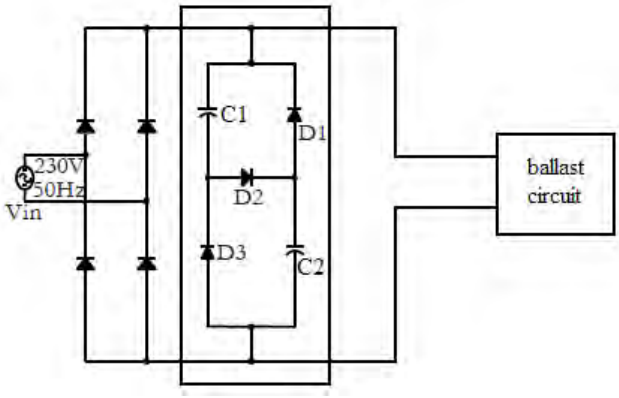

Figure 1.3: Valley-Fill Passive Power Factor Correction Circuit.

1.2 Problem Statements

In Malaysia, the 2 or 4 feet magnetic coil ballast fluorescent lamp is the most common lighting fixture in household. However this fluorescent lamp is not efficient energy due to the power loss in the coil. In way to prevent this power loss, the electronic ballast is introduced. However, some of this electronic ballast fluorescent lamp contents of very high current harmonic and low power factor. The total harmonic distortion of this fluorescent lamp recorded above than 25% refer to standard specified by Public Works Department. The power consumption of the fluorescent also high and this will cause a high using cost energy.

© Universiti Teknikal Malaysia Melaka

1.3 Project Objectives

This project focuses on the following two objectives:

1) Analysis and study the characteristic of the electronic ballast model RFO T8-36W based on design, operation, electrical characteristic such as current, power loss and voltage on transient and steady state.
2) To design and develop power factor correction and harmonics filter electronic ballast model RFO T8-36W.

1.4 Project Scopes

This project is covered the development of electronic ballast fluorescent lamp model RFO T8-36W. The project scope divided into 3 main parts:

1. Remodel the original and new design of electronic ballast fluorescent lamp model RFO T8-36W.
2. Test and measured both of the electronic ballast parameters based on power quality and harmonics.
3. Design the schematic both of the circuit by using OrCAD PSpice software simulation.

1.5 Literature Review

This section discussed the theory and concepts of this project in details. Besides that, it also discussed about the general function of every main part of the electronic ballast, valley-fill passive power factor correction circuit (VFPPFC), fundamentals and software use to simulate the circuit. Below are the parts that are discussed in literature review:

© Universiti Teknikal Malaysia Melaka

1) Main parts of electronic ballast
2) Fundamental
3) Simulation Software
4) Measurement equipments
5) Valley Fill Passive Power Factor Correction

1.6 Main Parts of Electronic Ballast

The existing of electronic ballast is use to replace the magnetic ballast conventional system. However, some of the electronic ballast still does not have the suitable electronic system which can use to increase the power factor and reduce the harmonic distortion. Electronic ballast divided into some parts which each part have there own function before turning-on the tube.

Each part needs to consider in term of input/output of current and voltage harmonic distortion. General electronic ballast has five mains component such as:

1) AC/DC rectifier
2) Capacitor Bank
3) Inverter
4) Filter
5) Ballast controller

1.6.1 AC/DC Rectifier

AC/DC known as an electrical device which is use to converts alternating current (AC) to direct current (DC) and this process is called rectification. A power supply is used as detectors of radio signals totally include in the rectifiers system.

© Universiti Teknikal Malaysia Melaka

Commonly rectifiers are made by solid state diodes, vacuum tube diodes, mercury arc valves, and other components.

The efficiency of the converting AC to DC process can be increase by comprises a number of the diode but not in one diode. The most common diode used in the day time is vacuum tube diodes and copper (I) oxide or selenium rectifier. These types of rectifier are used before the development of silicon semiconductor rectifiers.

Crystal radios which used a "cat's whisker" of fine wire pressing on a crystal of galena (lead sulfide) to serve as a point-contact rectifier or "crystal detector" is develop early of the development of radio. In gas heating systems flame rectification can be used to detect a flame.

The flame is presented along the current path and rectification by two metal electrodes in the outer layer which is applied the alternating voltage [4]. The full bridge controlled rectifier show as figure 1.4 below.

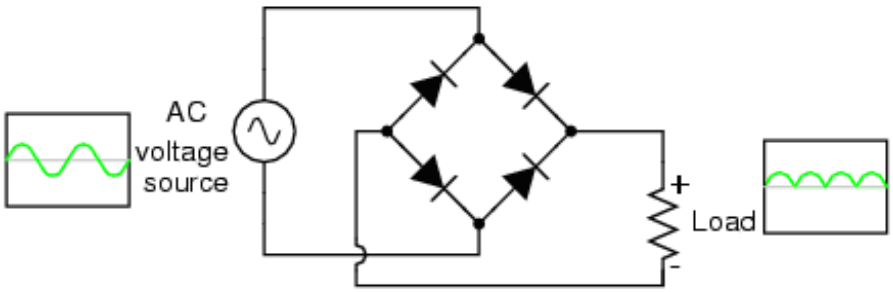

Figure 1.4: Full Bridge Rectifier Circuit

Commonly full bridge rectifiers are use four diode to achieve full wave of rectification process. The converting the AC power to DC power is done by the Bridge rectifier. When the input waveform reached the one of constant polarity whether positive or negative the systems are fully converted. The input waveform in DC is converted by full wave rectification at a both polarities. The four of the diode is needed for half-wave rectification in the non-center trapped transformer. The Diode Bridge or bridge rectifier content of four rectifiers arranged. [4].

© Universiti Teknikal Malaysia Melaka

1.6.2 Capacitor Bank

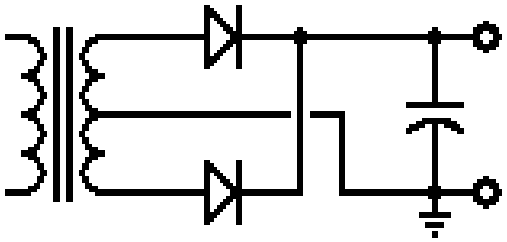

Figure 1.5: Buffer Capacitor

When capacitor is placed at the output of the full-wave rectifier as shown to the left, the capacitor will charge to the peak voltage each half-cycle, and then will discharge more slowly through the load while the rectified voltage drops back to zero before beginning the next half-cycle. Thus, the capacitor helps to fill in the gaps between the peaks, as shown in red in the figure 1.7.

Although we have used straight lines for simplicity, the decay is actually the normal exponential decay of any capacitor discharging through a load resistor. The extent to which the capacitor voltage drops depends on the capacitance of the capacitor and the amount of current drawn by the load; these two factors effectively form the RC time constant for voltage decay.

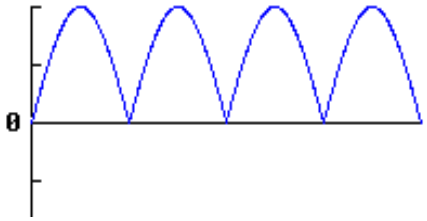

Figure 1.6: Input signal waveform

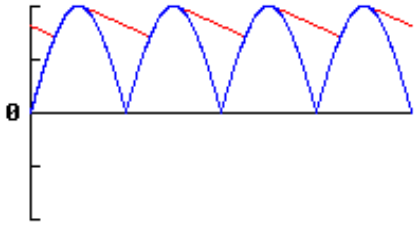

Figure 1.7: Unfiltered input signal waveform

© Universiti Teknikal Malaysia Melaka

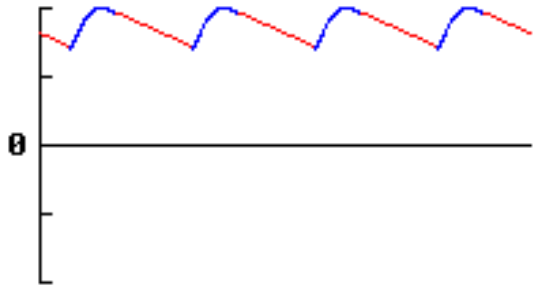

Figure 1.8: Filtered input signal waveform

The figure 1.8 shows the actual voltage output is never drop to zero condition. When the capacitor provides current to the load, its can show through the increase waveform which is provides current to the load and the decrease waveform show the capacitor provides current to the load.

At the unfiltered output of the rectifier not pure dc, has much less variation or called ripple. The capacitor will discharge considerably more between input pulses and at a half-wave the rectifier, the capacitor works as filter and filter the output voltage from the rectifier.

The capacitor filter many kid of loads if the output voltage from the can be kept high enough at all times [5].

1.6.3 Inverter

Inverter is an electronic component and it is used to converts the direct current to alternating current which is can be required voltage and frequency with the use of appropriate transformers, switching and control circuits. The inverter can be use at any kind of electrical and electronic system such as large electric utility high-voltage direct current applications that transport from small switching power in the computer.

The inverter is use direct current as power supply such as solar panel or batteries. The electrical inverter is a high-power electronic oscillator. System which converting the DC to

© Universiti Teknikal Malaysia Melaka