DESIGN OF SMART WIRELESS STREET LIGHTING SYSTEM

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Engineering Technology in Electrical

Faculty of Engineering Technology
UNIVERSITI MALAYSIA PAHANG

SEPTEMBER 2017

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ACKNOWLEDGEMENTS

Bismillahirrahmanirrahim,

Firstly, praise to Allah S.W.T. for giving me patient and spirit throughout this project and the research is successfully complete, with the mercifulness from Allah therefore I can produce a lot of useful idea to this project.

To my beloved father and mother, Che Ani Bin Ahmad and Salmah Binti Ismail, I am grateful to have both of you in my life and giving me full of support and pray to go through this life. I pray and wish to both of you are always in a good health and in Allah mercy. You are the most precious gift from Allah to me.

I am indebted to my supervisor Dr Yasir Hashim Naif, the lecturer from the Faculty of Technology Engineering for his advice, insightful comments and generous support. Thank you for your guide and without your guide this research will not complete and well organized. And not forgetting to Sir Wan Hassan Bin Wan Hamat for his technical support and guidance.

Not forgotten to all my beloved teammates who have accompanied me through this project. Thank you very much.

ABSTRACT

The large quantity of electricity of many coountries is consumed in lighting the streets especially in highway. Most of the 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 electrical power in a long term. Besides that, this project also may increase the lifetime of the street light lamp as well as reduce the pollutions. The operation of this system is to OFF the street light if no vehicles passing through the road. When the PIR sensor detects movements of the vehicle, the relay that act as a switch will turn ON the street light. Four microcontroller which are Arduino Uno have been used as the controller for the project. In addtition, there are other components used for this system which are PIR sensor, 1 channel 5V relay module and RF 433MHz Transmitter - Receiver module. PIR sensor function as a vehicle detector. The RF 433MHz Transmitter – Receiver module that are inside the circuit will send send and receive information that get from the PIR sensor. Range of the signal from the 433 MHz Transmitter – Receiver module are the key factor that need to be considered to make this system working as desired.

ABSTRAK

Kuantiti besar tenaga elektrik di kebanyakan negara digunakan pada lampu jalan. Kebanyakan system lampu jalan asas bertukar ON / OFF pada selang masa yg tetap. Dalam tesis ini, system ini adalah untuk membangunkam satu system kawalan penjimatan tenaga lampu jalan untuk mengurangkan tenaga jika tiada kenderaan melalui jalan-jalan tertentu. Secara logiknya, system ini boleh menyimpan sejumlah besar kuasa elektrik pada jangka masa Panjang. Selain itu, ia boleh meningkatkan jangka hayat lampu dan mengurangkan pencemaran. Operasi system ini adalah untuk memadamkan lampu jalan jika tiada kenderaan yang melalui jalan raya. Apabila sensor PIR mengesan pergerakan kenderaan, relay yg berfungsi sebagai suis akan menyalakan lampu jalan. Empat mikrokontroler Arduino Uno telah digunakan untuk mengawal system di dalam projek ini. Tambahan pula, terdapat komponen lain yang digunakan untuk projek ini iaitu sensor PIR, 1 saluran 5V modul relay dan RF 433 MHz Pemancar - Penerima. Modul pemancar RF 433MHz yang berada di dalam litar akan menghantar dan menerima maklumat yang diperoleh daripada sensor PIR. Julat isyarat dari 433 MHz Pemancar - Penerima adalah faktor utaman yang perlu dipertimbangkan untuk membuat sistem ini berfungsi seperti yang dikehendaki.

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LIST OF ABBREVIATIONS

IDA	International DARK-SKY Association
PIR	Passive Infrared
DC	Direct Current
DSP	Digital Signal Processor
DC	Direct Current
LED	Light Emitting Diode
PID	Passive Infrared Detectors
HVAC	Heating, Ventilation, and Air Conditioning
kWh	Kilo Watt hour
NC	Normally Close
NO	Normally Open
PCB	Printed Circuit Board

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, street lighting is essential for all areas whether urban or rural since people know that a street light is an alternative during the day night in order to keep the safety of the road users. Street lights management control is quite simple, yet as the urbanization, the number of streets increased rapidly.

The first experiments in electrical illumination were made by Sir Humphry Davy, chemist and inventor, in the 19th century. He took a filament, made from platinum strip, and connected it to a battery, the biggest one in the world at the time and in 1802 made first prototype of an incandescent lamp. Electric current ran through platinum filament, heated it and filament started emitting light. Platinum was used as a material because of its high melting point. Lamp didn't lasted long because heat burned the filament very quickly, but it was a starting point on which 20 and something inventors relied their ideas until we got first electric lamp that could be used for a longer time and with adequate strength of light.

Prototype of a first electric arc lamp was made in 1809, again by Sir Humphry Davy and became basis for another type of electric lamp. In the years to come, many inventors experimented on the design of electric light. They changed materials of filament and tried different atmospheres inside a bulb - from better vacuum to noble gas.

Sir Joseph Swann and Thomas Edison independently made first commercially usable electric light in 1870s. Main design idea, that prolonged working of the electric lamp, was using of carbon filament in better vacuum. That kind of electric lamp worked longer, up to 1200 hours, and gave better, stronger light. After that, filament was made from tungsten and used in the atmosphere of noble gas, which lessen evaporation of filament and gave longer lasting and even brighter light. At first, only few used electric lamps because of their high price but in time their use spread and it is estimated that by 1885, in the United States only, some 300000 electric lamps were sold. Electric light spread across the world and is still here today as necessity. It has wide spectrum of uses in many parts of our lives from home to street lightning.

Street lighting is important in order to ensure the safety to road user especially during at night. Street lighting can be define as the artificial illumination of street when natural light drop below pre-determine level (A.Lavric et al.,2012).

In recent years in the U.S. alone, outdoor lighting uses about 1200 tera watt-hours of energy and mostly to illuminate streets and parking lots. That's enough energy to meet New York City's total electricity needs for two years. International DARK-SKY Association (IDA) estimate that least 30 percent of all outdoor lighting in the U.S. alone is wasted, mostly by lights that aren't shielded. Besides that, that add up to $3.3 billion and release of 21 million tons of carbon dioxide per year. To solve this problem, we has introduced a design of smart wireless street light system (DSWSLS) with energy saving consumption which provides the flexible and efficient system in order to control the street lighting autonomously. This systems is controlled by one main sensor which called Passive Infrared (PIR) motion sensor. Generally, the PIR motion sensor is used to sense movement of animals, human or even other objects. The basic idea of the system is when any object that passing through the street light, this PIR motion sensor will detect and send the signal to the microcontroller (Arduino UNO) and will control the on and off the street light.

Figure 1.1 : Normal street light in highway

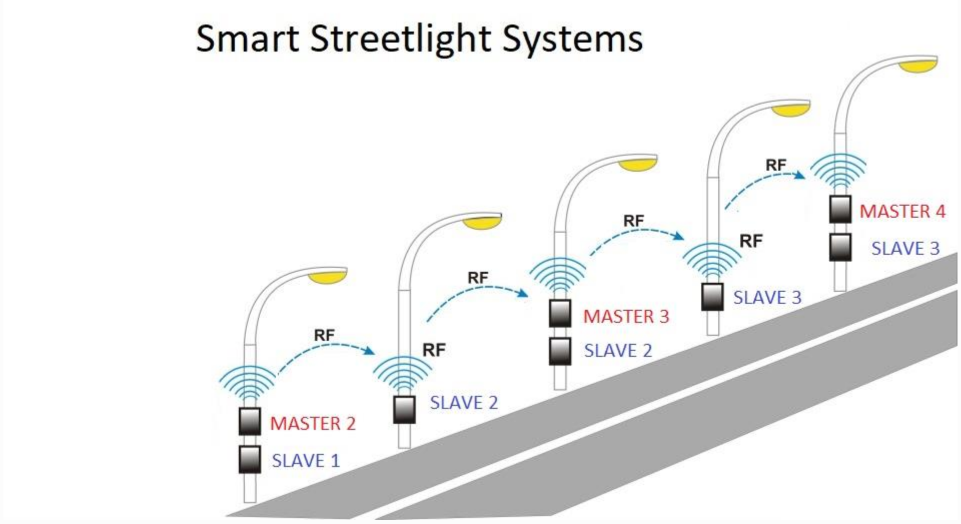

Figure 1.2 : Smart street light system

1.2 PROBLEM STATEMENT

It is very common to see the street light alight all night, which can caouse a great waste of energy. The power consumption and energy waste from this are relatively high day by day. Some of the streets are not fully occupied such as the main city streets, as well as at the highway. Sometimes, they are empty for a certain period time like in a middle of night. For example, the highway beside the Universiti Malaysia Pahang (UMP), only during the day it fully utilized but at night the road less user.

Based on the problem, the observation of street lighting was done to inprove the street light system to make sure the street light can be operate more efficient. In response to this problem, the study purposes to investigate several options that can increase the efficiency of street light. The usage of motion sensor as well as arduino uno as the main controller will provide some change in electricity consume by the street light.

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.

1.3 RESEARCH OBJECTIVES

The objectives of the project are as follows:

- To design a street lighting system with energy consuming.
- To validate the new design system.
- To understanding energy and environment relationship.

1.4 SIGNIFICANCE OF RESEARCH

The significance of this research is to be able to apply this principle in controlling street light in any places without human handling. The system will be programmed to control the flow of lighting on the main road and be measured using PIR sensor with precise accuracy. Besides that, it can also be able to be used in a residential area or in town area. The PIR sensor will be attached to the street light to detect the presence of cars or other vehicle. The PIR sensor will be placed to control every 3 street light respectively and the signals will sent through RF433Mhz Transmitter - Receiver, and received by other street lights. When the street light received the signal, it will turn on in a group (3 street light respectively) in one minute.

CHAPTER 2
LITERATURE REVIEW

2.1 Microcontroller

This system need to have a core controller that can be programmed to control the input and output from the sensors as well as actuate the equipment. A microcontroller is a small computer on a single integrated circuit containing a processor core, memory and programmable input and output peripherals. Microcontrollers are designed for embedded applications, in contrast to the microprocessor used in personal computers or other general purpose applications consisting of various discrete chips.

Microcontroller is more economical compared to digitally control even more devices and processes. This is because microcontroller is small in size and cost in lower compared to a design that uses a separate microprocessor, memory and input/output devices. Some microcontroller may use four-bit words and operate at clock rate frequencies as low as 4-kHz, for low power consumption. Generally, they have the ability to retain functionality while waiting for an events such as interrupt. Other microcontrollers may serve performance-critical roles, where they may need to act more like a digital signal processor (DSP) with higher clock speed and power consumption.

A modular hardware design is implemented using I2C bus to interface different sensors and motor drivers to the ATMEL microcontroller chip (AVR ATmega32). The hardware is integrated in one application board as embedded system design. The software is developed using C-compiler and a top-down approach is adopted to design different software modules (Waheid Gharieb Ali .2011). They are many advantages in developing microcontroller based circuits and incorporating new sensor technology into agricultural applications. Microcontrollers and solid-state sensors can be found in many commercial, industrial and consumer applications. Many sensors and auxiliary components such as memory, chips, clock are design to interface directly with microcontrollers, simplifying circuit design and modification.

There are a lot type of microcontrollers. The common use of microcontroller Arduino Uno. Arduino Uno is a microcontroller board based on the ATmega32.Nowadays, Arduino are common use because it make things easier due to the simplified version of C++ and the already made Arduino microcontroller (ATmega328 microcontroller) (P.D Minns. 2013) that we can programme, erase and reprohardware components used in the Arduino board. The software used in Arduino board is AVR studio and also Proteus.

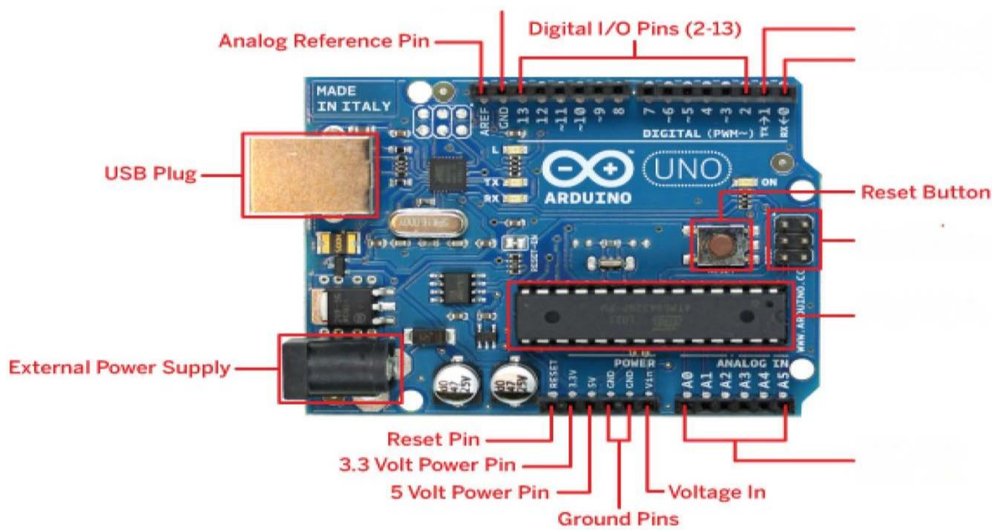

Figure 2.1: Arduino Uno Board

Arduino is an open-source platform (M.Banzi. 2009) used for constructing and programing of electronics. It can receive and send information to most devices, and even through the internet to command the specific electronic device.it uses a hardware called Arduino Uno circuit board and software program which is simplified C++ (P.D Minns. 2013) to programed the board. In these modern day, Arduino are used a lot in microcontroller (A.M. Gibb. 2010) programing among other things due to its user friendly or easy to use setting, like any microcontroller an Arduino is a circuit board with chip that can be programmed to do numerous number of tasks, it sends information from the computer program to the Arduino microcontroller and finally to the specific circuit or machine with multiple circuits in order to execute the specific command. An Arduino can help you read information from input devices (M. Margolis. 2011) such as Sensors, Antenna, Trimmer (potentiometer) and can also send information to output devices such as light emitting diode, LED, Speakers, LCD Screen as well as DC motor.

The software is a set of instructions that informs the hardware of what to do and how to do it. The Arduino IDE (Integrated Development Environment) is divided into three main parts which are Command Area, Text Area And Also Message Window Area.

2.2 Passive Infrared (PIR) Sensors

Passive Infrared (PIR) sensor is one of the important component in this smart wireless streetlight system. This PIR sensor is used to trigger any motion that passing through the master module of this system. According to the study of Carolyn Mathas of Hearst Electronic Produncts entitled "Sensing Motion with Passive Infrared (PIR) Sensors," a passive infrared (PIR) sensor measures infrared light emitted from objects that generate heat, and therefore infrared radiation, in its field of view. Crystalline material at the center of a rectangle on the face of the sensor detects the infrared radiation. The sensor is actually split into two halves so as to detect not the radiation itself, but the change in condition that occurs when a target enters its field. These changes in the amount of infrared radiation on the element in turn change the voltages generated, which are measured by an on-board amplifier. When motion is detected the PIR sensor outputs a high signal on its output pin, which can either be read by an MCU or drive a transistor to switch a higher current load.

What is actually detected is the broken field for a "normal" temperature. The field does not have to be broken by an object with a different temperature in order to register change, as highly sensitive sensors will activate from the movement alone. Designed for use at ambient temperatures of 15°C to 20°C, at higher temperatures the field of view narrows, and if below 15°C, the field of view widens and small or distant objects can activate the sensor. For this reason, it is not recommended that the sensors be used in drafty environments, near HVAC equipment, or facing windows where outside temperatures, or even motion, can cause false readings.

Commonly used in security lighting and alarm systems in an indoor environment, PIR sensors have a range of approximately 6 meters, depending on conditions. The sensor adjusts to slowly changing conditions that occur normally within the environment, but shows a highoutput response when a sudden change takes place.

Generally speaking, PIR sensors are small, inexpensive, low power, rugged, have a wide lens range, are easy to interface with, and are easy to use. Their best feature is that they don't wear out. While they may be easy to use, they are also fairly complex, since many variables that can change the sensor's input and output must be considered.

The PIR sensor typically has two slots on it, each made of material sensitive to infrared radiation. When idle, both slots detect the same amount of IR. When a person/animal comes into their environment, one half will intercept the IR, causing a positive change between the two halves. Once the entity passes through, there is a negative differential change. It is these change pulses that are detected by the PIR sensor.

PIR sensors are most frequently found in motion detector devices aptly called passive infrared detectors (PIDs). The PIR sensor in this case sits on a PCB that interprets signals from the pyroelectric sensor chip. Focusing the infrared energy onto the surface of the sensor is accomplished in two primary ways: (1) the window or cover of the PID has Fresnel lenses molded into it that are used to gather light from a very wide field of view and focus it onto the PIR sensor directly, or (2) the PID has segmented parabolic mirrors that focus the infrared energy inside of it.

For example, the Zilog ZMOTION Detection module solution (Figures 2.2 and 2.3) used for lighting control and other occupancy and proximity detection applications combines the Z8FS040 motion detection microcontroller with a pyroelectric sensor and a low-profile Fresnel lens.

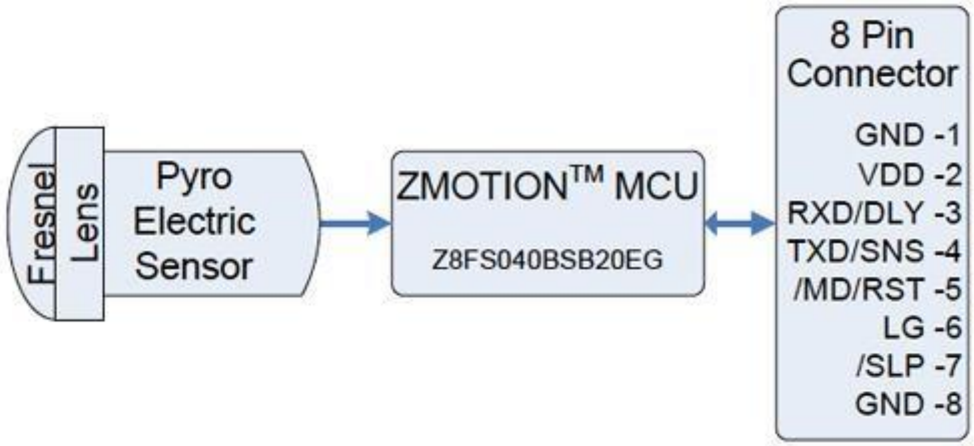

Figure 2.2: Block diagram of the Zilog ZMOTION detection module.

Figure 2.3: Zilog ZMOTION detection module.

Measuring only 25.5 x 16.7 mm, the module offers a 5 x 6 m, 60 degree detection pattern. This solution has a simple hardware or advanced serial (asynchronous) based configuration and interface, and features adjustable sensitivity, delay, and ambient-light threshold.

Applications include unattended vending and kiosks, display systems, home appliances, lighting control, power management, HVAC, access control, and general-purpose proximity. Zilog also offers a detection module development kit designated ZEPIR000102ZCOG.

An example of a PIR sensor used in alarm systems is the Parallax PIR sensor, a pyroelectric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects (Figure 2.4). This motion can be detected by checking for a high signal on a single I/O pin.

Figure 2.4 : A Parallax PIR sensor (Courtesy of Parallax).

Features of the Parallax PIR sensor include single-bit output, a small size that makes it somewhat easy to conceal in security applications, compatibility with all Parallax microcontrollers, and a 3.3 and 5 V operation with <100 µA current draw.

Alarm systems, should a person be detected within an area being monitored by the PID, infrared energy from their body produces a warmer area than the cool area that was previously experienced by the chip focusing on the space in the room being protected. The PID is aware of the amount of infrared energy that is focused onto its surface. A small, normally closed (NC) relay controls contacts that are connected to an alarm or control panel. When the infrared energy focused on the sensor changes within a given time frame, the relay is switched.

The internal mirrored segments, or Fresnel lenses, focus on the infrared energy emitted by whatever intrudes on the field, and the intrusion causes a hot spot to move along with the intrusion within the field. The hot spot de-energizes the relay and activates the detection mechanism on the alarm panel. Again, care is typically taken to avoid drafty HVAC Heating, ventilation, and air conditioning (HVAC)vents or windows, or placement near windows where external elements can cause a false alarm.

One solution, instead of having two detection zones, offers four. The Panasonic NaPiOn pyroelectric sensor module is ideal for small movement detection based on a quadtype (Figure 2.5) pyroelectric element with four receptors. Since the detection zone within the detection range is so precise, even small movements are detected. The lenses on this device are miniaturized because the pyroelectric element is small, enabling the use of a short focal point. This device detects small temperature differences between the detection target and its surroundings, and the lowest required temperature difference in the background is 4°C.

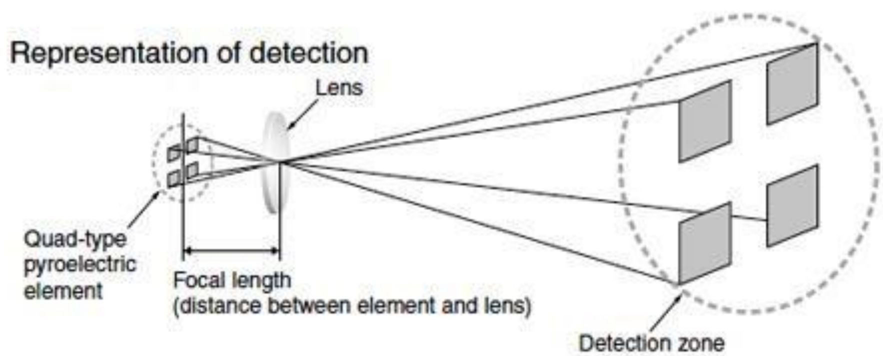

Figure 2.5: Quad-type element with receptors (Courtesy of Panasonic).

The detection zone has the polarity shown in Figure 2.2.5. When targets enter both the + and – zones with the same timing, the signals cancel each other, thus in this case there is a possibility that the object cannot be detected at the maximum specified detection distance.

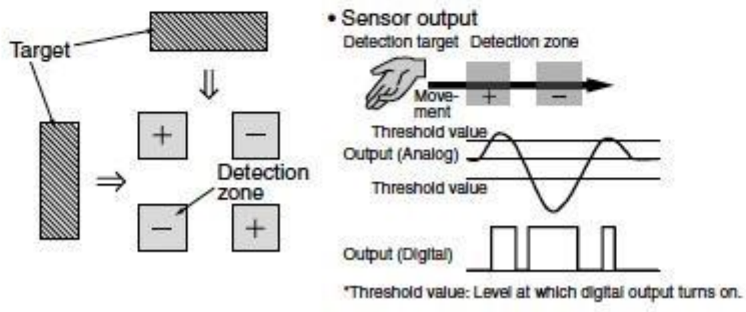

Figure 2.6: Detection zone and sensor output (Courtesy of Panasonic).

Additional applications for this device include home appliances, air conditioners, air purifiers, fan heaters, such construction equipment as lighting and automatic switches; commercial equipment including facilities in designated smoking areas, and the anti-crime device market, including crime-prevention sensors, simple anti-crime devices, and surveillance cameras.

2.3 Energy Saving in Street Light System

Energy conservation is becoming a topic of great concern all over the world, especially in the developing areas. As cities expand, people are searching for new solution to become more energy efficient and environmental friendly (Ross, 2008). The green technology is rapidly growing up and becoming the alternative action and frequent being used especially in urban areas in order the get benefited to the environment as well as energy saving by conserving the energy. One of the solution that can be implemented to reduce energy consumption is by renovating their street light. Although street light only contributes about 8% of the world energy consumption, the current technology only allows for these lights to use 25% of the energy that is provided to them while the rest is converted to heat and ultimately wasted (Coltrin, 2003).

Besides, there are several drawback about the street light such as evenness of light and proper visibility. Most of the civilian think that bright lightning will create safe environment and although being directly under the light may result in good visibility, bright lighting creates shadows that make certain areas very dark and in turn create a less than safe environment (IDA, 2008). Another reason why the developing cities change to green technology is to reduce the energy waste such as light pollution since most of the cities did not take into account about directing the light properly which can creating over lit areas as well as emitted light pollution to atmosphere.

Energy efficiency is the using of less energy to provide the same service. In the other hand, by replacing the bulb to more efficient bulb it consider as practicing energy efficiency and if the light is turn off when there is no user, it consider as energy conservation. Energy conservation is refer to a reduced of use of energy for example by using light dimmers, turning down the heat and lowering the consumption capacity standard on appliance are the example of energy conservation. All of this thing will lead to energy saving. By conserving the energy it will ensure a secure sustainable energy supply as well as reducing the greenhouse gases and emission. Based on International Darksky Association (IDA), least 30% of all outdoor lighting uses about 120 terawatt –hours of energy and mostly distribute to illuminate streets and parking lot. Energy efficiency does not mean that not to use the energy but the energy is use in proper manner which can minimize the amount of energy that need to provide the service especially in street lighting.

Previously, the street light is controlled by individual switches at every street lights. This type of street lights is inefficient as well waste the cost which need to hire the manpower to operate the street light every day. The other technology is by using the light sensor in order to command the light to on or off and other street light use the timer combines with optical control. All these street light technologies have some lack in term of energy efficiency at the same time will effected the energy saving. This happened because low reliability method and night street lighting is too bright and can contribute to energy waste (Wu et al., 2010). The element in previous technologies has lead to second generation street lightning with proper improvement which implement the automation system. As the result the labour intensity and cost can be reduce as well as improving the efficiency. However this new technology has drawback especially in intelligent management such mid-night night strategy which has poor energy effect. The reduction in energy consumption results in large saving on the town's energy costs (Danigelis, 2008).

The intelligent street light control system uses the street light energy saving control technology by using the motion sensor that can detect the moving object and the light will switch on according to the movement of the object. These sensor will connected to the microcontroller in which the data process and control the light switching concept. Whenever the passer is identified by the sensor, it will communicate to the neighboring street light then it will assist the road user.

The street light will dimming to low voltage when no movement detected. Due to increase on population that concern about saving the energy, this system will play major role in saving the electricity without affecting the comfort zone.

2.4 Intelligent Street Lighting to Recude CO_2 Emission

Lighting systems are an important facility of cities, increasing the safety of road traffic participants on the one hand, and pedestrians' sense of security on the other. A constant lightening is the best solution in busy areas; however, it is definitely not in rural residential areas. In the former case, a lot of people are walking around all night long, moving from their workplace or a shopping tour to restaurants, cinemas, and bars. In the latter case, however, only a low number of residents and passersby using the streets during the night, coming from their work and moving to their homes (or the other way round). In such a scenario, the temporal need for lighted streets are, in relation to a continuous illumination of streets, often incredibly small. As energy consumption (or CO2 emission) is an issue of increasing interest, possible energy savings in public street lighting systems are recently discussed from different viewpoints. With the proposal of this project, the research focus followed in this work. First, it recommends the application of improvements in street lighting technology (e.g. the usage of light-emitting diode (LED)'s instead of common light bulbs), and second, it introduces an efficient, user-centered street lamp switching system. The main motivation for this work is derived from the fact that lighting accounts for more than 10 percent of electricity consumption in Germany and nearly 19 percent worldwide (Siemens, 2007a) (This corresponds to emissions of 1.6 billion tons of CO_2 per year, which is equal to the emissions produced by 500 million passenger cars). The potential for saving energy is quite large, but relatively easy to exploit. Simply replacing common bulbs with energy saving LED lamps can reduce energy consumption by up to 80 percent. (As a side effect, in the case of LED lamps, they last about 50 times longer than conventional light bulbs.) A timely switching of street lights according to pedestrians personal requests can add further energy savings.

2.5 Energy Waste on Highway

The idea of planning a new system for the streetlight that consume minimum amount of electricity at the same time illuminate large areas with the highest intensity of light is the major concern nowadays. Allocating street lighting is one of the most important and expensive responsibilities of a city. Lighting can account for 10–38% of the total energy bill in typical cities worldwide (Mustafa et al). Street lighting is a specifically critical concern for public authorities in developing countries since it become the part of economic and social stability.

Inefficient lighting wastes significant financial resources every year, and poor lighting creates unsafe conditions. Energy efficient technologies and design mechanism can reduce cost of the street lighting drastically. Manual control is prone to errors and leads to energy wastages and manually dimming during mid-night is impracticable (Mustafa et al). Also, dynamically tracking the light level is manually impracticable.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is explaining about flow chart about process research, experimental study, experimental model design, equipment used, sample preparation and procedure of experiment.

3.2 Flow Chart

The methodology process flow chart for design of street smart wireless streetlight system as illustrated in Figure 3.1. The flow chart is including the components that are used and also the flow of the system.

Master circuit

Slave circuit

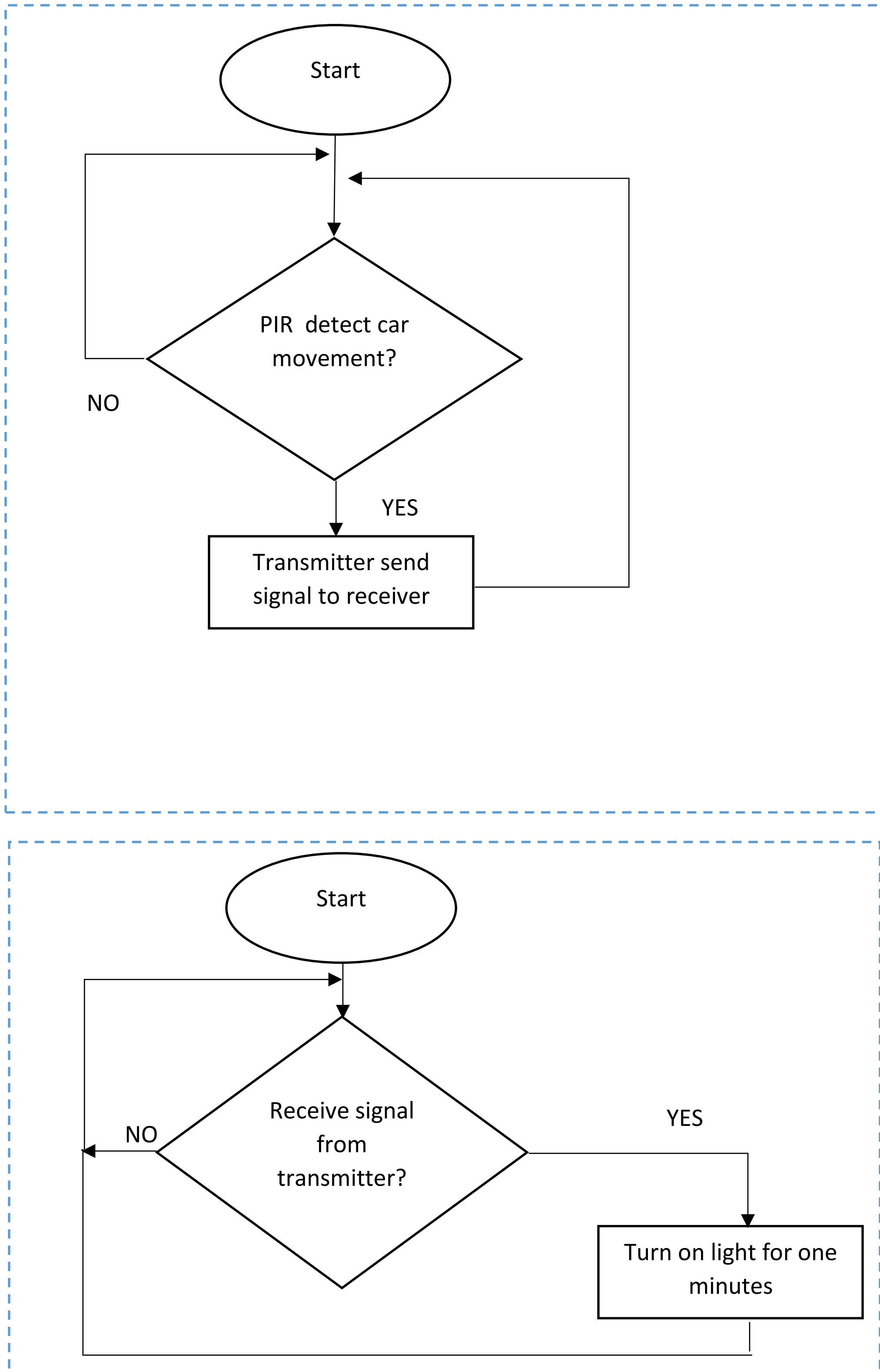

Figure 3.1

3.2.1 Flow Chart Street Lighting System with Energy Saving Consumption

Figure 3.1 show the flow of the smart wireless street lighting system. This system used two microcontroller (Arduino UNO).The first microcontroller act as a master circuit while the other microcontroller act as slave circuit. Besides, for the master circuit, this system requires one passive infrared (PIR) sensor to detect or sense any movement of animals, human or even other objects. The PIR sensor detect any movement from the first and second lane that passing by the master circuit. PIR sensor is a passive electronic device that detects motion by sensing infrared fluctuations. It is made up of crystalline material which generates surface electric charge when exposing to heat in the form of infrared. In our system, these PIR sensor act as input signal that will detect any movement (car) on the street light. There is a relay that uses in this system as a switch as well as to make the light from the street light turn on for a several period. This system was programmed to make the street light lighting for one minute. When any movement (cars, motorcycles) pass by the PIR sensor, transmitter (RF433MHz) from the first microcontroller (master circuit) will send the signal to the receiver. This receiver was set up to use the same transmission rate as a transmitter form the first microcontroller so that it only can receive signal from the transmitter from the first microcontroller. When the signal received, street light two will also turn on for one minute. Lastly, the system will loop into the first condition.

3.3 Material and Components Selection

The main components are we going to use for this system are microcontroller which is Arduino UNO, relay module, PIR sensor module as well as RF433MHz transmitter-receiver module. All these components will be purchased by responsibility of the UMP's lab instructors.

3.3.1 Microcontroller

A microcontroller is a self-contained system with peripherals, memory and a processor that can be used as an embedded system. Most programmable microcontrollers that are used today are embedded in other consumer products or machinery including phones, peripherals, automobiles and household appliances for computer systems. Due to that, another name for a microcontroller is "embedded controller." Some embedded systems are more sophisticated, while others have minimal requirements for memory and programming length and a low software complexity. Input and output devices include solenoids, LCD displays, relays, switches and sensors for data like humidity, temperature or light level, amongst others.

The microcontroller that we used in this project is Arduino UNO. The Arduino Uno (Figure 3.3) is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. There are two different role of Arduino UNO that have been used in this project. The first Arduino UNO was used as a master module and the other one was used as a slave module. For the master module, the arduino was programmed to transmit the signal that was detected by the PIR sensor to the second slave module.

Features of the Arduino UNO:

- 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 of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

Figure 3.2 : Arduino UNO

3.3.2 Relay module

Relay is device that use to power up electrical equipment using microcontroller as in this project use Arduino and relay is the best solution for this project. This relay module support one channel and can connect up to one electrical application inside home, office or industrial. The module is driven by rectangular where it provide an isolation ground between microcontroller and relay and if there are and electrical break down or trip, the microcontroller can be save form that damage. This relay module will be used to control the period of the on and off of the street light, it receive the command from Arduino board. This relay module is a single pole double throw (SPDT) configuration such relay 5 terminal pins which consist of a pair of coil pin, a normally open pin, and normally closed pin.

When the relay not activated, the common pin is in contact with the NC (normally close) pin. When the relay is not activated, the common pin will break away from contact with the NC pin and subsequently make contact with the NO (normally open) pin. Besides, when the relay is deactivated from activated state; the common pin will conversely break away from contact with the NO pin and return back in contact with the NC pin.

Technical specification of relay module:

- 12V 1-channel relay interface board, and each one needs 15-20mA driver current.
- Equipped with high current relay, AC250V, 10 A; DC30V 11A
- Standard interface that can be controlled directly by microcontroller
- Indication LED's for relay output status.
- Dimension 50mm x 26mm x 18.5mm
- Screw dimension 3.1 mm diameter,44.5mm x 20.5mm
-

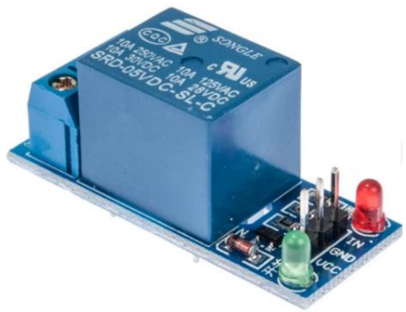

Figure 3.3 : Relay module

3.3.3 PIR sensor

PIR sensor is one of the important component in this project.In this smart wireless street lighting system, the PIR sensor are attached out of the box of master module. This sensor will detect if there are any vehicles passing through the master module. PIR sensors allow to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors.

IRs are basically made of a pyroelectric sensor , which can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation is emitted. The sensor in a motion detector is actually split in two halves. The reason for that is that we are looking to detect motion (change) not average IR levels. The two halves are wired up so that they cancel each other out. If one half sees more or less IR radiation than the other, the output will swing high or low.

Technical specification of PIR sensor

- Size: Rectangular
- Output: Digital pulse high (3V) when triggered (motion detected) digital low when idle (no motion detected). Pulse lengths are determined by resistors and capacitors on the PCB and differ from sensor to sensor.

- Sensitivity range: up to 20 feet (6 meters) 110° x 70° detection range
- Power supply: 5V-12V input voltage for most modules (they have a 3.3V regulator), but 5V is ideal in case the regulator has different specs

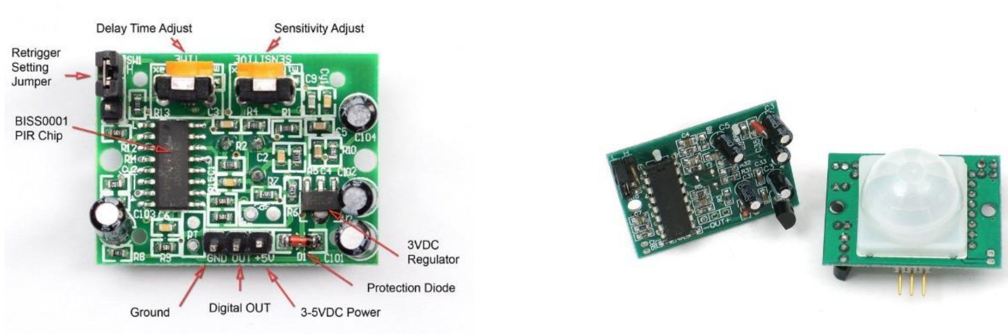

Figure 3.4 : PIR sensor

3.3.4 RF433MHz Transmitter-Receiver

RF433MHz Transmitter – Receiver are the components that are playing the important role in this smart wireless streetlight system. In this system, transmitter inside the master module will send the signal that are receive from the PIR sensor to the slave module. The slave module receive the signal from transmitter trhough the receiver that are inside the slave module.

RF wireless Transmitter & Receiver Module 433Mhz are allow Arduino to wirelessly communicate with other Arduinos or with radio frequency (RF) control device that operate in the same frequency (433MHz in this case). They work in pairs which need both a receiver and transmitter to communicate with each other. The receiver has 4 pins but actually need only 3 of them which are GND (Ground), (VCC) (5V) and one DATA pin.

Technical specification Transmitter

- Working voltage: 3V～12V
- Working current: max≤40mA (12V), min≤9mA(3V)
- Resonance mode: sound wave resonance (SAW)

- Modulation mode: ASK /OOK
- Working frequency: 315MHz-433.92MHz, customized frequency is available.
- Transmission power: 25mW (315MHz at 12V)
- Frequency error: +150kHz (max)
- Velocity: ≤10Kbps
- Self-owned codes: negative

Technical specification Receiver

- Working voltage: 5.0VDC +0.5V
- Working current:≤5.5mA (5.0VDC)
- Working principle: single chip superregeneration receiving
- Working method: OOK/ASK
- Working frequency: 315MHz-433.92MHz, customized frequency is available.
- Bandwidth: 2MHz (315MHz, having result from testing at lowing the sensitivity 3dBm)
- Sensitivity: excel –100dBm (50Ω)
- Transmitting velocity: <9.6Kbps (at 315MHz and -95dBm)

Figure 3.5 : RF 433MHz Transmitter – Receiver

3.3.5 9V Batterty

This smart wireless streetlighting system use 9V of battery to power up the system. A 9V battery will be connected to the Arduino to make the system function. The 9V battery is the most common form was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top.

Battery Type	Capacity (mAh)	Typical Drain (mA)
D	13000	200
C	6000	100
AA	2400	50
AAA	1000	10
N	650	10
9 Volt	500	15
6 Volt Lantern	11000	300

Table 3.1 : Conservative Power Rating for Battery

The battery capacity will be better with lower drain currents.To determine the battery life, divide the capacity by the actual load current to get the hours of life. A circuit that draws 10 ma powered by a 9 volt rectangular battery will operate about 50 hours: 500 mAh /10 mA = 50 hours

Figure 3.6 : 9V Battery

3.3.6 Connectors

The battery has both terminals in a snap connector on one end. The smaller circular (male) terminal is positive, and the larger hexagonal or octagonal (female) terminal is the negative contact. The connectors on the battery are the same as on the connector itself; the smaller one connects to the larger one and vice versa. The same snap-style connector is used on other battery types in the Power Pack (PP) series. Battery polarization is normally obvious since mechanical connection is usually only possible in one configuration. A problem with this style of connector is that it is very easy to connect two batteries together in a short circuit, which quickly discharges both batteries, generating heat and possibly a fire. Because of this hazard, 9-volt batteries should be kept in the original packaging until they are going to be used. An advantage is that several nine-volt batteries can be connected to each other in series to provide higher voltages.

Figure 3.7 : Connector

3.3.7 Waterproof Electrical Junction Box

This waterproof electrical junction box were used to cover this systems's circuit. Sometimes an electrical box is needed on the outside of your home, garage, or building. For this reason, a special type box and associated accessories must be used. Weatherproof boxes are the solution to achieving a weatherproof connection point outside. These boxes, when connected properly, seal out the weather without worry of moisture getting in and shorting out the connection

Figure 3.8 : Waterproof Electrical Junction Box

3.4 Block Diagram

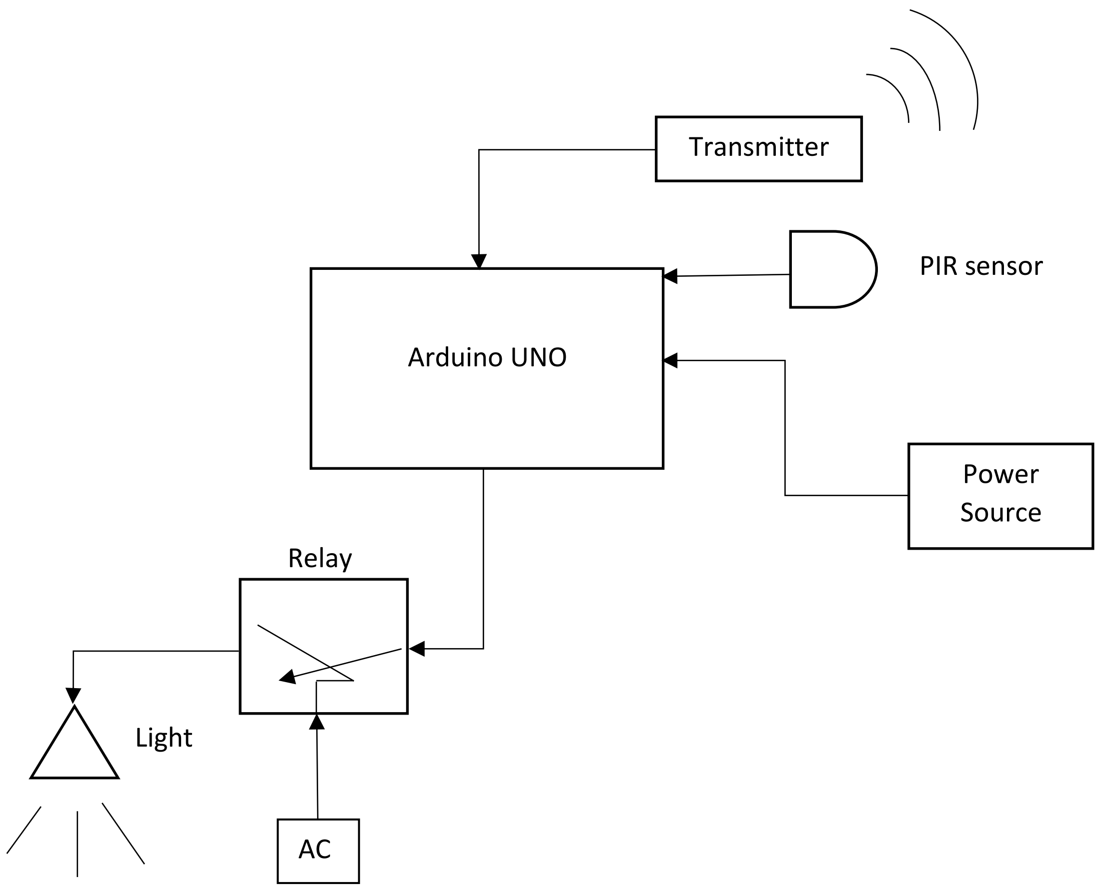

Figure 3.9 : Master Module Block Diagram

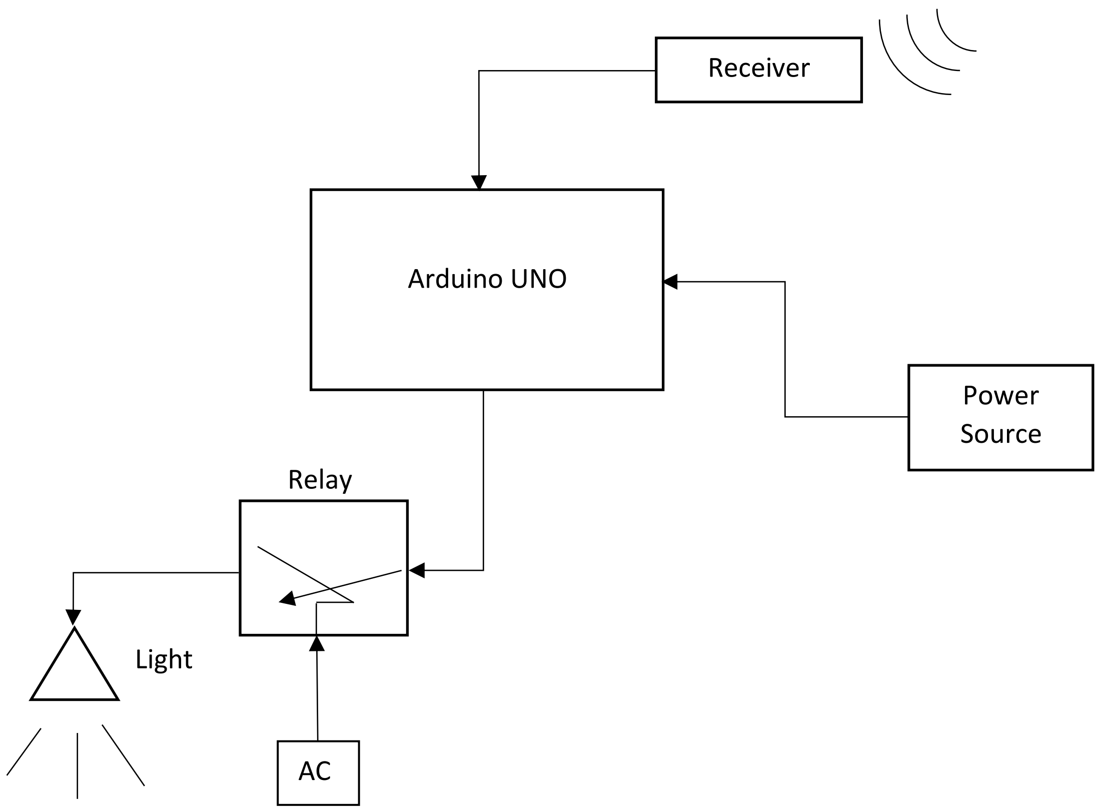

Figure 3.10 : Slave Module Block Diagram

3.5 Circuit Diagram

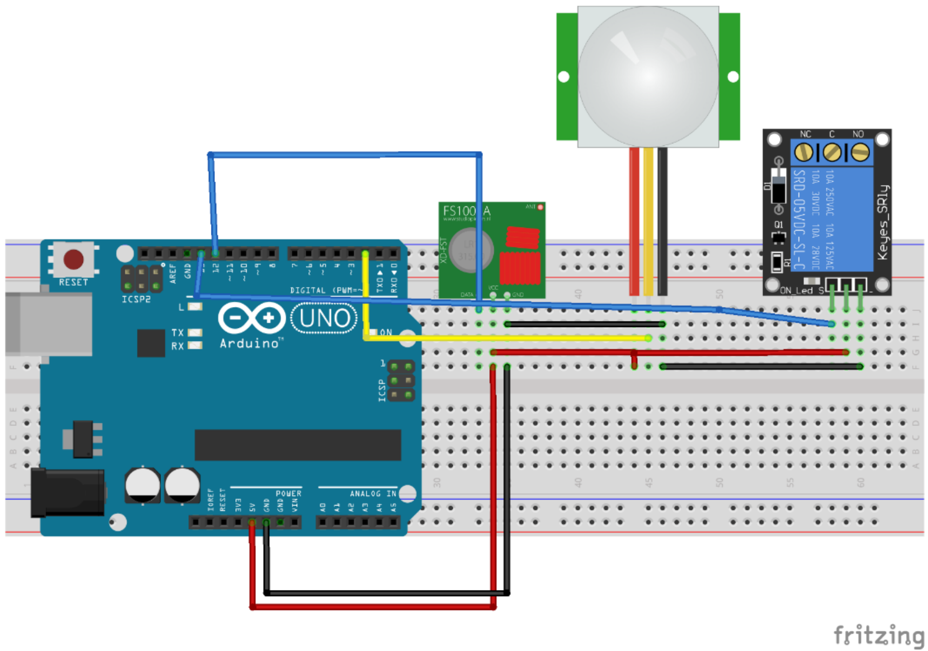

Figure 3.11 : Master Module Circuit

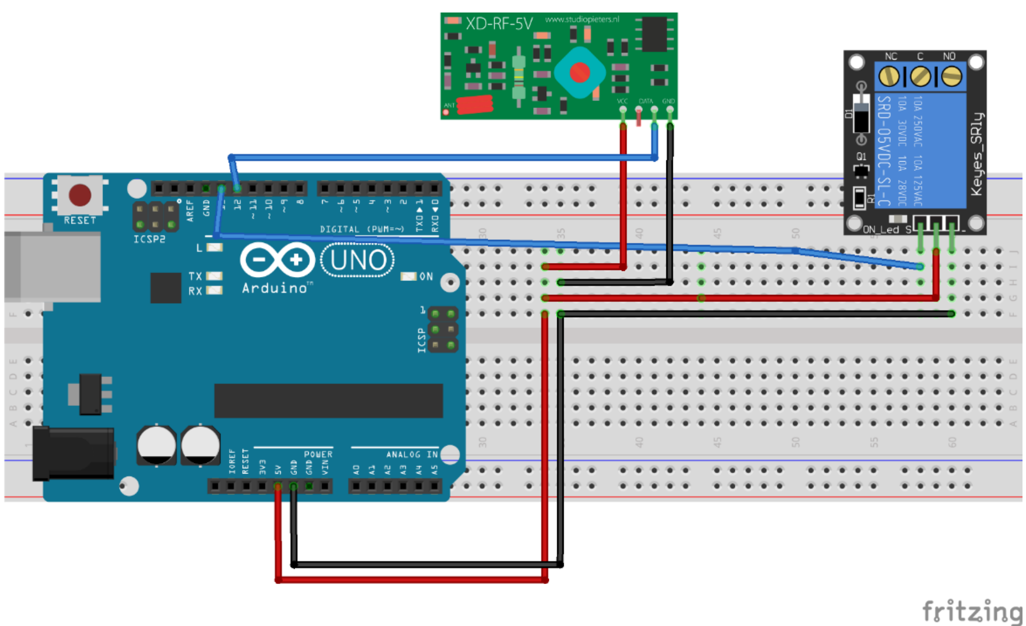

Figure 3.12: Slave Module Circuit

3.7 Testing the Circuit

We were decide to implement and assamble all the circuit in the printed circuit board (PCB) which where the electronic component will be fixed and look tidy. Upon finished assembled the circuit, we proceed with the circuit testing to check whether the circuit is fully connected or not. We tested the circuit with the multimeter to check whether all the component in the PCB have continuity. When there have continuity in between the components, the multimeter will make “beep” sound.

Figure 3.13: Testing the circuit

3.8 Develop Programming Coding

The programming are developed in order to execute the input data to output in order to make make sure all the components in the circuit well function as well as the system work fine.

3.9 Field Testing

The field testing is done at block T assembly point and the exit road of UMP Gambang. Based on the field testing, the range of signal from transmitter and receiver can be identified.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Calculation of Energy Usage in Streetlight

Normally, streetlight in Malaysia used bulbs with power 250 watt. . By estimating the normal condition, the streetlight with power 250 watt will light up at 7 pm to 7 am, which is 12 hours a day. By using this smart wireless streetlighting system, the usage of energy on the street light will be less than normal condition street light.

4.1.1 Normal Street Light

i) Street light power for a day use :

0.25kw x 12h/day = 3kwh

So one street light will consume 3kwh/day for normal condition.

ii) Cost for one street light in a day :

3kwh/day x 19.2sen/kwh = 57.6sen

iii) Cost for one street light in a year :

57.6sen/day x 365 day/ year = RM 210.24

Therefore, in a year the authority will spend RM 210.24/ year for one street light.

4.1.2 Smart Wireless Street light System

By implementing the system, estimate the average streetlight used in a day are 6 hour.

i) Street light power for a day use :

0.25kw x 6hr = 1.5kwh

ii) Cost for one street light in a day :

1.5kwh/day x 19.2sen/kwh = 28.8sen

iii) Cost for one street light in a year :

28.8sen/day x 365 /year = RM105.12

From the calculation, after implement, the system the energy consume is 1.5kwh/day and the authority will spend RM105.12/year.

Normal street light	Smart wireless streetlighting system
12 hours per day	6 hours per day
3kWh per day	1.5kWh per day
RM 210.24 per year	RM 105.12 per year

Table 4.1: The comparison between normal streetlight and smart streetlight.

Form the comparision, the energy usage when implementing smart wireless streetlighting system will be less about 50% from the normal street light. The energy usage for this system may be different base on the place of this system implemented.

4.2 Cost Analysis

Transmitter (Master) Module

Components and Materials	Price
Waterproof Electrical Junction Box	RM 13.00
Arduino UNO	RM 20.00
5V Relay Module	RM 10.00
RF 433MHz Transmitter	RM 5.00
Radio Antenna	RM 1.00
9V Battery Connector	RM 2.00
9V Battery	RM 5.50
PIR Sensor	RM 5.50
Total	RM 62.00

Table 4.2 : Cost for one Master Module

Receiver (Slave) Module

Components and Materials	Price
Waterproof Electrical Junction Box	RM 13.00
Arduino UNO	RM 20.00
5V Relay Module	RM 10.00
RF 433MHz Transmitter	RM 5.00
Radio Antenna	RM 1.00
9V Battery Connector	RM 2.00
9V Battery	RM 5.50
Total	RM 56.50

Table 4.3 : Cost for one Slave Module

The table 4.4 show the cost analysis for one group streetlight which consist of one master module and two slave modules.

Item	Quantity	Cost/unit (RM)	Cost
Arduino UNO	3	RM 20.00	RM 60.00
Pyroelectric Infrared PIR Motion Sensor Detector Module w/ 3-pin Cable for Arduino - Blue + White	1	RM 5.50	RM 5.50
RF 433MHz Transmitter-Receiver	3	RM 5.00	RM 15.00
5v Relay	3	RM 10.00	RM 30.00
Waterproof Electrical Junction Box	3	RM 13.00	RM 39.00
9v battery	3	RM5.50	RM 16.50
Battery connector	3	RM2.00	RM 6.00
Radio antenna	3	RM 1.00	RM 3.00
Total			RM 175.00

Table 4.4 : Cost analysis for one group of streetlight

After implementing the system, the total expenditure for one group is

RM105.12 X 3 = RM 315.16

Time taken to cover the cost for one group of this system is

RM 175.00/RM 315.16 = 0.55 year, which is equivalent to 200 days.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this project, we have completed the designing the smart wireless streetlighting system with the guidance from our supervisor, technical staff from our faculty as well as our friends. Besides that, this smart wireless streetlighting system has meet their objectives. This smart wireless streetlighting system is a system with energy efficient system in different ways such as the use of LED in street light and solar powered street light which save a vast amount of power every year. Unlike typical lighting system which consumes large amount of power, this system is able to minimize the power consumption as well as can save the environment in terms of emission of CO_2 gas. Although the initial cost to install this systems are more than normal street light, the installation cost for one group of this system can be covered between 200 days. After 200 days, we can use the street light for free and just minor maintenance for the components inside the system.

There are few limitations in our project which is the major drawback of our project. In this project, we used 5V bulbs instead of using street light bulb as we didn't have authority to operate with it. Furthermore, the RF433MHz Transmitter- Receiver that we are using are not very stable and the range for this transmitter and receiver are not very long. In order to overcome this problem, we tried to attach antenna to the transmitter and receiver. However, the type of antenna also need to be considered in order to get the optimum range for the transmitter and receiver. There are few types of antennas that we had tried to used such as single core wire, coaxial cable as well as rabbit antenna.Among these three antennas, we found that the rabbit antenna can give the long range which is up to 100m. The antenna also difficult to solder at the RF433 transmitter receiver since the component is very sensitive and easy to blow.

5.2 Recommendations

As for the recommendation, use the long range transmitter receiver module which has further range in order to improve the efficiency of this system. Besides, identify the ideal length of antenna to improve the range of signal as well as the best material for the antenna. Lastly, is do some research related to this system to improve it function such as at the function to active this sistem only in peak hours as well as perform the experiment by using the real sample of streetlight to obtain the better data for the consumption.

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APPENDIX A

Charge and Tariff Rates fron Ternaga Nasional Berhad

Charges and Tariff Rates

"Street Lighting Consumer" means a consumer lighting up public roads, highways and bridges excluding tolled roads and highways.

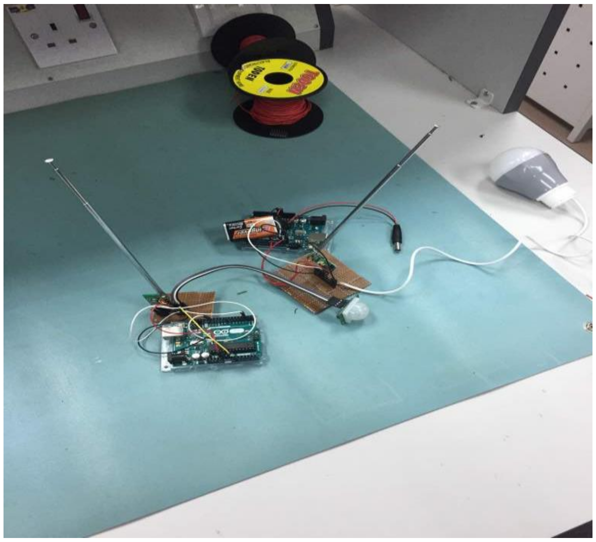
"Neon & Floodlight Consumer" means a consumer lighting up neon and floodlight installations for roadside advertisements, billboards, buildings, traffic lights, signages, bus-stops and telephone kiosks or for decorating the facade of buildings. For this purpose, the consumer must install facilities for separate metering system and pay full installation costs incurred by TNB to provide the supply.

TARIFF CATEGORY	CURRENT RATE (1 JAN 2014)
TARIFF G - STREET LIGHTING TARIFF	
For all kWh (including maintenance)	30.5 sen/kWh
For all kWh (excluding maintenance)	19.2 sen/kWh
The minimum monthly charge is RM 7.20	
TARIFF G1 - NEON & FLOODLIGHT TARIFF	
For all kWh	20.8 sen/kWh
The minimum monthly charge is RM 7.20	

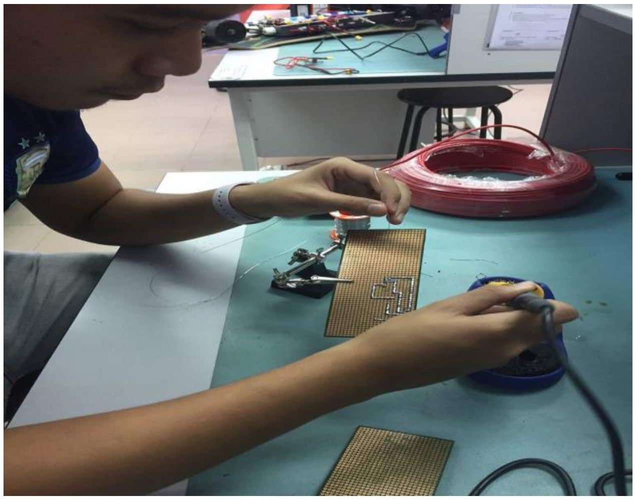
APPENDIX B

Photos

a) Testing Circuit



b) Soldering process



c) Master module

d) Slave module

APPENDIX C

Coding

a) Master Module

tx §

```
//Master Module
// Include VirtualWire library
#include <VirtualWire.h>

int led_pin = 13;
int transmit_pin = 12;
int pir_pin = 2;
int val = 0;
int pir_state = LOW;

void setup()
{
   Serial.begin(9600);
   vw_set_tx_pin(transmit_pin);
   vw_setup(4000); // Transmission rate
   pinMode(led_pin, OUTPUT);
   pinMode(pir_pin,INPUT);
}

void loop()
{
  char msg[1] = {'0'};
  // Get sensor value
  val = digitalRead(pir_pin);
  // Change message if motion is detected
  if (val == 1)
  {
      msg[0] = '1';
      digitalWrite(led_pin, HIGH); // Flash a light to show transmitting
      vw_send((uint8_t *)msg, 1);
      vw_wait_tx(); // Wait until the whole message is gone
      if (pir_state == LOW)
      {
      Serial.println("Motion detected!");
      pir_state = HIGH;
      }
   }
 else
 {
   msg[0] = '0';
   digitalWrite(led_pin, LOW);
   vw_send((uint8_t *)msg, 1);
   vw_wait_tx(); // Wait until the whole message is gone
   if (pir_state == HIGH)
   {
      Serial.println("Motion ended!");
      pir_state = LOW;
   }
  }
}
```

b) Slave Module

rx §

```
// Slave Module
// Include VirtualWire library
#include <VirtualWire.h>

// Pins definition
const int led_pin = 13;
const int receive_pin = 12;

void setup()
{
   Serial.begin(9600); // Debugging only
   // Initialise the IO and ISR
   vw_set_rx_pin(receive_pin);
   vw_setup(4000); // Transmission rate
   // Start the receiver PLL
   vw_rx_start();
   // Set LED pin and Buzzer
   pinMode(led_pin, OUTPUT);
}

void loop()
{
   uint8_t buf[VW_MAX_MESSAGE_LEN];
   uint8_t buflen = VW_MAX_MESSAGE_LEN;

   // Check if a message was received
    if (vw_get_message(buf, &buflen))
    {
      if(buf[0]=='1')
      {
      Serial.println("Motion detected!");
      digitalWrite(led_pin,1);
      delay(60000);
      }
     if(buf[0]=='0')
     {
     Serial.println("Motion ended!");
     digitalWrite(led_pin,0);
     delay(300);
     }
   }
}
```