POWER FACTOR CORRECTION FOR VARIOUS TYPE OF MAGNETIC FLUX BALLAST FLOURESCENT LAMP

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"I declare that this report entitle *"Power Factor Correction for Various type Of Magnetic Flux"* is the result that my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

Student :MOHD ALL FADZIL BIN NASIR

Date :….MAY 2009

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ABSTRACT

This project report is to analysis the electrical parameter of various types of magnetic ballast fluorescent lamp. This project is conducted to improve power consumption of magnetic ballast fluorescent lamp by improving the power factor. A few model of magnetic ballast fluorescent lamp were selected as the sample of study. The electrical characteristic of magnetic ballast were analysis such as starting voltage, current, power consumption, power factor and harmonic. Based on the sample analysis on a few brand ballast magnetic have low power factor around 0.6 and as we known the good for electrical appliance have a power factor between 0.8-0.99 The design of the power factor correction for magnetic ballast has been broken down into its subsections and the theory, analysis and design the power factor improvement for magnetic ballast fluorescent lamp All this discuss by detailed in this report. This project was developed with included the selected magnetic ballast and will be analyzed the electrical parameter such as starting voltage, current, steady-state condition, power consumption, power factor and harmonic

ABSTRAK

Laporan projek ini dibuat menganalisis ballast magnetik bagi lampu pendafluor. Kegunaan projek ini adalah untuk memperbaiki factor kuasa ballast magnetik lampu Beberapa jenis ballast magnetic akan di pilih untuk bahan kajian. Ballast magnetic yang di pilih akan di analisis dari segi parameter elektrik seperti permulaan voltan, arus, penggunaan kuasa, factor kuasa dan harmonic. Daripada analisis yang di lakukan ke atas beberapa jenis ballast magnetik mempunyai factor kuasa yang rendah iaitu kira-kira 0.5 dan seperti mana yang di ketahui sesebuah perkakasan adalah lebih bagus mempunyai nilai factor kuasa di antara 0.8-0.99. Oleh yang demikian, pembinaan projek ini dipecahkan kepada dua bahagian iaitu bahagian teori, analisis dan pembangunan litar bagi ballast magnetic untuk mempertingkatkan factor kuasa. Semua ini dibincangkan secara terperinci di dalam laporan ini. Pembangunan projek ini merangkumi ballast magnetik yang telah di pilih dan di analisis dari segi voltan, arus masukan, penggunaan kuasa, factor kuasa dan harmonik.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Generally, fluorescent lamp is an electrical type of the lighting in various kind adobes. Fluorescent lamps equipped with magnetic ballast to provide the starting voltage to initiate the discharge and limit the running current from the power supply. Based on this project, selected magnetic ballast will be analyze such as on starting voltage, current, steady-state condition, power factor, power consumption and harmonic. A study has been conduct and it proves that magnetic ballast fluorescent lamp can have poor phase displacement between the voltage and current. The poor phase displacement on the magnetic ballast that means the poor power factor will occur in the magnetic ballast. Power compensation can be done by the use of a capacitor. Power factor correction will be built and develop for selected magnetic ballast fluorescent lamp After that the electrical will be analyze such as the starting voltage, current, steady-state condition, power consumption, power factor and compare with the magnetic ballast fluorescent lamp without power factor correction. The result will be showed; the power consumption will be decrease after power factor improved. This will saved the power consumption in magnetic ballast fluorescent lamp.

1.2 Problem statements

Based on the problem faced nowadays which is an increase in electricity rated, a research in conduct on other electricity usage that can produce the saving the power consumption In this project, power saving can be done by reducing total power consumption used by electrical appliance. Power consumption can be decreased with increasing power factor for all electrical appliance for instance at fluorescent lamp. The magnetic ballast at fluorescent lamp has the power factor as low as 0.5. Several model of magnetic ballast have a high quantity and concentration of winding within a piece of equipment reduces the power factor. In this project, magnetic ballast fluorescent lamp will be selected and all of its electrical parameter will be analyze such as starting voltage, current, steady-state condition, power consumption, power factor and harmonic. Power factor improvement will applied to the selected ballast model with addition suitable done of power factor correction.

1.3 Project Objective

These are the objectives of this project:

1. Identify the electrical model for selected type magnetic ballast fluorescent lamp.
2. To analysis the electrical parameter such as starting voltage, current, steady-state condition, harmonic, power consumption and power factor.
3. To design the power factor improvement for the selected type magnetic ballast fluorescent lamp.

1.4 Project Scope

These are the scope of this project:

1. This project is analysis on the selected three type of magnetic ballast, there are IL LEMAX, XR, EFR, LITE fluorescent lamp.
2. Electrical model of magnetic ballast will be calculated and simulated based on the measurement of actual referred model.
3. Measurement the parameter of magnetic ballast from the lab test and simulation based on the actual model.
4. Power factor improvement will be applied for each magnetic ballast model.

CHAPTER 2

LITERATURE REVIEW

2.1 Fluorescent Lamp

A fluorescent lamp can be defined as a low-pressure mercury-vapor electrical-discharge having the inside wall of glass bulb or tube coated with fluorescent material so that the ultraviolet (UV) radiation from the discharge of phosphor converted to visible radiation into the light of an acceptable color. Electrical energy dissipated in the electrical discharge is converted mainly into electromagnetic radiation in the ultraviolet (UV) region of spectrum [1]. The visible portion of the spectrum covers the wavelength range from approximately 380 nm to 780 nm as shown in Figure 2.1.

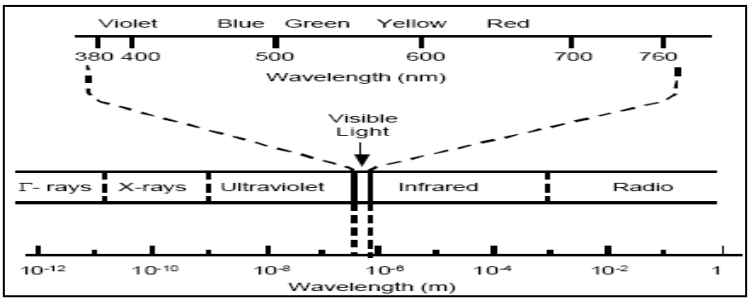

Figure 2.1: The electromagnetic spectrum [1]

2.1.1 Fluorescent Lamp Parts

Basically, a fluorescent lamp is made up of five components:

- Glass Tube - coated on the inside with fluorescent powder called Phosphor
- Two Electrodes (cathode) – coated with emitter, supported by a glass mount structure and sealed at the end of the tube.
- Filling Gas – usually a low-pressure of Argon or Krypton/Argon mixture.

- Mercury Vapor – small amount(less than 20mg), which vaporizes during the lamp operation.
- Lamp Cap – lamp cap cemented to each end of the tube to connect the lamp to the lighting circuit.

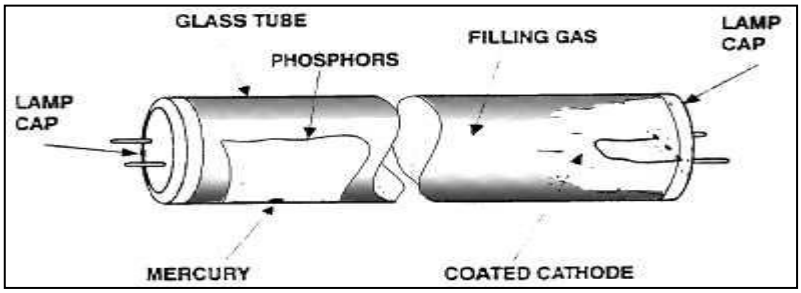

Figure 2.2: The fluorescent lamp [9]

2.1.2 Fluorescent Lamp Operation

When the circuit is energized, electricity heats the cathodes. See Figure 2.3. The cathodes are coated with material which, when heated, emits electrons. The electrons establish an electric arc between the cathodes at opposite ends of the tube. The electrons collide with the mercury atoms, causing mercury to emit invisible ultra-violet radiation [2]. The ultra-violet is absorbed by the phosphor coating on the tube and re-radiated as visible light.

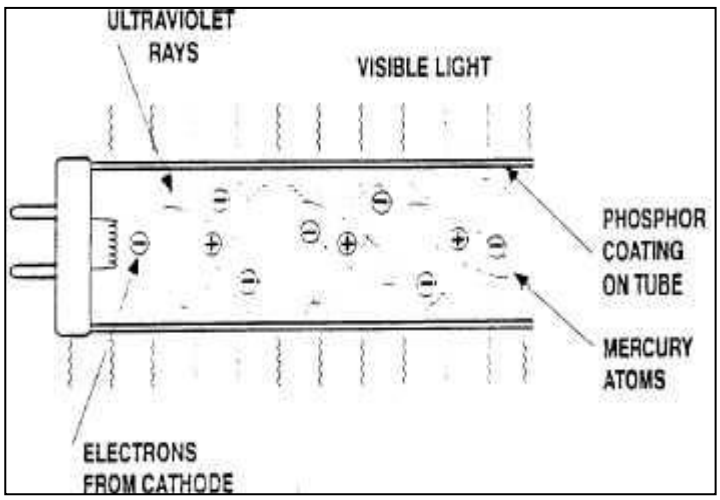

Figure 2.3: Structure of fluorescent lamp [9]

2.1.3 Fluorescent Lamp Circuit Operation

Figure 2.4 shows the basic fluorescent lamp circuit. The circuit must contain a ballast to limit the current and a starter to provide the pre-heat conditions. Initially the starter switch closes so the two cathodes are connected in series. Current flows and the cathodes heat up emitting electrons. After a short time the starter switch opens so voltage is applied across the tube. If sufficient electrons are available an arc is struck and the starter plays no further part until the next starting operation. If there are insufficient electrons, the tube will flicker, fail to start, and the starter will repeat the heating of the cathodes. The ballast limits the current to a safe and appropriate level for the power of lamp. Without the ballast, the current would increase to a high level and the lamp would destroy itself [9].

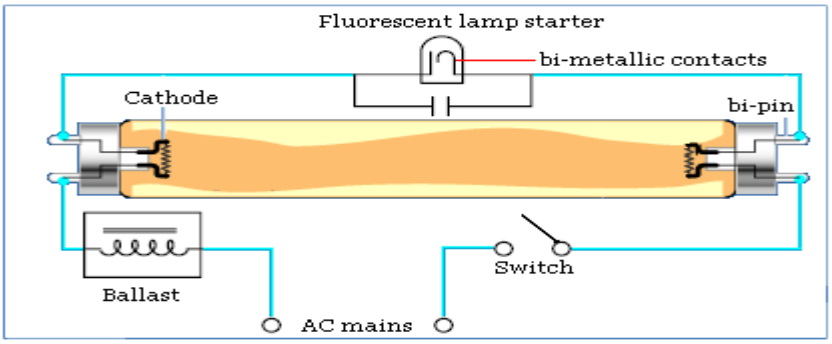

Figure 2.4: Circuit of fluorescent lamp [10]

2.2 Electrical Characteristic of Lamp

All fluorescent lamp and discharge lamps require suitable circuits and control gear or ballast components for starting and operation. The electrical characteristics and the behavior of such lamps are complex and depend on the type of circuit, the supply source, the design of the ballast components and sometimes the operating condition [2].

2.2.1 Lamp Starting and Run Up

i. Starting Voltage

A higher and normal voltage is required to initiate the ionization process in discharge lamps. If the supply voltage is insufficient the additional starting voltage may be generated by transformers, starting devices, semi-resonant circuits or pulse producing components. The voltage required for lamp starting may depend on the external temperature, humidity and any electric fields [2].

ii. Lamp run-up

The time of run-up depends on the lamp, the circuit and the ballast. Fluorescent lamp stabilizes in a very short time and gives full light output very shortly after starting. Discharge lamps containing only rare gas required no run-up time and the electrical characteristics do not change significantly after starting [9].

2.2.2 Lamp Running and Stability

i. Current runaway

In the arc discharge region the characteristics has a negative slope due to the cumulative effect of electron-atom collisions producing ionization. To prevent current runaway and ensure stable operation from a constant voltage power supply the negative characteristics must be counterbalanced by circuit element having positive characteristics. This element is called ballast [2].

ii. Alternating current operation

When operated on an alternating supply, the electrical properties of gas vapor discharge depend on the frequency and the type of ballast. The

effective impedance of the lamp is approximately equivalent to a non-linear resistance and an inductance in series.

2.3 Magnetic Ballast

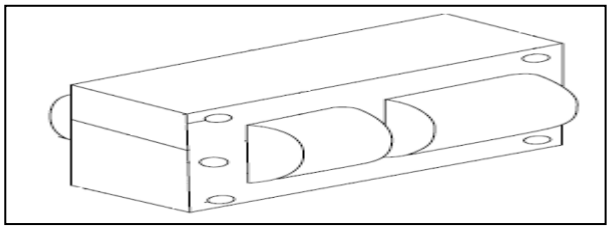

Figure 2.5: Magnetic Ballast

Magnetic ballast is device intended to limit the amount of current in an electric circuit. All fluorescent lamps require ballast for starting operation to generate the required starting voltage and during running condition for limiting the alternating current us the lamp impedance becomes very low during running. For higher-power installations too much energy would be wasted in resistive ballasts, so alternatives are used that depend upon the reactance of inductors, capacitor or both. All electromagnetic ballasts are basically inductor having core made up of iron laminations and winding made up of copper or aluminum wire [9].

- Component in magnetic ballast:
  - Inductor
  - Iron (Plat E & I)

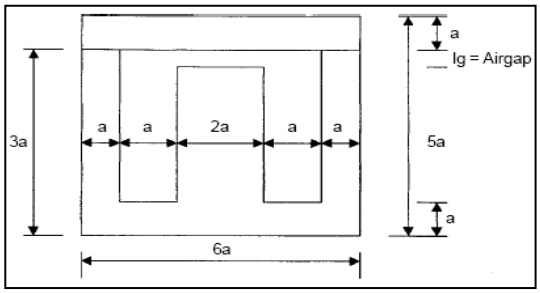

Figure 2.6: Connection Plat E & I [2]

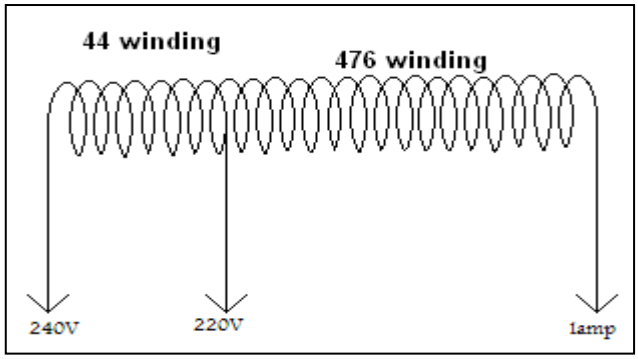

Figure 2.7: Winding copper at the Plat

The ballasts made to operate fluorescent lamp are not all the same. Each specific type of fluorescent lamp requires its own ballast design. Both the lamps and the ballasts are categorized according to the method by which they start and operate. The first fluorescent lamps were instants-started.

2.3.1 The Preheat Circuit

The preheat circuit was developed next as a way to reduce the ballast size, weight and cost. The lamp filaments are preheat prior to lamp ignition, but separate switching device is needed to start the lamp Most common used is referred to as the ‘glow bottle” starter.

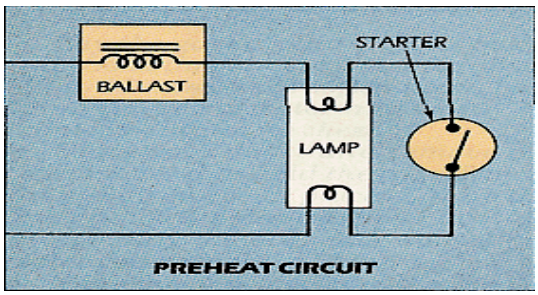

Figure 2.8: Pre-Heat circuit [9]

2.3.2 Lead-lag Switch

Almost at the very onset of fluorescent lamp usage, it was found desirable to operate two lamps from the same ballasts. One of the lamps is connected in series with an inductor, while the other is in series with a capacitor plus an inductor, which it still needed to help limit the current. The overall circuit will then provide a power factor close to unity.

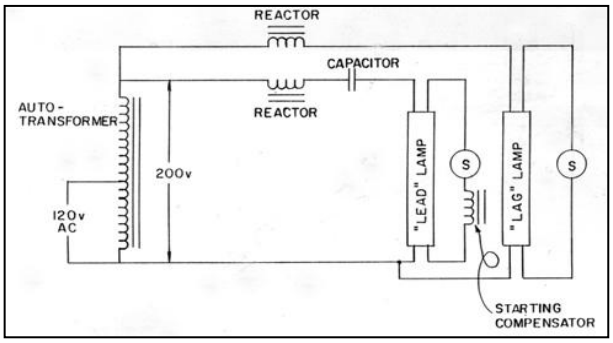

Figure 2.9: Lead-lag Switch for two lamps [11]

2.3.3 Series-connected magnetic Ballast

The series-connected choke ballast produces a phase displacement of 55 to 65 degrees between supply voltage and lamp current and this enables a hanger sustaining voltage to be available at the start of every half-cycle(Figure 2.11.a). Operation is more stable and the current distortion is low (Figure 2.11.b). The prime function of ballast is to prevent current runaway and to operate the lamp at its correct electrical characteristics. The ballast should be efficient, ensure proper lamp starting and ensure stable lamp run-up and operation. Supply voltage in the range 220-240 V, a nominal lamp voltage in the 70-145 V.

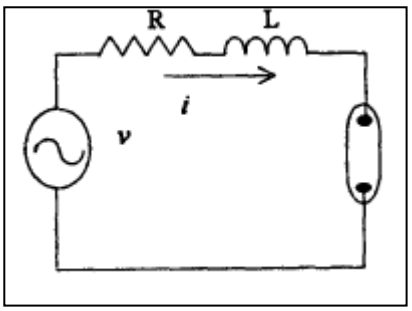

Figure 2.10: Equivalent circuit of series connected ballasts

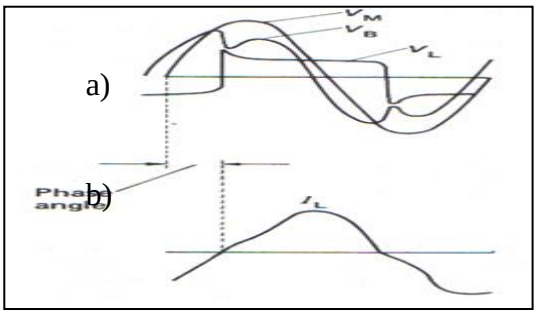

Figure2.11: Phase displacement of V_M (Supply), V_B (Ballast), and V_L (Lamp)

2.4 Starter of Lamp

A fluorescent light does not have the usual glowing filament of an incandescent bulb, but instead contains a mercury vapor that gives off ultraviolet light when ionized. The ultraviolet light makes particles that coat the inside of the tube, and these particles glow.

Figure 2.12: Starter of Lamp [9]

Fluorescent starters are used in several types of fluorescent lights. The starter is there to help the lamp light. When voltage is applied to the fluorescent lamp, here's what happens because the starter (which is simply a timed switch) allows current to flow through the filaments at the ends of the tube. Secondly, the current causes the starter's contacts to heat up and open, thus interrupting the flow of current and since the lighted fluorescent tube has a low resistance, the ballast now serves as a current limiter.

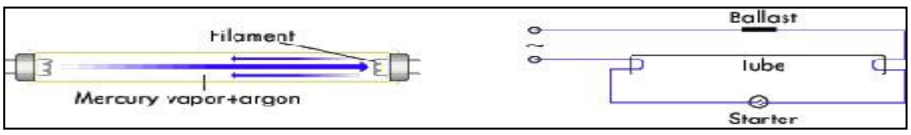

Figure 2.13: Place of Starter Lamp [9]