FINAL YEAR PROJECT REPORT

DEVELOPMENT OF SMART DRIVER FOR LED STREET LIGHTING

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"I hereby declare that I have read through this report entitle "development of smart driver for LED street lighting" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)"

Signature : ....

Supervisor's Name : Dr. Gan Chin Kim

Date : 25/6/2012

"I declare that this report entitle "development of smart driver for LED street lighting" is the result of 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 : ....

Name : JASPAL SINGH

Date : 25/6/2012

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ABSTRACT

This project is to design a LED lighting system that can adjust to darkness automatically and has a great potential to reduce CO2 emissions and save money. Many countries uses Light Emitting Diode, LED as street lights due to its low maintenance and long life span. This project shows LED is better than High Power Sodium (HPS) lighting system in term of energy efficiency, long life, smaller size and flexibility.

LED can adjust to darkness automatically by lighting up the number of LED lights operations vary depending on the operation hours, with this it save cost. LED lights are also known to be environmentally friendly products as they do not release any hazardous material such as mercury or lead, unlike HPS lights which are widely use as street lighting these days.

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CHAPTER 1

INTRODUCTION

1.1 LED Introduction

Light Emitting Diode (LED) is a type of semiconductor light source. LED had been introduced in 1962 and is increasingly used for lighting. LED can only operate in forward bias condition as the carrier which is electron and holes are able to recombine, thus releasing energy in form of photon. LED has many advantages over other types of light as it has low power consumption, long lifetime, small in size, and great reliability. LED also does not contain mercury or emit carbon dioxide gas. Due to its long life time and low maintenance, LED can be applied into street lighting system. The time for the LED to switch on or off are depending on the control system which can save more energy and costs. As costs in term of electricity bills and maintenance can be cut down drastically by using LED as street light, it definitely will save energy, and bring more profits in long term.[1]

1.2 Background of Project

Light Emitting Diode (LED) technology was developed rapidly in these current years. Research by research has been done make it possible for LED to be considered for replacing previous lighting technology such as conventional halogen and incandescent lamps in general illumination. For example in street lighting, because of wide spread adoption of this technology, LED has received more and more attention by the consumers. [1]

Besides all the attention that LED get, LED continuously growing its performances level such as providing high efficiency, good reliability and long operating life. LED also produced in variable colors. The high efficiency is due to the ability of LED to produce more light per watt compared to other lamps. Moreover, LED is nontoxic as it does not contain mercury contrasting from fluorescent lamps.

LED has gone through much improvement to become more reliable and adaptable. Nowadays, LEDs are being used increasingly and play important role in many daily applications. Users are eager to use LED because it is an energy saving technology and cost saving product as well.

1.3 Problem Statement

Current street-lighting system use High Pressure Sodium (HPS) system which cost more and also has high carbon emission. LED has no glare, the color temperature is comfortable, the objects that can been seen in LED street lighting look more clear than HPS street lighting, and people feel more comfortable.

Compared with conventional light each high power LED lamp saves more in expenses annually, and we will save RM 23,632.80 in 10 years.

1.4 Objectives of Project

To design a driver for LED lighting system (prototype) that can adjust to darkness automatically. The proposed system has a great potential to reduce CO2 emissions and save money.

1.5 Scope of Project

The scope of this project is to develop a prototype for LED street lighting system which can adjust to darkness and has great potential to reduce CO2 emissions. This prototype main circuit is the dimmer circuit which will dim according to darkness. In this project financial analysis will be performed to change HPS street lighting to LED street lighting and by using this prototype.

CHAPTER 2

LITERATURE REVIEW

This literature review explores the history of lighting technologies, characteristics efficiency and life time. It also shows the design of street lighting and while others are requirements that needed to complete this project.

2.1 Brief History of Lighting Technologies

Incandescent lamp practically were created in 1879, this early bulb use carbon filament which cannot operate at high temperature to produce needed light and it also has limited lifetime. In 1906 the first tungsten filaments were used commercially and further improvement includes the coiled tungsten filament which is filled in by an inert gas. Incandescent bulbs converts' electricity to lights has reached the light intensity just under 18 lm/w. [1]

In 1903 General Electric developed the low-voltage fluorescent lamp, apparently fluorescent was great potential for all-purpose lighting. Fluorescent technology are growing rapidly and the light intensity were well above 100 lm/w. [1]

In 1962, Holonyak with General Electric's Soled State Device research laboratory develop a red emitting GaAsP inorganic Led. In 1996, Nichia developed the first white

LED based on a blue monochromatic light. Today LED better than other light such as high intensity discharge technologies and fluorescent. [1]

2.2 Lighting Systems Characteristics

Lighting system characteristic involve:-

1. Efficiency and Lifetime
2. Choice of Lighting Technologies

2.2.1 Efficiency and Lifetime

Efficiency can be defined as a system that converts energy into preferred service such as hearing, transportation, light or cooling. Policymakers and consumers have concern on the quality of the light as well as the cost to buy it due to its performances. The main issues were to find the way to improve the efficiency of the light which will be converted from electricity and same time to find a cost-effective way, also with suitable color balance.

Luminous flux, which is measured in lumens, represents the light power of a source as real by human eye. A monochromatic light source that emits optical power of 1/683 W at 555 nm has a luminous flux of 1 lm. System efficacy and distance between lamps were obviously significant, because a high source efficacy doesn't always indicate the overall system efficacy. Figure 2.1 show the efficacies range for incandescent, fluorescent and LED sources. The center columns show the range of efficacies of commercial devices. The right Column shows overall system efficacy, the output light from the system per watt as same as 60Hz ac input power. The first and third Column shows ballast and fixture efficiencies. [1]

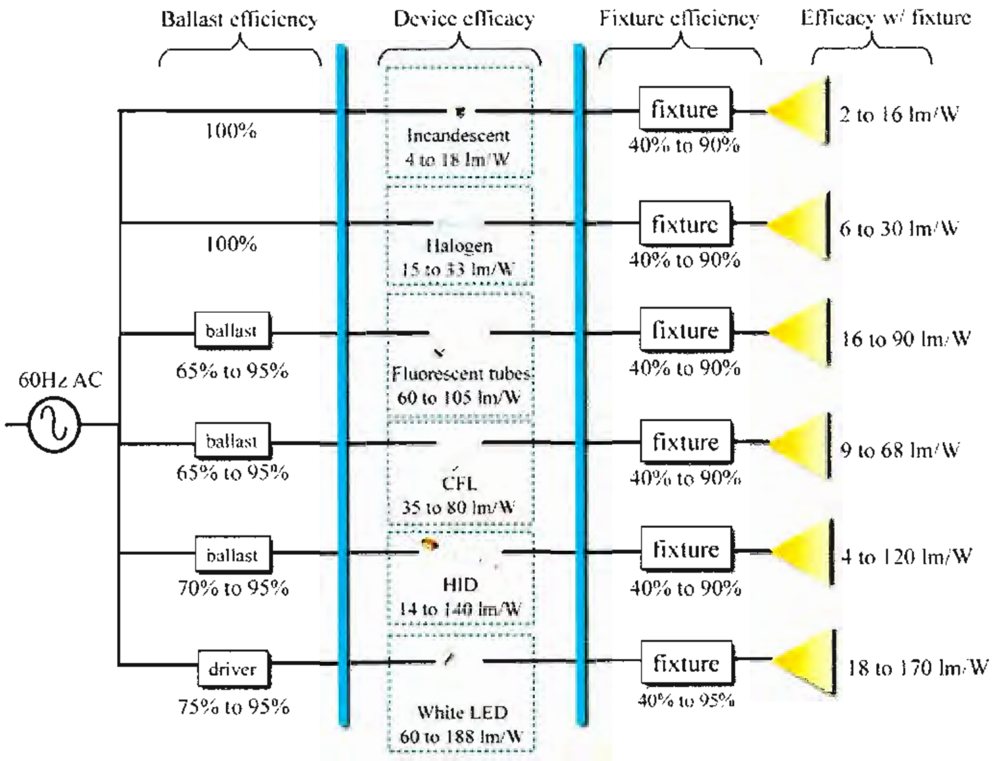

Figure 2.1: Fixtures and Efficacy of lighting device [1]

2.2.2 Cost for the Lighting

A number of ways can be used to find the estimated cost of the light supplied by all types of lighting system. All participants in the solid-state lighting program mostly refer to to the 'cost of light' metric and to the upfront cost .The cost for the lighting can be defined as

$$Cost\ of\ Light = \frac{10}{lamplumens} \times \frac{lamp\ cost + labor\ cost}{life\ time} + energyuse \times energy\ cost \qquad (1)$$

The lamp lumens is the output from the lamp which measured in lumen, the initial cost of the lamp is in RM/Lamp, and labor cost is necessary because it's used to replace the lamp, meanwhile lifetime in this calculation is the theoretical lifetime of the lamp in thousands of hours from the datasheet of the lamp, lastly energy cost is the electricity cost that been used by the lamp and this power consumption of the lamp is in W/lamp, and energy cost is the cost of electricity in RM/kWh. [1]

2.3 Design of a LED Street Lighting System

The most common approaches today if use high pressure sodium (HPS) as street lighting. These lamps currently provide the highest lumens per watt, 110 Im/W. High intensity discharge lamps that emit white light are ceramic metal halide and have an efficiency of 90 Im/W. However, these lamps take a long time to reach ideal operating temperature, are not easily dimmable and have a maximum useful operating life of 12,000 hours.

The recent emergence of ultra-bright, white, high-power LEDs brings the onset of a new approach to street lighting. LEDs have excellent reliability, instant turn on, dimmability, high operating hours (approximately 50,000) and good color rendering. Their efficiency is typically 90 Im/W in 2007, and manufacturers indicate that this value will improve. Yet an array of LEDs needs to be powered by an offline, power factor corrected, AC-DC converter.

Street lamps in Europe currently operate on average for 4000 hours per year. This equates, for a typical city of 18000 lamps, each of approximately 150W rating, to a consumption of 11GWh per annum. In the current climate of carbon emission quoting, this equates to 3.7 kilo Tons of CO2 per annum. [2]

2.3.1 Street Light Requirement

Street lights are subject to demanding conditions such as environmentally, electrically and optically. It is generally taken for granted that street light luminaries have to operate in all weather conditions, during large temperature variations, varying humidity, high wind speeds and must be immune to dust and insect ingress. Electrically, the luminaries should provide a high operating efficiency, a good power factor and system protection which meet the TNB standards and must adjust the current supplied to the light engine in order to control light output. [2]

2.4 Planned Lighting System

Number of LEDs that been used in the fixture is an important variable that need to be considered in the project of the lighting system, both design of the photovoltaic solar panels and battery bank are dependent to the number of LED. Following factor are important for the number of LEDs needed in the fixture:

1. Lamp to be replaced
2. LEDs model

2.4.1 Lamp to be replaced

High pressure sodium (HPS) currently install in the lighting system instead of LEDs. That is the reason, a clear design of LED lighting for street lighting cannot be found in the literature.

A case study were referred where, a 70W HPS lamp was replaced with LED street lighting, particularly an OSRAM lamp model Vialox Nav-E Standard, to a set of LEDs that produce same luminous efficiency.Other characteristics that is applied are as below: [3]

• Luminous flux = 5600lm.

• CRI ≤ 25.

• Average life = 28000 h.

• Fixture efficiency = 80%.

2.4.2 LEDs model

General method that used to obtain white light is by using a blue LED coated with phosphor that, when excited by the blue light, emits a broad range spectrum, producing the white light. By this method, LED color can be obtained and known as cool white, neutral white and warm white, by varying the amount of phosphor. The cool white LEDs are considered the most efficient in scotopic conditions, since they require fewer phosphors and produce light with wavelengths close to the peak of sensitivity of the human scotopic vision.

Usual Commercial LED available for 350, 700 and 1000mA and it is also depends on the total LED are install in a system, more LED need more current (nominal mean current for LEDs) [3]

Based on market analysis, the 700mA LEDs gives the lowest price per lumens, among the high power LEDs. So, the model Luxeon Rebel –Cool White Lambertian – 145 lm @ 700 mA was chosen for LED analysis. Important characteristics for the model choosen are: [3]

• Luminous flux = 145 lm.

• Average life = 50000 h.

• Fixture efficiency = 100%.

• Average power = 2.4 W.

2.5 Light Emitting Diode (LED)

Light emitting diode (LED) is a semiconductor type light source [4]. LED converts the electricity into light. LED has been introduced as practical electronic components in the 1960's [5] . The basic LED is the red, blue, and green LED. By controlling the current flow the each of them can eventually yields white light.

Although the LED is small in size, it can be grouped together to be used in high intensity application. LED is the best choice for single direction light. Nowadays, LED has becomes more rugged and more efficient compared to other light.

Figure 2.2 shows the structure and parts of a LED.LED parts consist of the case to protect all the components inside the LED, wire bond, semiconductor die and lead frame. The lead frame consists of anvil and post which represent the anode and cathode side.

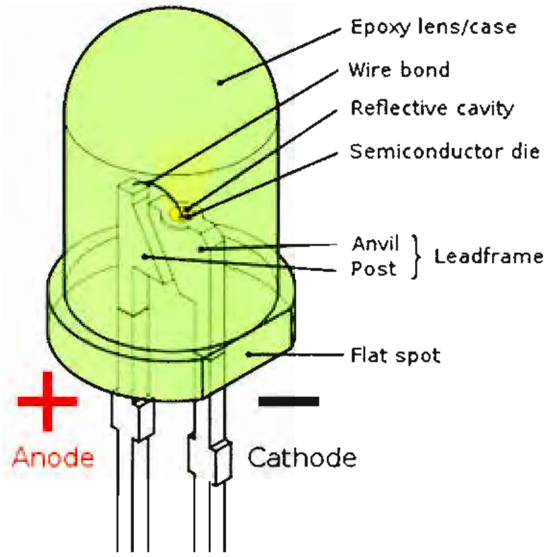

Figure 2.2: Light Emitting Diode (LED)

2.6 Types of LED

There are varieties of shapes and sized of LED as can in Figure 2.3 the most commonly produced LED is the 5 mm cylindrical package. Miniature LED, high power LED, and medium power LED are the main types of LED produced.

The miniature LED comes in different sizes from 2 mm up to 8 mm. It is single die LED that commonly being used as indicator. Usually, miniature LED produced in simple design that it doesn't required any separate cooling body. The typical current rating for miniature LED is from 1 mA up to 20 mA [4].

The high power LED can be lighten up from current of hundreds of mA up to more than 1 A. Since it is driven at high current, overheating cannot be avoided. Therefore, high power LED must be provided or mounted with heat sink to allow the heat to dissipate. If not, the high power LED can be burn out in seconds due to overheating.

Usually, single high power LED is being used to replace incandescent bulbs in a torch or other system in array to get full performance or lumens from the LED.

The medium power LED is used when a few lumen output is needed. For better heat conduction, sometimes the medium power LED has diode mounted to four leads which are two cathode leads and two anode leads. The application of this LED can be found in automotive tail-light, traffic light, and emergency lighting.

LED can carry high current due to large amount of metal in the LED. This high current is needed for higher lighting output especially for emergency lighting and tail-lights [4].

Figure 2.3: Types of LED

2.7 High Pressure Sodium Lamp

The high pressure sodium (HPS) lamp is the family of high intensity discharge (HID) lamp [6]. It was developed and introduced in 1968 for many lighting applications. The HPS lamp consists of a compact arc tube filled with xenon, sodium and mercury. When a voltage is supplied, the xenon gas facilitates striking the arc which eventually produces heat that vaporized the sodium and the mercury. As the arc tube has sufficient pressure, the sodium vapor will produces light. In order to produce light, HPS lamp used about 29% of energy.

The disadvantage of HPS lamp is that the arc must be cooled down in order to strike again. The re-strike period last about one to two minutes which also depending on the type of HPS being used.

Figure 2.4: High Pressure Sodium Light

2.8 Comparison between LED and High Pressure Sodium Light

Table 2.1 shows the comparison between LED and HPS, it also shows the working life, power consumption and etc. This table shows the reason to choose HPS.

Table 2.1: Comparison between LED and HPS [7]

Items	High Pressure Sodium Light	LED Street Lighting
Photometric Performance	Bad	Excellent
Radiator Performance	Bad	Excellent
Electric Performance	Electric Shock Easy (High Voltage)	Safe (Low Voltage)
Working Life	Short (5,000 hours)	Long (>50,000 hours)

Working Voltage Range	Narrow (±7%)	Wide (±20%)
Power Consumption	Quite High	Quite Low
Startup Speed	Quite Slow (Over 10 minutes)	Rapid (2 seconds)
Strobe	Yes (Alternating Current Drive)	No (Direct Current Drive)
Optical Efficiency	Low	High
Color Index / Distinguish Feature	Bad, Ra <50 (The Color Of Object Is Faith, Boring, Hypnosis)	Good, Ra >75 (The Color Of Object Is Fresh, Veritable And Comfortable)
Color Temperature	Quite Low (Yellow Or Amber , Uncomfortable)	Ideal Color Temperature (Comfortable)
Bad Glare	Strong Glare (Dazzle)	No Harmful Glare
Light Pollution	Strong	No
Heating	Serious (>300°C)	Cold Light (<60°C)
Lampshade Turn Dark	Easy (Absorb Dust)	No (Static Proof)
Lamp Aging Turn Yellow	In A Short Time	No
Shockproof Performance	Bad (Fragile)	Good (No Filament Nor Glass)
Environment Pollution	Contains Lead Element Etc.	No
Maintenance Cost	High	Quite Low
Product Cubage	Big	Small (Slim Appearance)
Product Weight	Heavy	Light
Cost-Effective	Low	High
Integrated Performance	Bad	Excellent