DEVELOPMENT OF STREET LIGHT ENERGY SAVING USING ARDUINO

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation) with Honours

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2015

I hereby declare that I have read through this report entitle "*Development of Street Light Energy Saving Using Arduino*" and found out that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)"

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I hereby declare that this report entitle "*Development of Street Light Energy Saving Using Arduino*" 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 : NOOR ADLIA SYUHADA BINTI MAAMIN

Date : …………………………………………

To my

Beloved Father and Mother

Hj.Maamin bin Dollah and Hjh Rusnani binti Asan,

My respectful Lecturers,

Also my faithful friends

ACKNOWLEDGMENT

Assalamualaikum w.b.t.

All praises be to Allah, Lord of the Universe, the Merciful and Beneficent to Prophet Muhammad S.A.W, His Companion and the people who follow His path. First and foremost, I would like to thank Almighty Allah because only by his will, I had finally finished preparing this FYP thesis for this semester. I would like to take this opportunity to express my sincerely gratitude and appreciation to my parents and my family for the support.

The special thank goes to my helpful supervisor, Mr. Ahmad Fairuz bin Muhammad Amin for her guidance, support, advice, and time during the completion of my project. Without their continued support and interest, this project would not have been same as presented here.

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ABSTRACT

The large quantity of electricity of many countries is consumed in lighting the streets. Most of basic street lighting systems are switched ON/OFF at regular intervals of time. In this thesis, the system is to develop a street light energy saving control system to reduce energy if no vehicles pass through certain roads. Logically, this system may save a large amount of the electrical power. In addition, it may increase the lifetime of the lamps and reduce the pollutions. Operation of this system is to maintain the intensity of street lighting to 40% of the maximum intensity if no vehicles passing through the road. When the PIR sensor detects movement of the vehicle, block the street lights will be switched to 100% intensity. Arduino microcontroller has been used as a controller for the project. In addition, among other components used for this system is PIR sensor and current sensor. PIR sensor functions as a vehicle detector will be send a signal to the arduino will be control the intensity of the LED while the current sensor is used as the current detector LED lamp. The prototype for the street lighting energy saving control system is also has safety usage that is the light will not turn OFF completely but only dimming and the user can easily see from far away and the light will full turn ON if it detecting movement. The system has shown a great energy savings and if the system can be upgrade with many functions and user friendly the system can be commercialize and the cost for retrofitting the street lighting energy saving control system can be lowered.

ABSTRAK

Kuantiti besar tenaga elektrik di kebanyakan negara digunakan pada lampu jalan. Kebanyakan sistem lampu jalan asas beralih ON / OFF pada selang masa yang tetap. Dalam tesis ini, sistem ini adalah untuk membangunkan satu sistem kawalan penjimatan tenaga lampu jalan untuk mengurangkan tenaga jika tiada kenderaan melalui jalan-jalan tertentu. Secara logiknya, sistem ini boleh menyimpan sejumlah besar kuasa elektrik. Di samping itu, ia boleh meningkatkan jangka hayat lampu dan mengurangkan pencemaran. Operasi sistem ini adalah untuk mengekalkan keamatan lampu jalan 40% intensiti maksimum jika tiada kenderaan yang melalui jalan raya. Apabila sensor PIR mengesan pergerakan kenderaan, menghalang lampu jalan akan beralih kepada keamatan 100%. Mikropengawal Arduino telah digunakan sebagai pengawal untuk projek tersebut. Di samping itu, antara komponen lain yang digunakan untuk sistem ini adalah sensor PIR dan sensor arus. PIR sensor berfungsi sebagai pengesan kenderaan yang akan menghantar isyarat ke Arduino yang akan mengawal keamatan LED manakala arus sensor digunakan sebagai pengesan arus lampu LED. Prototaip bagi sistem kawalan tenaga penjimatan lampu jalan juga mempunyai penggunaan keselamatan yang ringan tidak akan berubah OFF sepenuhnya tetapi hanya ‘dimming’ dan pengguna boleh melihat dari jauh dan cahaya penuh akan bertukar ON jika ia mengesan pergerakan. Sistem ini telah menunjukkan penjimatan tenaga yang besar dan jika sistem boleh menaik taraf dengan banyak fungsi dan mesra pengguna sistem boleh dikomersialkan dan kos untuk mengubah suai sistem kawalan lampu jalan penjimatan tenaga boleh diturunkan.

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CHAPTER 1

INTRODUCTION

1.1 Overview

In this section will give a short introduction of the project. Some explanations about a development of street light energy saving will be considered to acknowledge the system. The problem statement, objectives, scopes and the project outline for the whole project are clearly explained in this chapter.

1.2 Project Motivation

Smart cities and green technology are becoming one of the world agenda in preparing for a better future. The smart street lighting system is one of the technologies that support green environmental related work. The technology that evolves with the advance in wireless communication and low energy street light has become the foundation in the development of smart cities [1].

Apart from supporting works toward better future, smart city technologies allow improvement in the area of response and maintenance where failures or breakdowns within the deployment area is almost real time detectable, allowing immediate response from the respective person.

Street lighting is one of the important parts of a city's infrastructure where the main function is to illuminate the city's street during the dark hours of the day. There are several factors that should be considered for the design of road lighting systems, such as a safety night for members of the public and other road users, provide public lighting at a cost effective, reduce crime and reduce its impact on the environment.

Generally, street light is switched on for the whole night and during the day the street light is switched off but during the night time, street light are not necessary if there is no traffic user. Saving of this energy consumption is a very important factor these days as energy resources get reduced day by day. Alternatives for natural resources are very less and our next generations may face lots of problems because of lack of these natural resources [2].

Photoelectric control unit (PECU), wireless control system by using ZIGBEE, Programmable Logic Controller (PLC) controller circuit and microcontroller programming control system is the previous automatic control system that has been used. All this technique will be operated based on the decreasing or increasing of light level. The system was declared either to switch on or switch off the street lamp. The previous control system sometimes it does not operate efficiently due to less sensitivity of the light, problem to the receiving part of the wireless system and imperfect time to switch on and switch off the street lamp. Based on the consideration of previous work and street lighting problem, the improvement of street lighting control system was proposed by using Arduino microcontroller system. The Arduino microcontroller system has some advantages such as inexpensive, easy to run the programming, simple and clear programming environment, have open source and extensible software and also have extensible hardware. This is the reason why Arduio microcontroller has been choosen as the controller for the system. Arduino microcontroller system is the device that can very fast and capable of running thousands of lines of code each seconds [3].

1.3 Problem Statement

It is very common to see the street light alight all night, which is a great waste of energy. The power consumption is relatively high day by day. Some streets are not fully occupied like the main city streets; sometimes they are empty for a certain period time. For example, the highway towards the main entrance of Universiti Teknikal Malaysia Melaka (UTeM), only during the day it fully utilized but at night the road less user. In addition, the route along the main road and hostel at the main campus also underutilized at night.

Based on the problem, the observation of street lighting was done to improve the street lighting control system to make sure the street light can operate properly. By applying this system, it can reduce energy consumption and also can reduce electricity wastage. Therefore it is important to know the ways how to minimize the power consumption of the street light.

1.4 Objectives

There are several objectives for this project which are:

1. To build an intelligent street lighting system equipped with vehicle presence sensors.

2. To provide a better solution to reduce electricity wastage in controlling street lights by using Arduino microcontroller and reduce the power consumption of the street lighting.

1.5 Scope of the Project

This project focuses on the development of street lighting energy saving in the areas of UTeM. The focus is more on the low road users such as road at the main campus UTeM that requires the speed below 30km/h. Besides, the project is to save energy consumption by dimmed the Led light and the Arduino Uno will be main the controller for the system. This system is to reduce energy if no vehicles pass through certain roads and this system also will control the intensity of the street lighting to the minimum intensity if no vehicles passing through the road but when the sensor detect movement of the vehicle the street light will be switched to maximum intensity.

1.6 Thesis Outline

The street lighting energy saving control system by using Arduino thesis was described about the problem that always occur and the new design or improvement of street lighting based on the street lighting control design. All of the detail about this project was defined in every chapter of this thesis as shown below.

Chapter 1: In this section will give a short introduction of the project. Some explanations about a development of street light energy saving will be considered to acknowledge the system. The problem statement, objectives, scopes and the project outline for the whole project are clearly explained in this chapter.

Chapter 2: This chapter will discuss about sources or articles that related to the project. There are many sources or researchers done before and from there details about this project are known and can understand briefly about the project. In this chapter the theoretical background, literature review of previous work, and the summaries about the previous work will be covered.

Chapter 3: This chapter will discuss on steps involve completing the project. There are several steps to be applied in designing street light energy saving. This part provided of project flowchart, methodology that being used and the explanation about hardware and software for this project.

Chapter 4: In this section will shows the result obtained that have been achieved throughout the whole semester. In this section also will show the result of the project based on the software and hardware testing.

Chapter 5: This chapter will describe about conclusion and recommendation for the street lighting energy saving control system. This section includes project summary, project finding and further recommendation to improve the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will discuss about sources or articles that related to the project. There are many sources or researchers done before and from there details about this project are known and can understand briefly about the project. In this chapter the theoretical background, literature review of previous work, and the summaries about the previous work will be covered.

2.2 Theory and Basic Principle

2.2.1 Street Light Control System

For the installation of street lights in Malaysia, street lights must be designed in accordance with the criteria and specifications set by the Public Works Department. Type of light, type of lamp posts and distance between the light pole installations must follow the guidelines that have been specified. For example, according to LS-20 (refer to appendix C) the distance between the poles must between 40 meter to 50 meters. The purpose of street lighting is to allow the road users to travel safely. Street light also to allow pedestrians to see hazards, orientate themselves, recognize other pedestrians and give them sense of security. The street light was designed to make all the road junctions and roundabouts must be clearly visible from a distance for road users to recognize other vehicles. Street lights also to improve the night time appearance of the environment. Street lights must be selected according to the correct category of road to provide sufficient light that suitable to the road user [4].

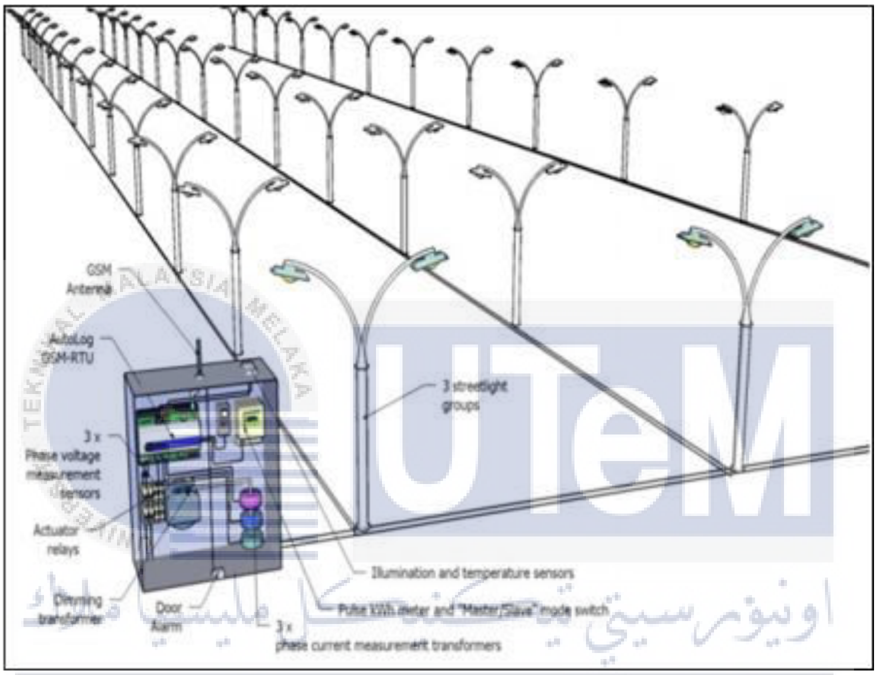


Figure 2.1: Street light control system architecture [15]

One of the examples that exist in the market for automatic lighting control are Manual dimming, Photo sensors, and Occupancy Sensors, Clock switches or timers. Manual dimming control allows space to adjust the light output or lighting. This can lead to energy savings by the decrease input power, as well as a reduction in maximum power demand and improved lighting flexibility.

In the Philippines, the manual operation of lighting in different establishment, schools, roads and recreational areas are being replaced by automatic switching system. Street light in some part of Metro Manila has photo sensors attached to it, that will automatically turns the light ON and OFF. Other street lights are installed on a programmable timer which controls the switching of light from dusk until dawn but in other areas are still on the manual switching using a panel switch.

Street light in the city of Iloilo is controlled by a timer, which is preset by an operator to its desired time. In other areas there is also a street light that uses a photo sensor as a switch. The Central University of the Philippines, every street lamp located on the campus has its own photo sensor mounted on it [5].

2.2.2 Street Lighting Technology Comparison

Nowadays, there are various types of lighting technology such as incandescent light, metal halide, mercury vapour, high pressure sodium, low pressure sodium, fluorescent, compact fluorescent, induction and LED. The street lighting technology can be classified according the type of lamps, lamp service life, luminous efficiency, ignition time and their consideration.

Table 2.1: Lighting technology comparison based on luminous efficiency, life time and their consideration [9].

Light Technology	**Life time**	**Lumens per watt**	**Ignition time**	**Considerations**
incandescent light	1000 -5000	11 - 15	instant	very inefficient, short life time
mercury vapour light	12000 - 24000	13 - 48	up to 15 min	very inefficient, ultraviolet radiation, contains mercury
metal halide light	10000 - 1.000	60 - 100	up to 15 min	high maintenance UV radiation, contains mercury and lead, risk of bursting at the end of life
high pressure sodium light	12000 - 24000	45 - 130	up to 15 min	low CRI with yellow light, contains mercury and lead
low pressure sodium light	10000 - 18000	80 - 180	up to 15 min	low CRI with yellow light, contains mercury and lead
fluorescent light	10000 - 20000	60 - 100	up to 15 min	UV radiation, contains mercury, prone to glass

				breaking, diffused non-directional light
compact fluorescent light	12000 - 20000	50 - 72	up to 15 min	low life / burnout, dimmer in cold weather (failure to start), contains mercury
induction light	60000 - 100000	70 - 90	instant	higher initial cost, limited directionality, contains lead, negatively affected by heat
LED light	50000 - 100000	70 - 150	instant	relatively higher initial cost

In term of energy saving, LED lighting is the best way to be installed due to its characteristic in 40% - 80% energy consumption. LED street lights can efficiently replace High Intensity Discharge (HID) lamps with numerous advantages such as long life time, high lumen per watt and do not have long warm-up times. Apart from that, the light from LED shines at full brightness as soon as the switch is turned on and can be dimmed for added energy saving during low traffic.

Figure 2.2: The different lighting between HPSV lamp and LED lamp [16]

2.2.3 Type of Street Light

a) High Pressure Sodium Vapor (HPSV)

High pressure sodium vapor (HPSV) lamps are a member of the high intensity discharge (HID) lamp family. HPSV were developed and introduced in 1968 as energy-efficient sources for exterior, security, and industrial lighting applications, and are particularly prevalent in street lighting applications.

In a HPSV lamp, a compact arc tube contains a mixture of sodium, mercury and xenon. The xenon gas is easily ionized and facilitates striking the arc when voltage is applied across the electrodes. The heat produced by the arc then vaporizes the mercury and sodium. The mercury vapor raises the gas pressure and operating voltage and the sodium vapor produces light when the pressure within the arc tube is sufficient. High pressure sodium lamps are the most efficient artificial white light source with about 29% of the energy used by the lamp producing light.

Figure 2.3: 400W High pressure sodium vapor Lamp Street light [6]

Due to their high efficiency and long life, today's HPS lamps are also suitable for interior applications, particularly where color rendering is not a crucial concern [6]. However, the light produced by HSPV is a golden white color which is may not be suitable for certain applications. Besides, the HSPV lamps also need a ballast to operate and take five to ten minutes to reach full light output. They also require at least a one minute cool-down to re-strike and end of life is characterized by on-off-on cycling; continued operation can damage the lamp ballast if not replaced quickly.

b) Light-Emitting Diode (LED)

Light emitting diodes (LEDs) were first developed in the 1960s, but only in the past decade LEDs had sufficient intensity for use in more than a handful of lighting applications (Stringfellow and Craford 1997). LEDs are a relatively old technology that has advanced from use in numeric displays and indicator lights to a range of new and potential new applications. LEDs currently dominate the exit sign market and many cities have adopted them as a replacement for incandescent lamps in traffic signals and street light. In the architectural market, the development of a visible/white light LED has awakened lighting designers to new possibilities with this light source.

LED has the potential to be more energy efficient and last far longer than most current lighting technologies. Besides, LED considered environmentally friendly, since they contain no mercury, and the visible light applications for home or business do not emit infrared (IR) or ultraviolet (UV) light. LED produces very little heat, and their lifetime is not affected by frequent on/off switching. The cost of materials needed to make LED lighting has plummeted in the past several years. Although LED remains more expensive than their counterparts, their prices are steadily declining. The others benefit

Another benefit of LED is that LED lights can be turned ON immediately without having to wait five to ten minutes to reach full light output like HPSV and LED also can be easily dimmed.

Figure 2.4: 60W LED Street light [7]

2.2.4 Energy Saving

According to a study, 40 per cent of the city's energy budget is spent on street lights, and street lights emitting 200 kg of CO2 per year, the impact on the environment is important. Power saving, carbon reduction, lower operating costs and a general push by state and local governments for greener cities are all driving application advanced network technology controls [7].

In several industries, lighting contributes more than 60 percent of the electricity bills for the facility and 40 percent of the total energy bill. Additional indirect costs such as increased load on the cooling system and increased maintenance of lighting systems can make the total bill would be higher. Lighting controls may consist of simple wall switch for dimming complex combined systems with other building systems. Every lighting control system has a unique set of capabilities and price points.

Refering to the website of Tenaga Nasional Berhad [8], the current tariff rate for street lighting including maintenance is 30.5 cents / kWh. If 1000 full-brightness LEDs used in the past 12 hours, the RM 5935 is required to be expended. However, if the brightness decreases to 40% over 6 hours, it can save up to RM 2377.

2.2.5 Arduino Uno

Arduino is an open source electronics prototyping platform that is used by an expert to beginner programmer. The aim of Arduino is to provide flexible, easy to use hardware and software. The programming language for the Arduino is controlled by a set of C or C++ functions.

The Arduino Uno is a microcontroller board based on the ATmega 328. It has 14 digital inputs and output pins which are 6 pins from the 14 pins can be used as Pulse Width Modulation (PWM) output and another 6 pins can be used as analog inputs. The Arduino Uno contains everything needed to support the microcontroller. To start the microcontroller, simply connect the Arduino to a computer with a USB cable [3]

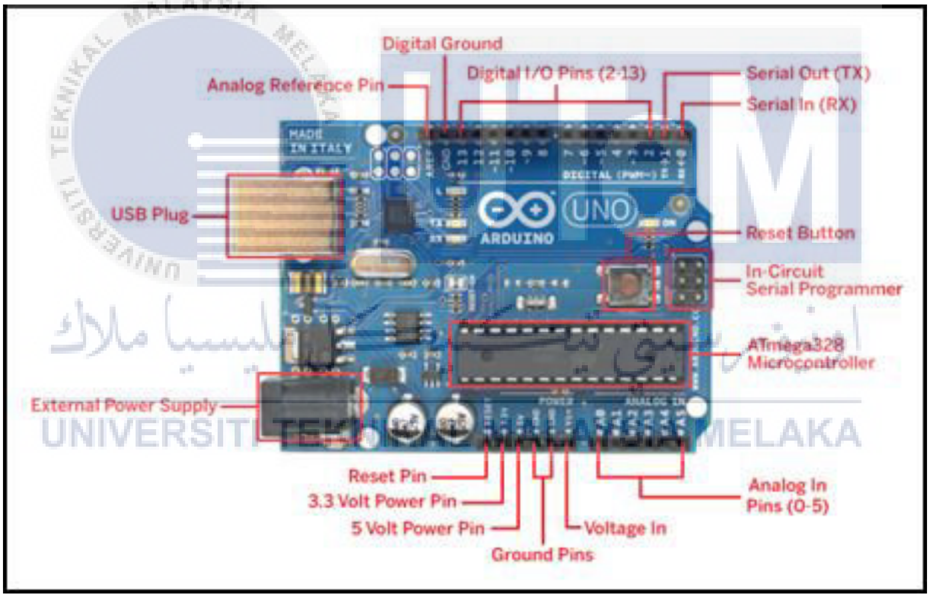


Figure 2.5: Arduino Uno Board [3]

2.3 Review of previous related works

There are many types of street lighting control system that was proposed in the past project. Gustavo W. Denardin [10] deals about a control network for an LED street lighting system. Due to the longer lifetime, higher luminous efficiency and higher Color Rendering Index (CRI) the LEDs are being considered promising solution for modern street lighting system. From the proposed control network, it enables disconnection of the street lighting system from the mains during peak load time, reducing its impact in the distributed power system automatically consumption, decline the management cost and can observe the status information of each street lighting unit.

Nevertheless, due to well-known weakness of the existing techniques, a novel routing algorithm is proposed. The acquired experimental results show that the proposed control network is able to meet the specification of an LED street lighting system. It mainly deals about safer roadways with an intelligent light system to reduce power consumption. The system has automatic street light intensity control based on vehicle movements and switch ON or OFF the street lights depending on light conditions. This will help in reduces power consumption during low-use roads. Consequently street lamp module installed for each specific distance.

RadhiPriyasree [11] describes the system used to reduce the power consumption street lights to avoid inefficient lamps that can cause a great waste of financial resources each year. For this purpose dimming lights during low traffic have been done by placed the PIR sensor that can detect any movement of vehicles. This project purpose to reduce road accidents and road fatalities caused by alcohol consumption. This is done using breadth sensors inside the vehicle and also using skin sensors placed on vehicle doors. By implementing this death rate due to drunken driving can be reduced to a great extent. The prototype has been implemented and works as expected and will prove to be very useful and will fulfil all the present constraints if implemented on a large scale. This plan will help the government to save energy and meet the needs of domestic and industrial.

In SomchaiHiranvarodom [12] project, he describes a comparative analysis of photovoltaic (PV) street lighting system in three different lamps. Namely, a low pressure sodium lamp, a high pressure sodium lamp and a fluorescent lamp have been used for installation in each mast to determine the suitable system to install in a typical rural area of

Thailand. All three systems have been mounted with the same module type and wattage in different places within the Rajamangala Institute of Technology, Thanyaburi district, Pathumthani province of Thailand. An operation of solar street lighting system can be divided into 2 periods of time, namely, at 18.00-22.00 hours and 05.00-06.00 hours. The design of a control circuit was experimentally done in this work.

In energy efficient street lighting control project by S. Vijaya kumar and S.Kartthik Srinivas [2012] proposed to design a street lighting control system based on ZIGBEE wireless technology that involving ZIGBEE coordinator, ZIGBEE end-node interfaced with a microcontroller (ATMEGA16). ZIGBEE is a low power spin off of WIFI. This type of WIFI was used for specification for small, low power radios based on IEEE 805.15.4-2003 for Wireless Personal Area Network Standard. The function of ZIGBEE end-node is a reduced functional device (RFD) that can only transmit or receive short messages but cannot route it. The coordinator is a full functional device (FFD) that would be functioning as a main component of the ZIGBEE function. The microcontroller was interfaced with a GSM modem to achieve long distance communication. The street lighting can be monitored and controlled from centralized area by Dual Tone Multi Frequency (DTMF). Street lighting also can be controlled remotely via cell phone that was installed a suitable street lighting application. Brightness of the street lighting also can be control by using dimmer control that adjust respect to surrounding ambient using light depending resistor (LDR) at the microcontroller side [13]. The disadvantages of this street lighting control system are ZIGBEE systems require an expensive costs for installation. The wireless system of this system is not secure and can be interrupted by the disturbance signal.

Lastly, in automatic street lighting using PLC project by V.V.S Madhuri, P.Mallikarjuna Sarma and M.N.Sandhya Rani [2013], PLC was proposed for street lighting control system design. This project used XD26 PLC controller. The street lighting control system operated automatically based on the sunlight that sense by the LDR, which play the major role in this project. In the other word, the output of the LDR is taken as an input of the PLC. When the LDR sense the change of light, the PLC control will operate to decide between to switch on or off the street lamps [14].

2.4 Summary and Discussion of the Review

Based on the study that have been done, there are so many technologies and techniques now exist to make the street lighting system more economical and reduce the power consumption. From the first review, due to the longer lifetime, higher luminous efficiency and higher CRI the LEDs are being considered promising solution for modern street lighting system. Furthermore, a wireless sensor network can monitor the street light system and it can reduce maintenance cost in case have a major problem with the street light. From the second review, by dimming the lights during low traffic hours the power consumption of the street light can be reduced. Passive Infra-Red (PIR) is used to detect motion or any movement. This project purpose to reduce road accidents and road fatalities caused by alcohol consumption. By implementing this death rate due to drunken driving can be reduced to a great extent. The prototype has been implemented and works as expected and will prove to be very useful and will fulfil all the present constraints if implemented on a large scale. This plan will help the government to save energy and meet the needs of domestic and industrial. From the third review, the various types of lamps have been used in order to analyze the data. A type of lamps used is a low pressure sodium lamp, a high pressure sodium lamp and a fluorescent lamp. Each lamp has been used to determine the suitable system to install in a typical rural area. From the fourth review, the ZIGBEE wireless technology system was connected to the microcontroller that the input of the microcontroller is LDR respect to surrounding ambient. The dimmer of the street lighting was control by ZIGBEE end-node that connected to the dimmer control. All the operation such as to switch on, switch off and adjust brightness of the street light after the GSM modem sense the short message system (SMS) to the cell phone. The wireless control systems operate poorly when the system has signal disruption that caused by rain or disruption from other signals. From the fifth review, the street lighting control that used PLC control is the simple circuit of the control system and it also can be implement by using a relay. This system also used LDR to operate the PLC control system. It depends on light changing to declare whether to switch on or switch off the lamp. The advantages of this method are this system not suitable for large area or large amount of data such as to connect at the street lighting control panel that control more than one lamp.

In conclusion, the street lighting control systems need some improvement to solve this entire problem. It is because the failure of control system can cause the street lighting not lit or running during the day and also cause energy wastage. The improvement of street lighting control system that was purpose in this project is street lighting control system by using Arduino microcontroller system. It is because the Arduino microcontroller easily to program. Arduino microcontroller have a small size that easily to combine inside the street lighting connection inside the lantern and also good for the prototype design. It also built-in USB connection and power jack and also have many port.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Overview

This chapter will discuss on steps involve to completed the project. There are several steps to be applied in designing street light energy saving. This part provided of project flowchart, methodology that being used and the explanation about hardware and software for this project.

3.2 Project Flow Chart

The flow chart for the overall project is shown in Figure 3.1 and Figure 3.2. The flow chart consists of two stages which are stage 1 for FYP 1 and stage 2 for FYP 2. In FYP 1, the project was started by doing some observation of previous work and some review about street light energy saving control system by journal and reference books. After that, the project proceeded with an example of some basic coding for control the street lighting such as LED blink, dimmers and automatic street light control using photocell.

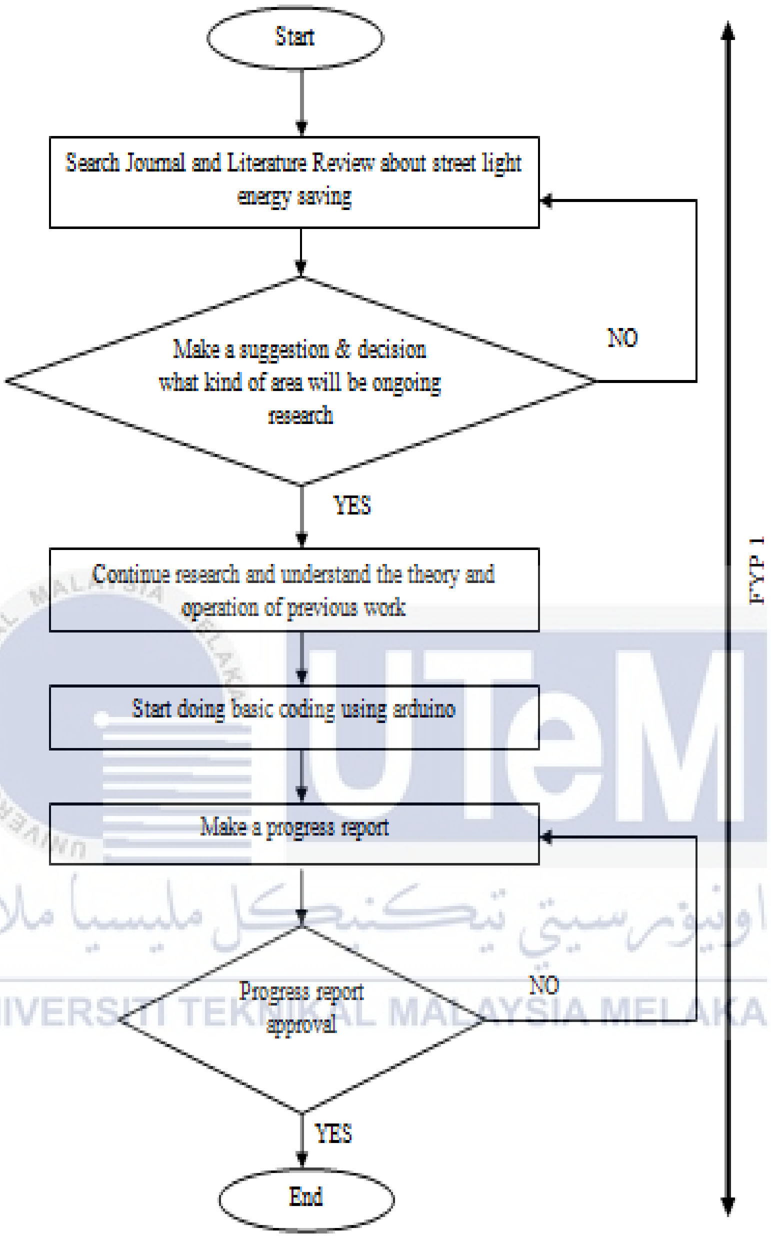


Figure 3.1: Flowchart for final year project 1

In FYP 2, this project was started by studied and understood the fundamental of a technique or method for street light energy saving control system. The street lighting control system programming was simulated by using Arduino IDE software. When the programming has been successful, the projects continue with design and test the circuit diagram using Proteus software. After that, this project was continued to design and testing the prototype of the street lighting energy saving control system. If the prototype of street light energy saving control system was functioning properly, this project will continue by writing a report. If the prototype isn't functioning well, the street lighting, energy saving control system will be redesigned until the testing successful.

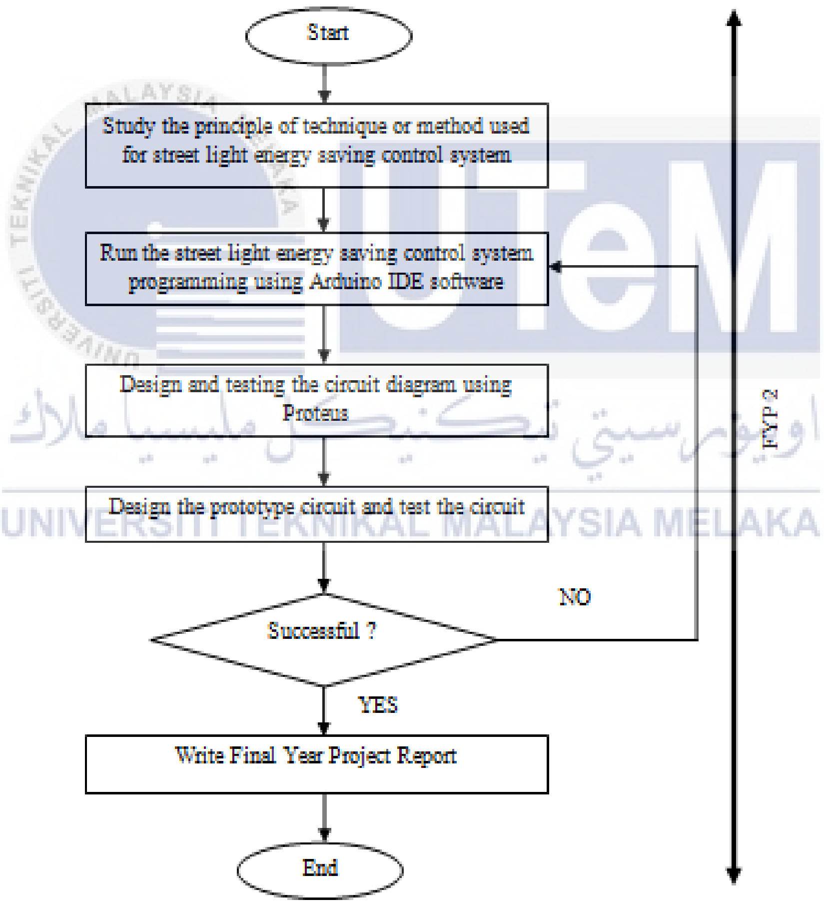


Figure 3.2: Project flowcharts for final year project 2 covering overall project

3.3 Project Methodology

The methodology of this project is to conduct the project to achieve the objective and also to accomplish the expected result. In this thesis, the parameter that will measure is the sensitivity of the motion sensor to control the lighting intensity. The achievements of this project will be tested by building the prototype of street lighting energy saving control system. The Arduino microcontroller system will be used in this project. The prototype of street lighting control system will be designed by using Arduino UNO R3, PIR sensor, resistor, transistor and LED.

The process of this project are firstly run the programming by using Arduino integrated development environment (IDE) and connect it to the Arduino UNO R3 microcontroller. The system will start by declaring the input pin of PIR sensor that connect to the Arduino microcontroller system the output pin of the LED lamp. After declare, the system will detect the movement of the vehicle, and if the signal is HIGH the system will increase the intensity to full brightness. Otherwise, if the signal is LOW the system will decrease the intensity of the lamp to 40%. This process will be rotated based on the movement sense by the PIR sensor.

After finishing the programming, the Arduino will connect to the street lighting prototype circuit to test the output of the programming. The Arduino will connect by using stand-alone power plug and will test the output again to make sure it follows the requirement. During the experiment carried out, there are some errors that occur as the sensor is too sensitive, error when write the programming by using Arduino IDE software and fault occurs when using the equipment.

3.4 System Flowchart

The system will start by declaring the input pin of PIR sensor that connects to the Arduino microcontroller system the output pin of the LED lamp. After declare, the system will detect the movement of the vehicle, and if the signal is HIGH the system will increase the intensity to full brightness. Otherwise, if the signal is LOW the system will decrease the intensity of the lamp to 40%. This process will be rotated based on the movement sense by the PIR sensor. The system flowchart of Street lighting energy saving control system was show in Figure 3.3.

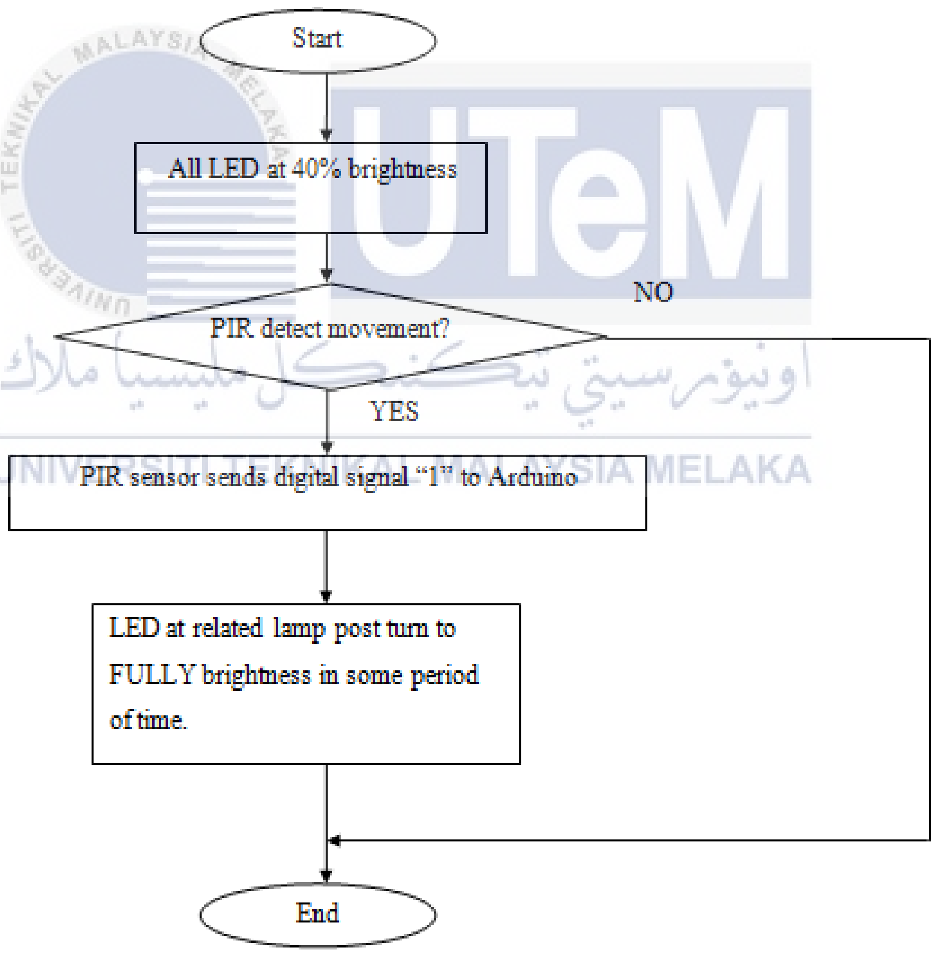


Figure 3.3: System flowchart of Street lighting energy saving control system

3.5 System block diagram

Figure 3.4 shows the system functional block diagram which mainly consist of an Arduino microcontroller block, input/output board, sensor and output load.

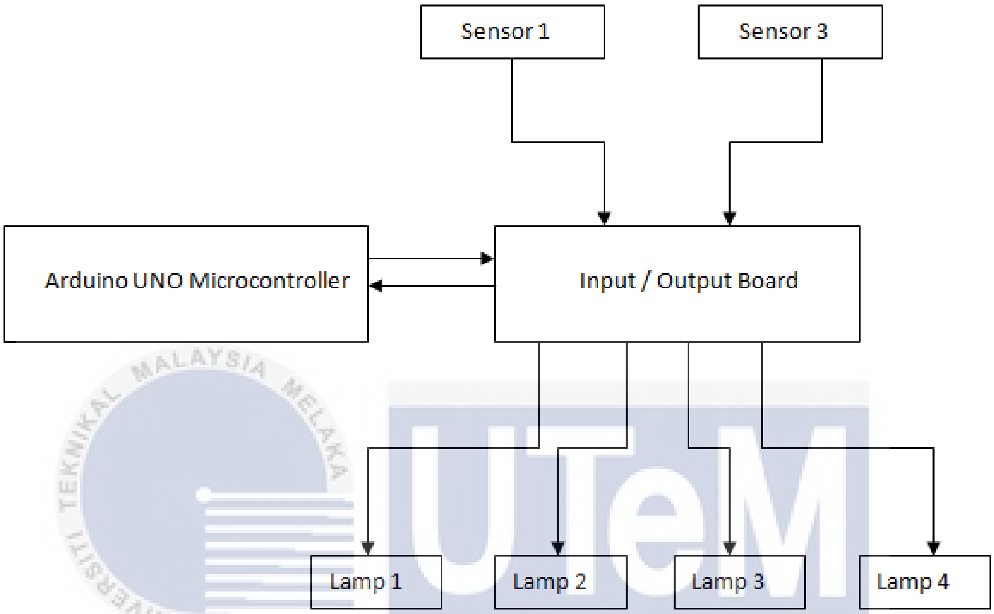


Figure 3.4: System block diagram

The microcontroller subsystem employs the Arduino Uno that is based on the Atmega 328. The Uno board has 14 digital input/output pins of which 6 can be used as PWM output, 6 analog input, a 16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The input/output are provides interfaces between the microcontroller and sensor inputs and lamp output. The Arduino Uno is isolated from its field inputs and outputs so that the any overvoltage or overcurrent conditions could not harm the microcontroller subsystem.

A two Passive Infra-Red (PIR) motion sensor are used for input sensor. The function of PIR sensor is to sense changes in infra-red energy emitted by nearby object. The sensor outputs a high signal on its output pin when an object in motion is detected; or else the PIR keeps a low signal. Sensors 1 are corresponding to lamp 1 and lamp 2. Sensors 3 are correspond to lamp 3 and lamp 4. The output loads are twelve light emitting diode (LED) lamps, which offer efficient lighting.

3.6 Project Description

Street lighting energy saving control system by using Arduino microcontroller project will develop the new intelligent street lighting control system. This project will automatically increase the intensity of LED lamp based on the movement of the vehicle. The street light will operate at full brightness which is 100% intensity when it detected any movement on the road and it will decreased the brightness to 40% intensity when no movement has been detected after delay 5s.

Arduino UNO will operate using the arduino programming language based on the circuit that connects to the arduino board. The purpose of this project is to build an intelligent street lighting system equipped with vehicle presence sensor and this project also to provide a better solution to reduce electricity wastage by reduce the power consumption of street lighting system.

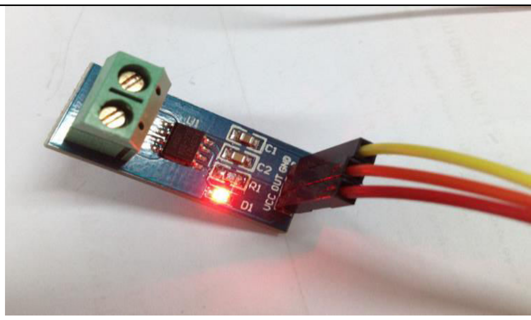
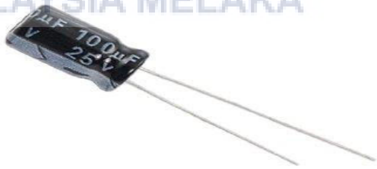
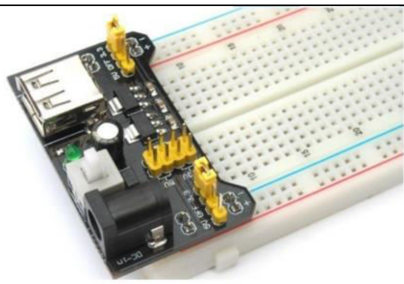
The new development of street lighting energy saving control system will be implemented on the low road user likes road at the main campus UTeM that requires the speed below 30km/h. This project can reduce the power consumption of street lighting by dimming or control the light intensity.

3.7 Hardware Requirement

This part will describe the hardware requirement that will used to complete the street lighting energy saving control system. There are table of the entire component that used to design the hardware of the project.

Table 3.1: List of Component

NO.	COMPONENT	FIGURE
1	Arduino UNO R3	
2	Super Bright Led	
3	Resistor (100 ohm & 1K ohm)	

4	Passive Infra-Red Sensor	
5	Current Sensor ACS172	
6	Transistor NPN	
7	Capacitor	
	Power Supply 5V	

3.7.1 Passive Infra-Red (PIR) Sensor

PIR sensor is a motion sensor used to identify the passage of vehicle or pedestrian that gives an input to turn on the street lighting. The term 'passive' means the PIR does not emit any energy of any type but merely sits 'passive' accepting infrared energy through the 'window' in its housing [17]. The most common object is a PIR sensor detects the human body, so the PIR sensor is widely used in automatic light switches, alarm systems, and door openers.

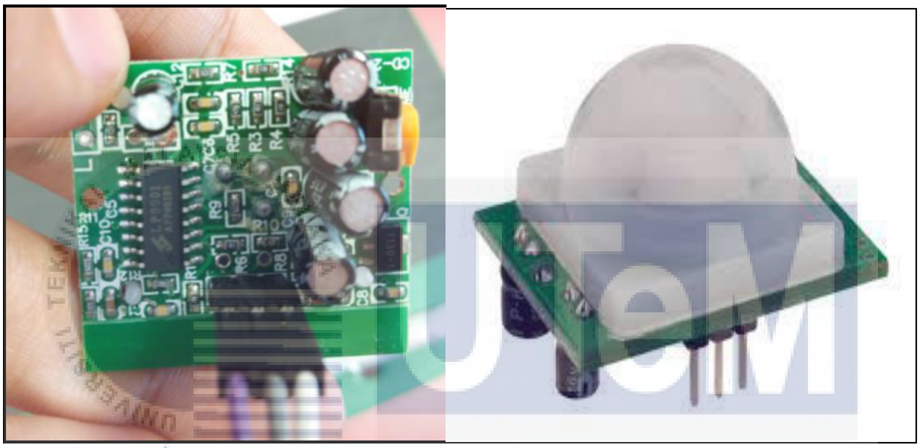


Figure 3.5: Passive Infrared motion sensor

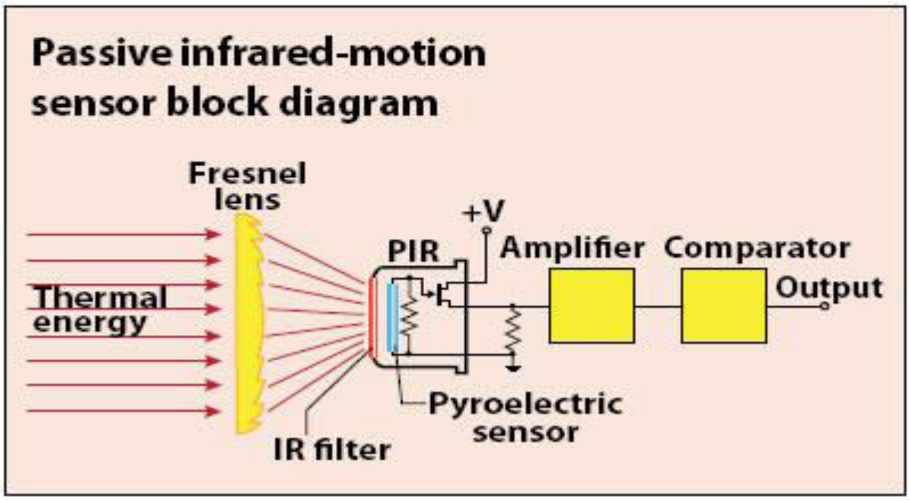


Figure 3.6: Passive Infrared motion sensor block diagram [17]

By using a Fresnel lens the PIR Sensor can detects motion up to 20 feet away. PIR modules have a 3-pin connection at the side or bottom. One pin will be ground, another will be signal and the final one will be power. Power is usually 3-5VDC input and for this project the power used is 5V. The type of PIR sensor that used in this project is LC-100-PI-6PK.

3.7.2 Current Sensor

The ACS712 current sensor is based on the principle of Hall-effect, which was discovered by Dr.Edwin Hall in 1879 [18]. The current sensor provides actual current measurement for AC and DC signals. Moreover, the current sensor measures up to 5A of DC or AC current and these are good sensors for measuring and metering the power consumption of street lighting energy saving control system. In this project, current sensor ACS712ELC-20A has been used.

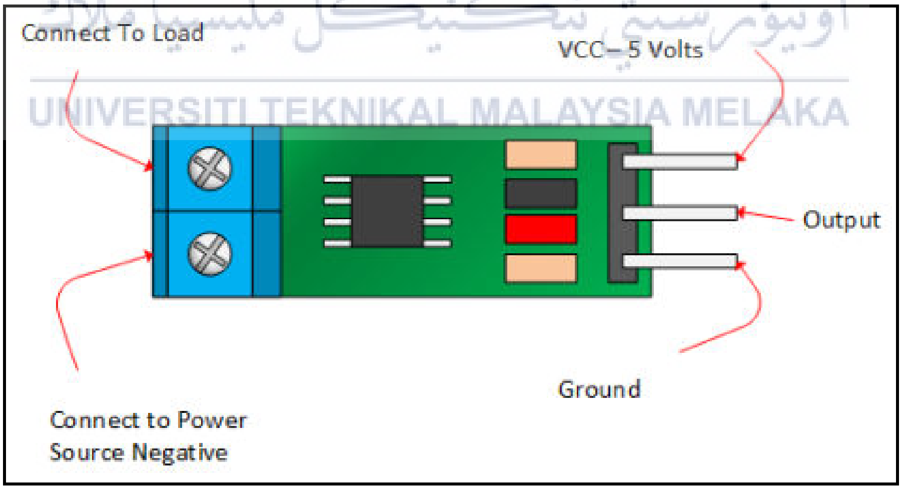
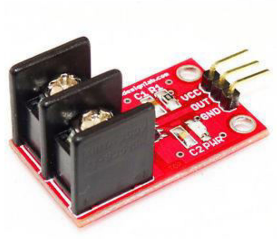
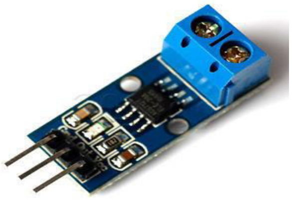


Figure 3.7: ACS712 Module Pin Outs and Connections [18]

Table 3.2: The differences sensor module with their specification [18]

	5A MODULE 	**20A MODULE** 	**30A MODULE** 
Supply Voltage (VCC)	5Vdc Nominal	5Vdc Nominal	5Vdc Nominal
Measurement Range	-5 to +5 Amps	-20 to +20 Amps	-30 to +30 Amps
Voltage at 0A	VCC/2 (nominally 2.5Vdc)	VCC/2 (nominally 2.5Vdc)	VCC/2 (nominally 2.5VDC)
Scale Factor	185 mV per Amp	100 mV per Amp	66 mV per Amp
Chip	ACS712ELC-05A	ACS712ELC-20A	ACS712ELC-30A

3.7.3 Arduino UNO R3

Due to the low cost, compatibility, compact size and easy interfacing over several type of other controller including Programmable Logic Controller (PLC) and Programmable Integrated Circuit (PIC), Arduino UNO Atmega328 has been selected as controller in the street lighting energy control system.

Arduino UNO R3 is the microcontroller system that capable of running thousands of line of code each seconds and it very fast. The delay command will insert into the code to slow it down. Arduino has two different type of pin, digital and analog. This two type of different pin used for declare two type of condition on and off application. Digital pin will read the on condition is HIGH or 5V and off condition is LOW or 0V. These pins get the signal from or to the outside world. Digital pin also can be used to transferring data to another device by encoding it as patterns of HIGH and LOW. Analog pin are suitable to perfect measuring all those “real world” values. This pin will translate an input voltage into a number that ranges from 0 (0V) to 1023 (5V) [3].

Table 3.3: Features of Arduino Uno [3]

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)

Figure 3.7 shows the schematic diagram of the Arduino UNO R3 that contains 14 digital input/output pins, 6 analog inputs, 6 digital pins can be PWM output, 16 MHz crystal oscillator, reset button, power jack, USB connections and ICSP header.

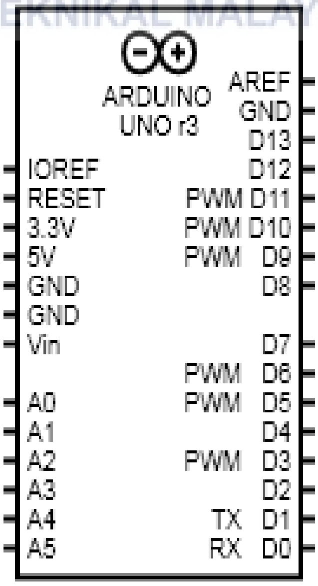


Figure 3.8: Arduino UNO R3 schematic diagram [3]

Moreover, Arduino IDE software will be used in this project to build the programming and also to run the coding. The programming will run by connect the USB cable from computer to the Arduino UNO R3. It will automatically supply exactly 5V. Arduino UNO R3 need 5V for operates by using computer and 7V to 12V for stand-alone supply. The supply for stand-alone supply must exactly between 7V – 12V, if less than 7V the system will run incorrectly and if exceed 12V the Arduino will be blow or damage.

3.8 Software and Hardware Development

This part will discuss about the programming of Arduino by using IDE software. Furthermore, the prototype development of street lighting energy saving control system also will be described in this section.

3.8.1 Arduino IDE software

In this software development, the Arduino programming has been used to construct the program for the proposed design. The programming of street lighting control system by using Arduino microcontroller was start by declare the integer pin of the PIR sensor and LED. In this coding, the sensor pin was connected to analogue pin, A2, A3, A4 and A5. The integer pin of the output was declared as LED that connects to the PWM pin 6, pin 9, pin 10 and pin 11. Figure 3.9 shows the coding of pin declares to set up the input and output of the system.

```
int ledPin1 = 6;

int ledPin2 = 9;

int ledPin3 = 10;

int ledPin4 = 11;

int sensor1 = 2;

int sensor2 = 3;

int sensor3 = 4;

int sensor4 = 5;
```

Figure 3.9: Input and Output coding of Arduino

After that, the coding was recalling the setup command to declare the output and input pin mode of Arduino. The output of the Arduino was declared as LED and the input pin was declared as PIR sensor. The system will continuously repeat overall process that was program to Arduino microcontroller. The Figure 3.10 shows the coding of this process.


```
void setup()
{
   pinMode(sensor1, INPUT);
   pinMode(sensor2, INPUT);
   pinMode(sensor3, INPUT);
   pinMode(sensor4, INPUT);
   pinMode(ledPin1, OUTPUT);
   pinMode(ledPin2, OUTPUT);
   pinMode(ledPin3, OUTPUT);
   pinMode(ledPin4, OUTPUT);
   Serial.begin(9600);
}

void loop ()
```

Figure 3.10: Programming command coding of the Arduino

3.8.2 Proteus Simulation Software

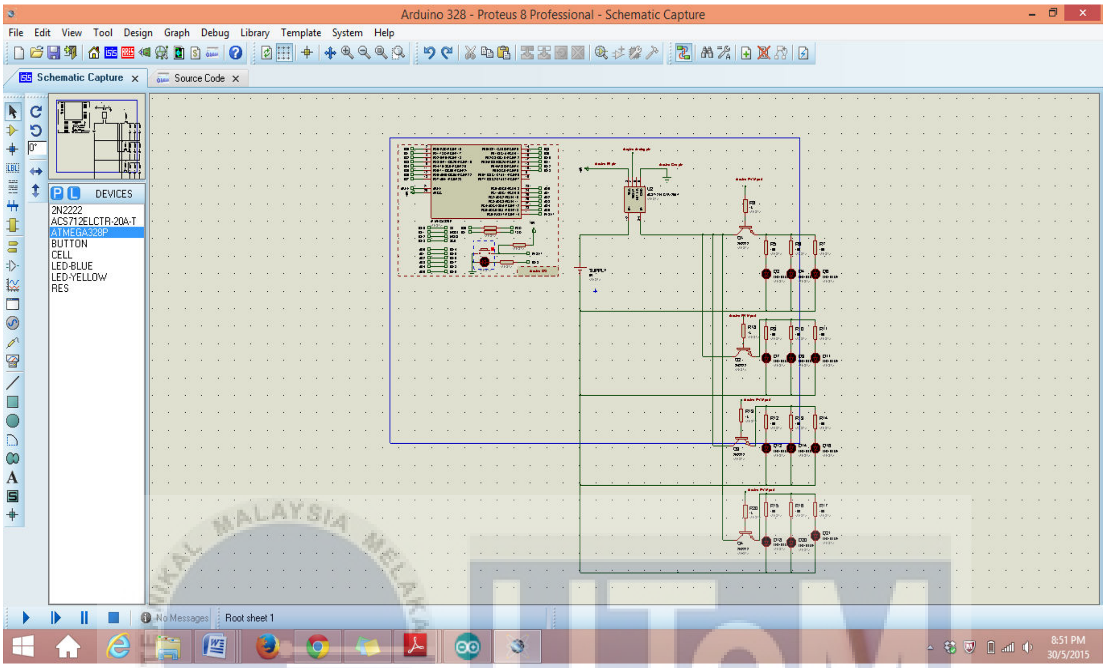


Figure 3.11: Proteus simulation software

Before the hardware can be assembled, first it must be simulated so that it can shows the expected result of the circuit that has been designed. By using Proteus the circuit designed can simulate and shows the expected result and then the hardware can be assemble. Proteus also can be use to link with microcontroller and shows the simulation of the circuit. The Proteus is a simulation program that shows the running of the circuit in the real life. The wrong connection for the circuit can damage the component therefore the simulation is a must before the connection of the real circuit. Proteus has another function and that is the design of the Printed Circuit Board (PCB). The circuit design was ran in the Proteus software to find out the output of the circuit and refine the design by adding or removing component and also the connection until the circuit can run correctly and stabilize. When the designed circuit developed and need to be modified Proteus can be use again to redesign the circuit.

3.8.3 Project Prototype

In hardware development, power supply is used to power up the overall system. The supply is controlled by the switch for the power switch on and off. The PIR motion sensor was placed on the between of the lamp post. PIR is used to detect the presence of vehicles to determine the density of traffic. Each vehicle that passes the motion sensor will be counted and the decision will be made based on the number of vehicles across the sensor. Due to the low cost, compatibility, compact size and easy interfacing over several types of other controller including Programmable Logic Controller (PLC) and Programmable Integrated Circuit (PIC), Arduino UNO Atmega328 has been selected as the main controller in this system. Moreover, the LED lamp represents the street light and the brightness of the LED is controlled by adjusting the PWM in Arduino. The Figure 3.12 shows the prototype design of street lighting energy saving

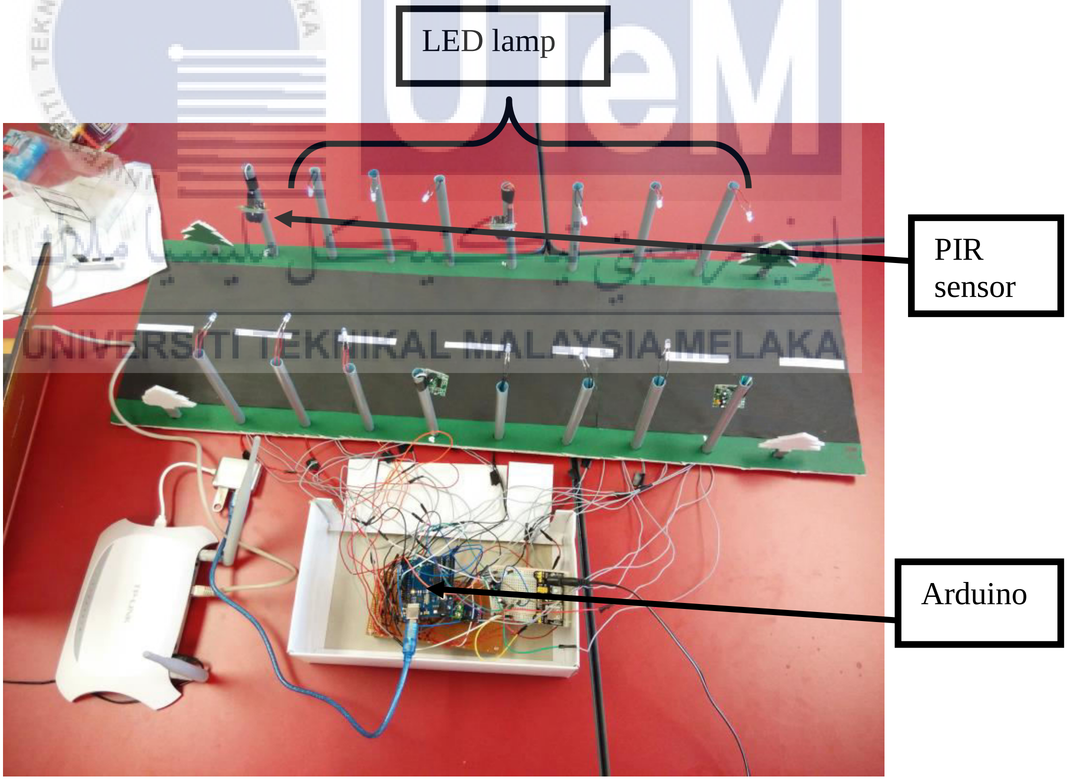


Figure 3.12: The prototype design of street lighting energy saving

CHAPTER 4

RESULT AND DISCUSSION

4.1 Overview

In this section will shows the result obtained that have been achieved throughout the whole semester. In this section also will show the result of the project based on the software and hardware testing.

4.2 Voltage Consumption Analysis

The project aims were to reduce the side effects of the current street lighting system, and find a solution to save power. There is some data that should be collected and analyzed before setting up parameters such as the level of brightness and power consumption of LEDs in different duty cycle. Therefore, an analysis of the use of voltage in some duty cycle has been performed. Table 4.1 shows the data that has been collected.

Table 4.1: Energy consumption of LED in several duty cycle

Duty Cycle (%)	LED		
	Consume Voltage (V)	**Current (A)**	**Consume Energy (mW)**
7	0.08		1.6
10	0.09		1.8
20	0.19		3.8
30	0.29		5.8
40	0.39	0.02	7.8
50	0.48		9.6
60	0.58		11.6
70	0.68		13.6
80	0.78		15.6
90	0.88		17.6
100	0.97		19.4

From the measurement obtained above, it can be seen that the higher the duty cycle, the voltage and power consumption is also increasing. Therefore, this project decided to used 40% duty cycle of PWM with voltage consumption and energy consumption of 0.39V and 7.8mW respectively. With 40% duty cycle of the PWM, the LED only consumes 40% of energy and can provide a suitable brightness for the human eyes.

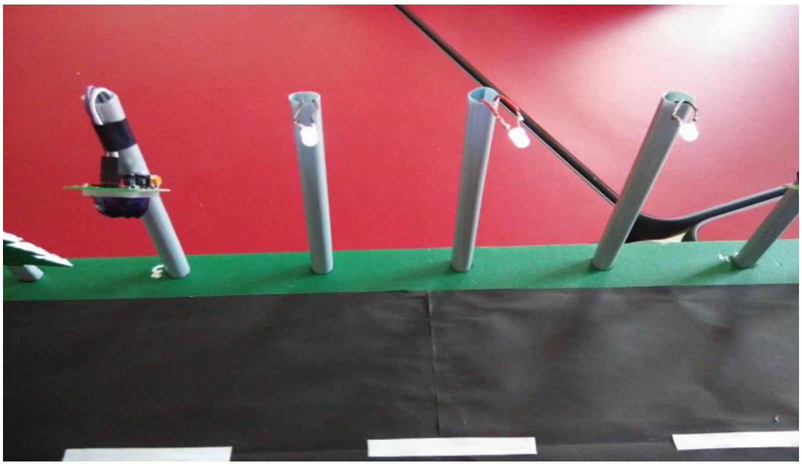


Figure 4.1: LED brightness at 40% duty cycle

Figure 4.2: LED brightness at 100% duty cycle

4.3 Power Consumption Analysis

To find out the distinction LED power consumption by over 12 hours, data from Table 4.1 has been divided into 5 cases. The duty cycle from a 100% fully brightness and 40% duty cycle are taken, with an estimated operating time is from 7pm until 7am as presented in Table 4.2.

Table 4.2: Five cases in 100% and 40% duty cycle

Case	Duration (Hour)	
	100 % duty cycle	40% duty cycle
1	12	0
2	9	3
3	6	6
4	3	9
5	0	12

Power consumption for LED in five cases are calculated by multiplying the duration in hour from Table 4.2 with energy consumption from Table 4.1. The power consumption of one LED and twelve LED for one night was recorded in Table 4.3 and Table 4.4.

Table 4.3: Power consumption for 1 LED

Case	Power Consumption (mWh)	
	100% duty cycle	**40% duty cycle**
1	232.8	0
2	174.6	23.4
3	116.4	46.8
4	58.2	70.2
5	0	93.6

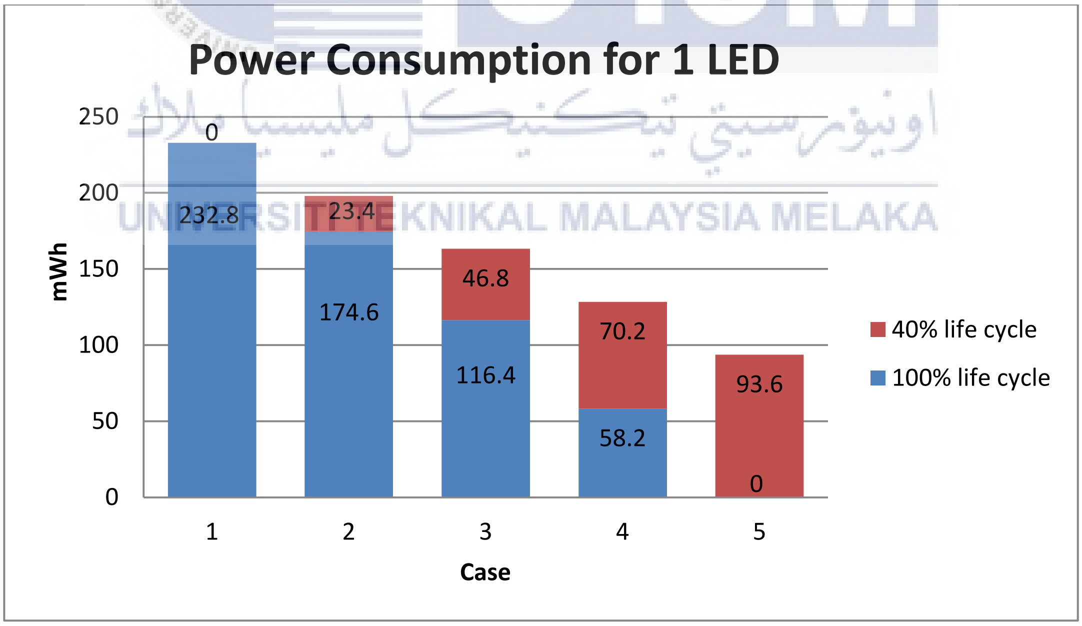


Figure 4.3: Power consumption of one LED at 100% and 40% duty cycle in five cases for one night.

From the figure above, 232.8mW is a value for the energy consumption of 1 LED with 100% duty cycle that light up for 12 hours. However if the LED light up in fully brightness for only 6 hours and the rest in a state of 40%, energy consumption can be reduced to 162.2mWH. Apart from that, the power consumption can be reduced until 93.6mW in a state where LED brightness is 40% for 12 hours. This condition can avoid wasting energy when not in use. It is obvious that the energy in the current street light system is not wisely used especially in the housing or low activity area. The analysis of energy consumption for twelve LED for prototype system is shown in the table and figure below.

Table 4.4: Power consumption for 12 LED

Case	**Power Consumption (mWh)**	
	100% duty cycle	**40% duty cycle**
1	2793.6	0
2	2095.2	280.8
3	1396.8	561.6
4	698.4	842.4
5	0	1111.2

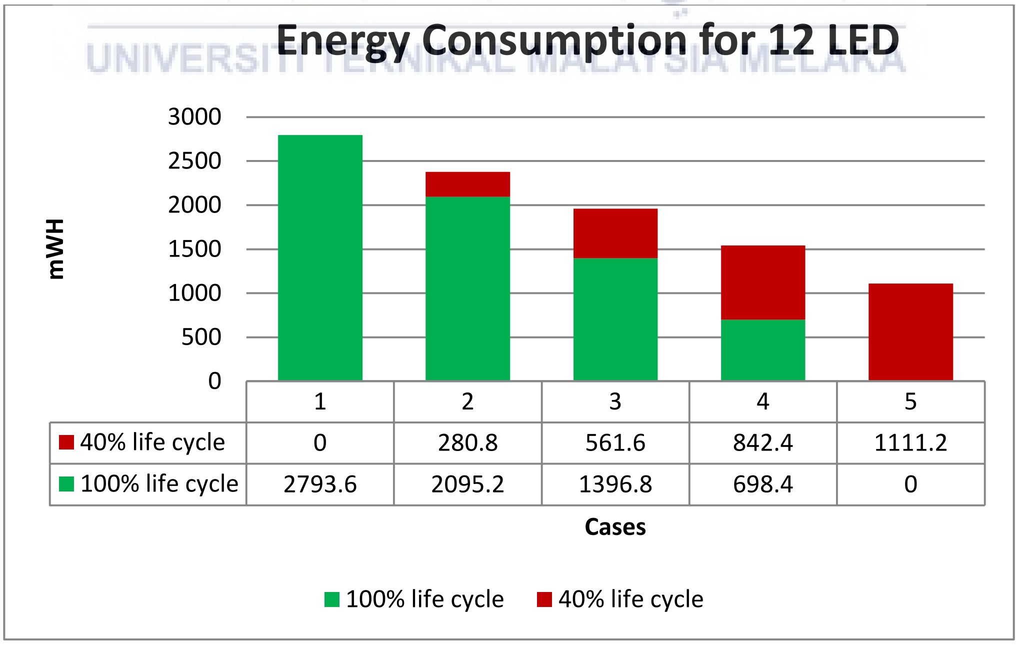


Figure 4.4: Power consumption of twelve LED at 100% and 40% duty cycle in five cases for one night.

4.4 The Cost of Power Consumption

Refering to Tenaga Nasional Berhad website [8], the current tariff rate for street light including the maintenance is 30.5 sen/kWh. If 12 LED are utilized in fully brightness for 12 hours, RM 85.20 is needed to be spent. However, if the brightness is decrease to 40% for 6 hours, it can save up to RM25.47. In case 5, if there is no movement detected for 12 hours, RM50.94 can be saved. Figure 4.5 shows graph of energy consumption for 12 LED and electricity charges for a year in five different cases.

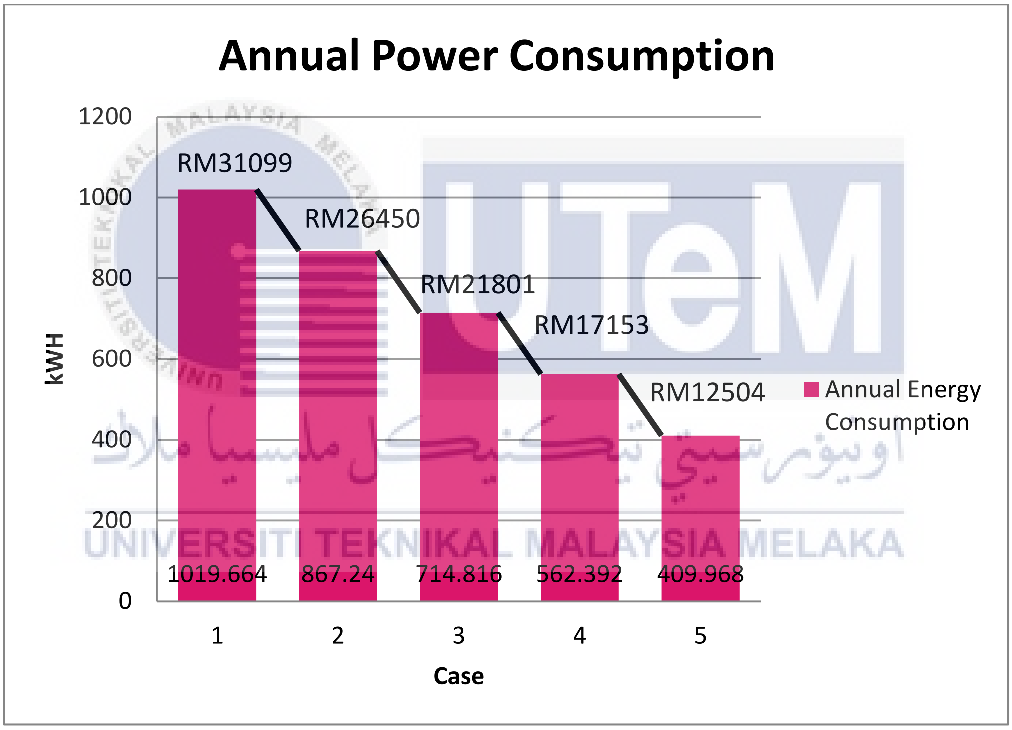


Figure 4.5: Annual power consumption for 12 LED and the electricity charges.

From the graph it is clear that electricity charges are gradually decreased from RM31099 to RM12504. This situation is due to the reduction of energy consumption of the LED. Refering the diagram above, the total energy consumption for 100% duty cycle of LED is as much as 1019,664 kWh with the electricity charges amounted RM31099. In case 2, the total power consumption was 867.24 kWh when the LED fully brightness for 9 hours and 40% brightness for 3 hours. With the number of such usage, the electricity charge was RM26450 with the savings of RM4649 compared with the case 1. Next, for case 3 and case 4 the electricity charges was RM21801 and RM17153 respectively with the power consumption by 714,816 kWh and 562,392 kWh. If there is no movement is detected as in the case 5, around 40% of electricity charges can be saved with the energy usage of 409.968 kWh. In addition, besides being able to cost effective by reducing the brightness of the LED also helps to reduce carbon dioxide (CO2) into the air from the environment point of view.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Overview

This chapter will describe about conclusion and recommendation for the street lighting energy saving control system. This section includes project summary, project finding and further recommendation to improve the project.

5.2 Conclusion

In short, energy saving street light control system may provide advantages in street lighting system in Malaysia. By having this system, the power consumption and electricity wastage also can be reduce However, energy efficiency is not only benefit but maintenance scheduling can be improved without the need for roving inspection. This proposed system also utilizes the high efficient LED lighting technology and the microcontroller based intelligent management of the lamp posts activities of the local pedestrian, automotive traffic and the ambient light conditions. The proposed control is especially appropriate for the street lighting in suburban areas where the traffic is low at night times. Furthermore, the minimal components including the low cost microcontroller and LED lamp produce the better saving in term of cost. On top of that, the lifetime, better illumination and low power consumption of LED are the other criteria for reducing the operational and maintenance cost after installation compare to high pressure sodium vapor lamp and other.

The prototype for the street lighting energy saving control system is also has safety usage that is the light will not turn OFF completely but only dimming and the user can easily see from far away and the light will full turn ON if it detecting movement. The system has shown a great energy savings and if the system can be upgrade with many functions and user friendly the system can be commercialize and the cost for retrofitting the street lighting energy saving control system can be lowered

5.3 Recommendation

The recommendation for the Street Lighting Energy Saving Control System that has been developed has many flaws and needs improvement in the system. The following is the suggestion for improving the Street Lighting Energy Saving Control System:

1. The failure detector can be installed to make the street lighting component failure easy to monitor.
2. Make web based as a medium for controlling the streetlights such as ON and OFF the street light without depending on a timer or LDR.
3. Android based applications can be developed for Mobile Phones or Smart Tabs making mobility of control possible.

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APPENDIX A

Gantt chart

Project Task	Final Year Project 1					Final Year Project 2				
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mei	Jun
Discussion with supervisor related to FYP title										
Search Journal and Literature Review about street light energy saving										
Understand the theory and operation of previous work										
Progress Report - Introduction & Literature Review										
Progress Report – Methodology, Preliminary Result & Conclusion										
Doing Model Simulation usingArduino software										
Make a circuit design of Street Lighting System										
Hardware Implementation										
Hardware Testing										
Analysis & Discussion										
Full Report Writing										

APPENDIX B

Arduino Coding

APPENDIX C

LS-20

Specification for road lighting installation

APPENDIX D

Arduino UNO Datasheet

APPENDIX E

PIR motion sensor datasheet