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DEVELOPMENT OF SOLAR POWERED SMART TRAFFIC LIGHT SYSTEM

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Bachelor of Electrical Engineering
(Power Industry)

June 2014

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"I hereby declare that I have read through this report entitle '*Development of Solar Powered Smart Traffic Light System*' and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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MOHAMAD FIRDAUS BIN ARIFIN

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electrical Engineering
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2013

"I declare that this report entitle '*Development of Solar Powered Smart Traffic Light System*' 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 : .....

Student's Name : Mohamad Firdaus Bin Arifin

Date : .....

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To my beloved mother and father

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In preparing this report, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and thought. In particular, I wish to express my sincere appreciation to my main project supervisor, Dr. Abdul Rahim bin Abdullah, for encouragement and guidance. I am also very thankful to my co-supervisors Cik Hazahsha Binti Shamsudin for his guidance, advice and motivation. Without their continued support and interest, this project would not have been same as presented here.

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ABSTRACT

Congestion is a normal situation in our daily lives. People need to face this problem especially when driving during peak hours in big cities with lots of traffic lights. They still can plan their route earlier to avoid traffic jams, differently with emergency vehicle with unpredictable time travel. The purpose of this project is to develop and design a new technology that will overcome this problem. The current study used sensor to detect the number of cars on each side of the junction and gives long time for green lamp of traffic light to reduce the congestion. However, there is still no priority given to the emergency vehicle by the system. Thus, this project will introduce a bypass system with the development of GPS and XBee wireless communication to make sure that emergency vehicle keeps moving at a traffic light junction although they have longer queue due to saturation of traffic flow. GPS installed in the emergency vehicles will capture their current coordinate and XBee will transmit it to the nearest traffic light controller that also use XBee receiver. The traffic light controller will be triggered to the keep green light ON and at the same time turning ON the red light for the other phase of the junction until the emergency vehicle passes through traffic light. The system in this project is portable and can be easily used or transferred into different types of emergency vehicle. In order to support the green technology, this device is equipped with a battery and a solar panel to auto re-charges its battery when in used.

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ABSTRAK

Kesesakkan lalulintas merupakan suatu pekara yang normal dalam kehidupan seharian. Masyarakat akan berdepan dengan masalah ini apabila memandu pada waktu puncak terutamanya didalam bandar besar yang terdapatnya banyak lampu isyarat. Pengguna boleh merancang perjalanan mereka lebih awal bagi mengelakkan kesesakan lalu lintas tersebut. Kajian terkini menggunakan pengesan *'sensor'* bagi mengesan bilangan kenderaan di setiap persimpangan dan memberikan fasa hijau yang lama untuk mengurangkan kesesakkan lalulintas. Walau bagaimanapun, sistem tersebut masih tidak memberi keutamaan kepada kenderaan kecemasan. Oleh itu, projek ini akan memperkenalkan sebuah sistem dengan pembangunan *GPS* dan komunikasi tanpa wayar *XBee* untuk memastikan kenderaan kecemasan ini dapat terus bergerak dengan lancar walaupun berdepan dengan kesesakkan lalulintas yang teruk. Sistem *GPS* yang dipasang pada kenderaan kecemasan akan menentukan koordinat terkini kenderaan kecemasan tersebut, *XBee* pemancar akan menghantar isyarat kepada pengawal lampu isyarat terdekat melalui *XBee* penerima. Pengawal lampu isyarat tersebut akan mangaktifkan lampu hijau pada laluan tersebut dan dalam masa yang sama mengaktifkan lampu merah pada laluan yang lain sehinggalah kenderaan kecemasan tersebut melepasi persimpangan. Sistem yang dibangunkan ini adalah mudah alih dan sesuai untuk pelbagai jenis kenderaan kecemasan yang lain. Dalam menyokong teknologi hijau, sistem ini akan dimuatkan dengan bateri yang dicas oleh panel solar apabila digunakan.

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TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	LIST OF FIGURE	ix
	TABLE OF CONTENTS	x
1	**INTRODUCTION**	**1**
	1.1 Project Background	1
	1.2 Problem Statement	2
	1.3 Objective	4
	1.4 Scope of Work	4
2	**LITERATURE REVIEW**	**5**
	2.1 Literature Survey	5
	2.2 Literature of Microcontroller	8
3	**METHODOLOGY**	**11**
	3.1 Project Planning	11
	3.2 Project Development Workflow	13
	3.3 Software Implementation	15
	3.4 Hardware Implementation	18
4	**RESULT AND ANALYSIS**	**37**
	4.1 GPS Validation Testing	37
	4.2 XBee Wireless Communication Testing	39
	4.3 Boost Bypass System Testing	41
	4.4 GPS Satellite Connection Testing	42
	4.5 Charge And Discharge Testing	44
5	**CONCLUSION AND RECOMMENDATION**	**46**
	5.1 Conclusion	46
	REFFERENCE	47
	APPENDICES	49

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LIST OF FIGURE

FIGURE	TITLE	PAGE
1.1	Ambulance crashing at intersection of MYDIN Ayer Keroh.	3
1.2	Other road users crashing when giving priority to ambulances	3
2.1	PIC microcontroller	10
2.2	Arduino microcontroller	10
3.1	Project Workflow	14
3.2	Proteus software	15
3.3	Proteus design environment	16
3.4	Arduino Software	17
3.5	Arduino Compiler	17
3.6	Flowchart Solar Power Smart Traffic Light System.	18
3.7	Flowchart Solar Power Smart Traffic Light System (continue)	19
3.8	Schematic diagram of transmitter system	21
3.9	XBee wireless	22
3.10	Installation for transmitter and receiver system	24
3.11	GPS Module	25
3.12	Overview GPS module receive positioning information	26
3.13	Arduino Uno	27
3.14	Division of intersection	28
3.15	LCD display	29
3.16	Boost intercepts button	30
3.17	Normal traffic congestion	31
3.18	Extreme traffic congestion	31
3.19	Solar panel	30
3.20	Lithium ion battery	31
3.21	Receiver Circuit	33
3.22	Existing Traffic Light controller	33
3.23	Bypass System	33
3.24	Relay controller system	32
3.25	Relay double pole double through connection	34
3.26	Relay controller circuit	34
3.27	Transmitter devices	35
3.28	Receiver devices without cover	36
3.29	Receiver devices with cover	36
4.1	Coordinate displayed on LCD	38
4.2	Coordinate displayed on Google Earth Software	38
4.3	Emergency vehicle come from Block A to Block E	39
4.4	Emergency vehicle come from Block F to Block E	39
4.5	Coordinate distance calculator	40
4.6	Charge by Power Supply	44
4.7	Charge by Solar Panel	44
4.8	Batteries Discharge	45

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CHAPTER 1

INTRODUCTION

This chapter discusses about the project background, project motivation, problem statement, project objective, project scope and the expected result. This chapter also shows the view of the research work.

1.1 Project Background

Nowadays, the increasing number of cars on roads has created many problems, such as traffic congestion, the huge number of people who get killed in car accidents, and has a negative impact on the environment due to the huge amount of fuel consumption especially in highly congested traffic areas etc [1]. Traffic light control is a common feature throughout the world, controlling number of vehicles. Their main goals are improving the traffic safety at the intersection, maximizing the capacity at the intersection and minimizing the delays. However, there is still no priority given to the emergency vehicle by the system [2].

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Emergency vehicles such as ambulances, police force vehicles and fire fighting vehicles are required to reach their destination as quickly as possible [3]. Any unnecessary delays experienced on them along their way could eventually cause dangerous events leading to damages in lives or properties. One of the most important delays is the time that is consumed on travelling between the starting point and the destination point of these emergency vehicles and in intersections with traffic lights especially when these intersections are congested. In development of this project will discuss the design and implementation of an automatic pre-emption traffic light control system, based on the development of XBee wireless communication system and GPS system. The primary objective is to identify the

emergency vehicle and track its location so that we can provide a green light to the emergency vehicle. It ensures the arrival of emergency vehicles to their destinations on the minimum time possible. The results indicate that the proposed system has an optimum solution for the delay time experienced on the emergency vehicles along their path.

1.2 Problem Statement

Since the earliest times, emergency vehicles approaching intersections have depended upon sirens, horns, or other types of audible or visible warning devices to alert other people in the intersection. As we know, every emergency vehicles such as ambulances, police force vehicles and fire fighting vehicles are required to reach their destination as quickly as possible. Traffic congestion is the main problem faced by emergency vehicles because of blockage by other road users. After that, conventional traffic light controller system in Malaysia helps in reducing the traffic congestions but does not provides priority for emergency vehicles. This matter makes difficult for emergency vehicles to arrive at the location early.

Unfortunately accidents involving emergency vehicles often occur at intersections due to confusion, impaired hearing, inattention, noise conditions or overly aggressive drivers want to clear the intersection before the arrival of the emergency vehicle [4]. Figure 1.1 [5], and Figure 1.2 [6] shows an accident involving an emergency vehicle and others roads users.

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Figure 1.1: Ambulance crashing at intersection of MYDIN Ayer Keroh

Figure 1.2: Other road users crashing when giving priority to ambulances

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1.3 Objectives

The objectives of this project are

1. To design and develop a solar power smart traffic light system.
2. To integrate the system with hospital by using wireless communication system.
3. To analyze the performance of the proposed system.

1.4 Scope of Work

This project is divided into two major parts which are software and hardware system. Both of systems have its own criteria and scope of the project. The scope of the project are shown below:

Hardware system

1) Understand the operation of the XBee wireless communication, Arduino Uno as microcontroller and GPS module.
2) Design suitable circuit parameter for the transmitter and receiver system.

Software system

1) Write Arduino coding language for transmitter and receiver system
2) Using Arduino compiler to program the Arduino Uno as a microcontroller
3) Simulate the circuit by using Proteus and choose the suitable parameters for the circuit

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CHAPTER 2

LITERATURE REVIEW

In this chapter, the literature has been studied to collect the idea and information that related to the system development corresponding to the project. This kind of information is taken from books, journals, thesis, proceeding conferences and others from previous researchers. For this chapter, it covers about the basic principles, review of previous related work, and summary of this project.

2.1 Literature Survey

The increasing number of vehicle led to occurrence extreme congestion, especially in large cities. To overcome this problem, many innovations of traffic light system are designed. One of the innovations that have been develop is call dynamic programming system (DP)[7]. This system has been developed by Tsin Hing Heung and Tin Kin Ho. This system will devided the green time delay for each junction. Each junction is equipped with a local controller and the projected traffic flow from the adjacent junction is the coordination parameter confining the possible control space. The assignment of green time to each phase of a traffic cycle is considered as a multistage control problem with a finite number of possible control actions at each stage. Dynamic programming (DP) is then adopted to facilitate coordination.

Ehsan Azimirad, Naser Pariz, and M. Bagher Naghibi Sistani make improvement by develop a system calls Fuzzy Logic Controller (FLC) [8]. The techniques used in this system which is by control the traffic light time delay. The time delays depend with the number of vehicle at each lane. Therefore when the presence of many vehicles, the time delays become

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longer. By using this system, vehicle detector needs to install at the traffic light junction. It will count the number of vehicle at the junction and the data will process by microcontroller. By using this system, it will minimize traffic congestion. This system focuses in reducing the traffic congestion but do not give priority to emergency vehicles.

Nowadays, wireless communication systems are widely used. There are many types of wireless communication devices in the market which have the features and its own design. Among of wireless communication devices in the market which is Wi-Fi, ZigBee, XBee, Bluetooth and so on. S. Edwards in his studies use ZigBee as a wireless communication technology. The wireless communication technology that has been used is, to enhance the safety of road user such as car, lorry and so on. He introduced a sensor that installed inside a car that can communicate with road signboard through ZigBee wireless communication. By using ZigBee wireless communication system, road safety information that can be sent from sender to the road signboard. The main function of this system is to make sure the driver always alert along his journey. Besides that, this system are also provide detection of emergency vehicle and give the priority to the emergency vehicle when approaches to the intersection [9]. The emergency vehicle was equipped with a Smartdust WICO which broadcast a beacon message on the emergency trip. Smartdust WICOs were placed in the infrastructure to relay this message to the traffic light regulator. The traffic regulator was programmed to attend to the trigger signal provided. The traffic regulator was given time to change its status taking into account the time lost because of communication mechanisms and other time periods required.

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Table 2.1: Comparison between FLC, DP and Wireless technology systems

	System	Disadvantage
Dynamic Programming (DP)	Divide the green light time delays for each junction. The organized control is extend to the adjacent junction by considering the coordinate parameter	Traffic congestion might be reduces, but this system still did not gives priority for emergency vehicle.
Fuzzy logic controller (FLC)	Install a sensors at intersections to detect the number of vehicles, and extend the green light time delays when the presence of many vehicles on the route	This system can reduce traffic congestion, but cannot detect the presence of emergency vehicle
Wireless technology system	Introduced a sensor that install inside a vehicle that can communicate with road signboard via ZigBee, to help road users always alert during travelled	Only to enhance road user safety by sharing road safety information

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Table 2.2: Comparison between Bluetooth, XBee and Wi-Fi

	Bluetooth [10]	**XBee**	**Wi-Fi**
Range	Small coverage range (10m)	Wide coverage range, (<100m)	Middle coverage range (>100m)
Application focus	Cable replacement between device	Monitoring and control	Web, Video Email

Table 2.1 shows the differences between the previous system and mostly all the system did not gives priority to the emergency vehicle. Table 2.2 shows the difference between wireless communication system among Bluetooth, XBee and Wi-Fi. XBee wireless communication systems provided wider range for transmitting a signal which is more that 100m. It will detect the emergency vehicle further distance compare with others. This is one of the advantages XBee wireless communication system.

2.2 Literature of Microcontroller

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Nowadays, there are many type of microcontroller that can be used. By manipulating the input signal, various types of output can be produces. The famous microcontrollers which commonly use are PIC and Arduino microcontroller. Among of these two types microcontrollers have their own advantages and disadvantages. Figure 2.1 and 2.2 shows the design of PIC and Arduino microcontroller. The advantage of Arduino microcontroller which is it has been designed for beginner who has no software or electronic experience. Arduino is capable to make an electronic project that can give output application that responding from input given.

Table 2.3: Advantages of Arduino

Advantages	Details
Inexpensive	Arduino is more cheaper compared to other microcontroller.
Cross-platform	The Arduino software can be run on variety of operating system which is Windows, Macintosh OSX, and Linux. Most microcontroller's software are run only limited on Windows platform.
Open source and extensible software.	The Arduino software is open source and available for extension by experienced programmers. The language can be change or add through C++ libraries, and people who want to understand the technical details can make the leap from Arduino to the AVR-C programming language on which it's based. Similarly, the AVR-C code can be add directly into Arduino programs if needed
Easy to use	Experienced circuit designers can make their own version of the module or inexperienced user can make the module on the breadboard to understand how it work and reduce cost.

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Arduino can response to light intensity, sound, movement, touch and others by depending on sensor attach at the Arduino and from the input sensor, Arduino can give out an output such as variable speed of dc motor, brightness of the LED movement of robot and so on. Arduino is a hardware and it need software to program it. Both hardware and software are called Arduino. Furthermore, it's included a lot of example code to demonstrate how to use Arduino board's facilities. It make easy to people who is beginner in microcontroller which is he or she can refer to the example code while doing code for their project work. There are a lot of Arduino advantages that shown in Table 2.3. In addition, there have Arduino community which is always active and supportive. It can be access through Arduino forum known as Arduino Playground which provided example and solutions to problems. The forum can give a few inspiration and assistance to continue the code of the project.

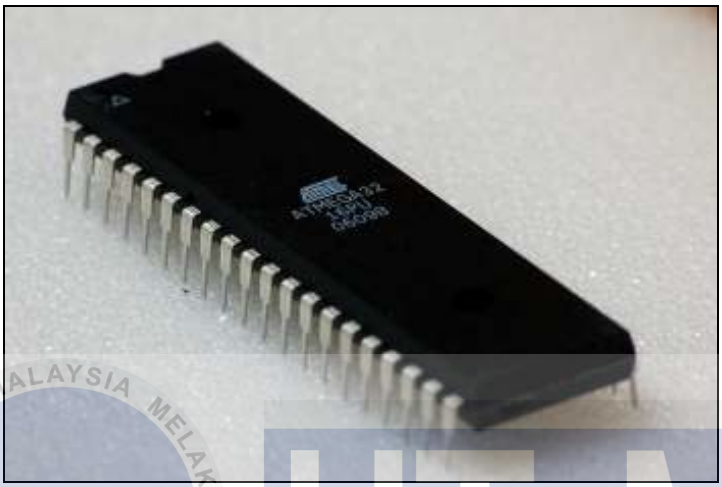

Figure 2.1: PIC microcontroller

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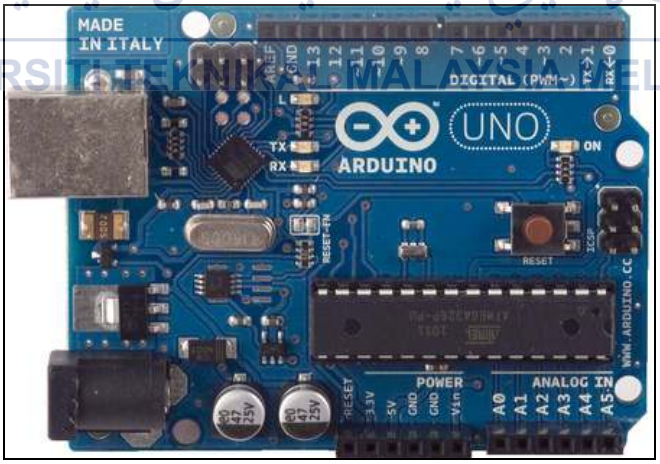

Figure 2.2: Arduino microcontroller

CHAPTER 3

METHODOLOGY

This chapter discusses the methods used in the development of this project. Based on study that have been done by reference of thesis, journals, IEEE articles and several theories the development of this project become clearer. In this topic also will explain that there are several important parts in the development of this project including project planning, the principle, equipment, and components that have been used.

3.1 Project Planning

Project planning is important in ensuring the flow of the project running smoothly. Project planning should be done before a project is started. The main purpose designing of project planning as a guide to the overall action to make it more structured and organized. There are various method of project planning that can be used. In development of this project, gantt chart is used as a method of project planning that have shown in Table 3.1.

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Table 3.1 Project Gantt Charts

Week	FYP 1													
	1	2	3	4	5	6	7	7	9	10	11	12	13	14
TITLE SELECTION														
FYP BRIEFING														
LITERATURE REVIEW														
HARDWARE DEVELOPMENT (DESIGNING CIRCUIT)														
SOFTWARE DEVELOPMENT (PROGRAM SKETCHING)														
HARDWARE DEVELOPMENT (TESTING AND TROUBLESHOOTING)														
REPORT PROGRESS														
SEMINAR 1 (PRESENTATION)														
	FYP 2													
SOFTWARE DEVELOPMENT (PROGRAM TESTING)														
HARDWARE DEVELOPMENT (TESTING AND TROUBLESHOOTING)														
COMBINING ALL ELEMENTS (TESTING)														
BUILD MODEL														
FULL REPORT														
SEMINAR II (FINAL PRESENTATION)														

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3.2 Project Development Workflow

In the development of this project, there are two main parts which are software and hardware. Figure 3.1 shows the workflow in completing this development of project solar powered smart Traffic Light System. Without these two main parts, the development of this project will not be success and complete. Software development can be conducted by using the Arduino programming compiler. The program used will be compiled inside an Arduino compiler to check whether the program complies with the conditions set language. When the set of program does not comply with the compiler set language, the set of program should be rewrite until the compiler can understand the command to be executed.

At the same time, hardware development is also conducted. Hardware development consists of two main parts. The first part is including transmitter system, while the second part is including the receiver system and both parts have their own hardware designs. In order to completing hardware development, testing should be done first on the hardware design to make sure satisfy the requirement. After the development of hardware complete, the next phase is combining between hardware and software. If there is any problem when combining between hardware and software, troubleshooting should be made to solve the problem. This workflow is considered completed if there are no problems and at the same time follows the requirement that has been plan.

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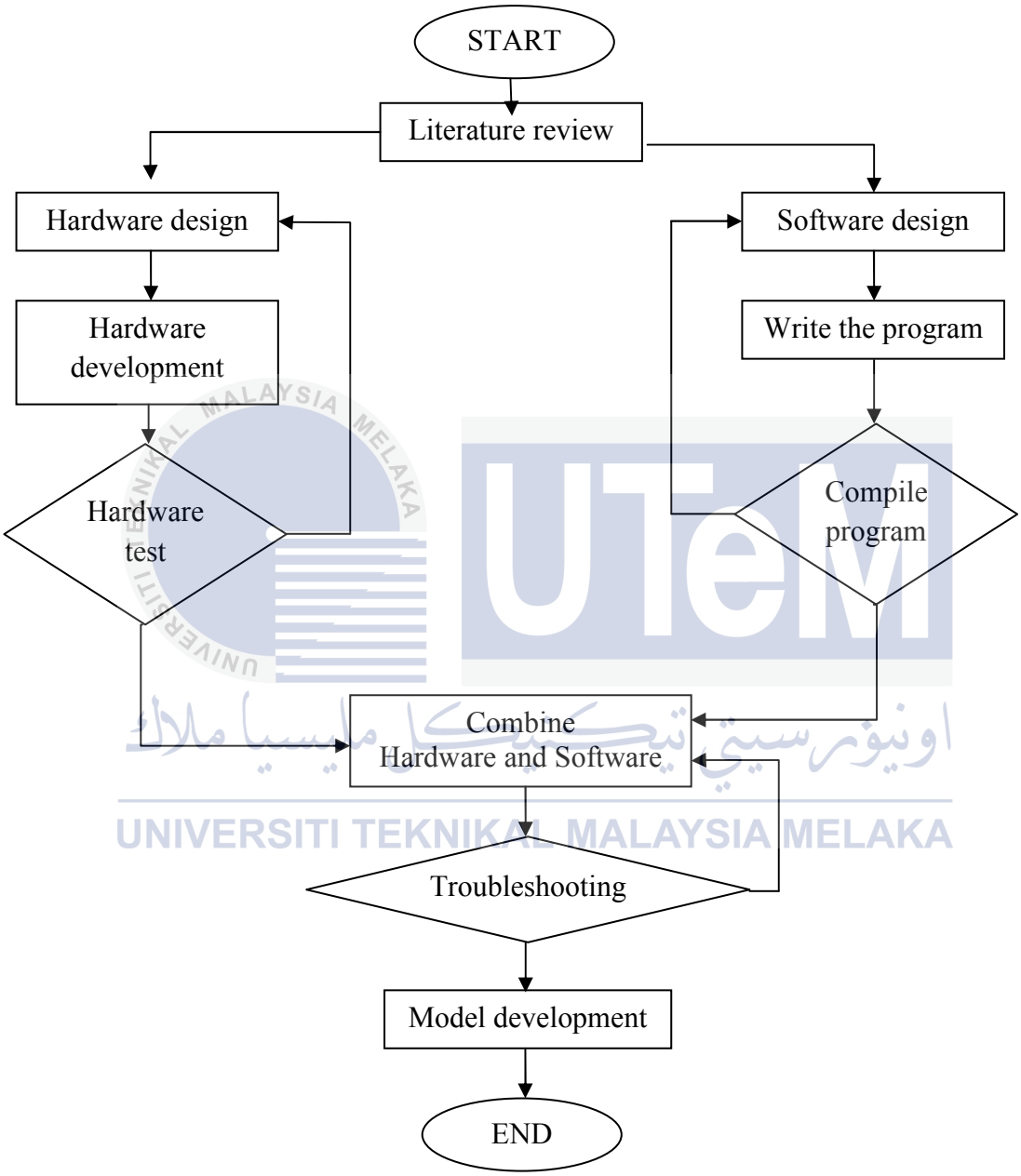

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Figure 3.1: Project Workflow

3.3 Software Implementation

Software implementation is important part in development of this project. There are two types of software that is used which is Proteus version 7.4 and Arduino compiler. Both of this software has different functions.

3.3.1 Proteus Circuit Design

The function of Proteus is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. It is developed by Lab center Electronics. By using this software, users can determine whether the circuit designed can be functioned well or not. Figure 3.2 and Figure 3.3 shows the Proteus software and Proteus design environment. The advantage of this software is consist variety of components inside library component. At the same time, this software is able to interact with the Arduino compiler because Proteus library component contain of Arduino module such as Arduino Uno, Arduino Nano and Arduino Mega.

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Figure 3.2: Proteus software

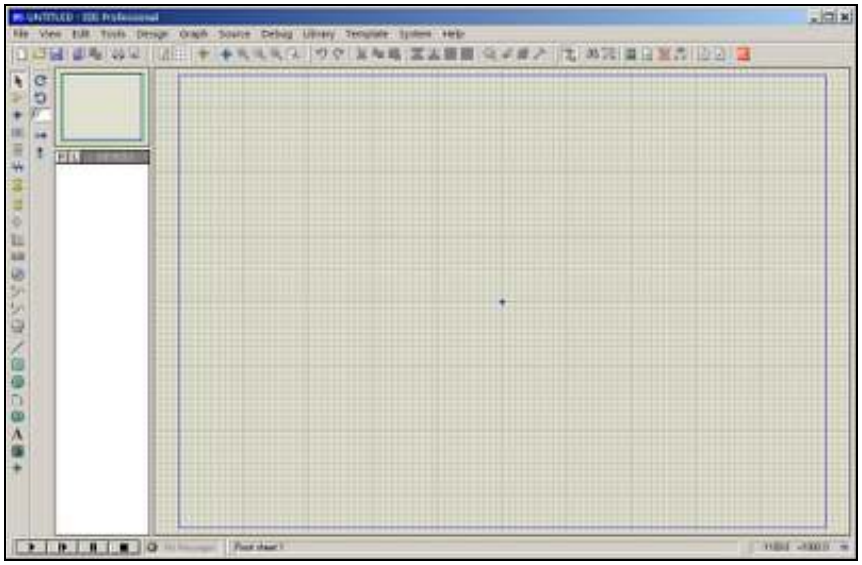

Figure 3.3: Proteus design environment

3.3.2 Arduino Compiler

As a mentioned before, the development of this project is using Arduino Compiler as a programming compiler. The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring projects. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. A program or code written for Arduino is called a "sketch". Arduino programs are written in C or C++. The Arduino IDE comes with a software library called "Wiring" from the original Wiring project, which makes many common input/output operations much easier. Users only need define two functions to make a run able cyclic executive program. Figure 3.4 and Figure 3.5 shows Arduino software and Arduino Compiler.

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Figure 3.4: Arduino Software

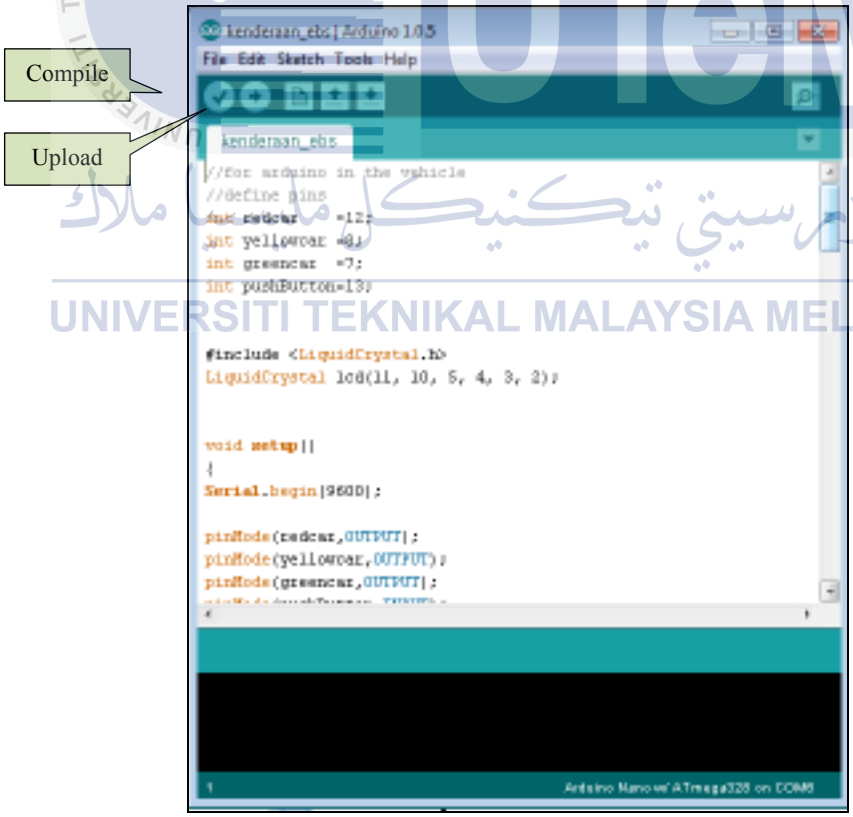

Figure 3.5: Arduino Compiler

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3.4 Hardware Implementation

In the development of this solar powered smart traffic light system project consists of transmitter system and receiver system. Both of elements will be discussed later.

3.4.1 Flow Chart of the System

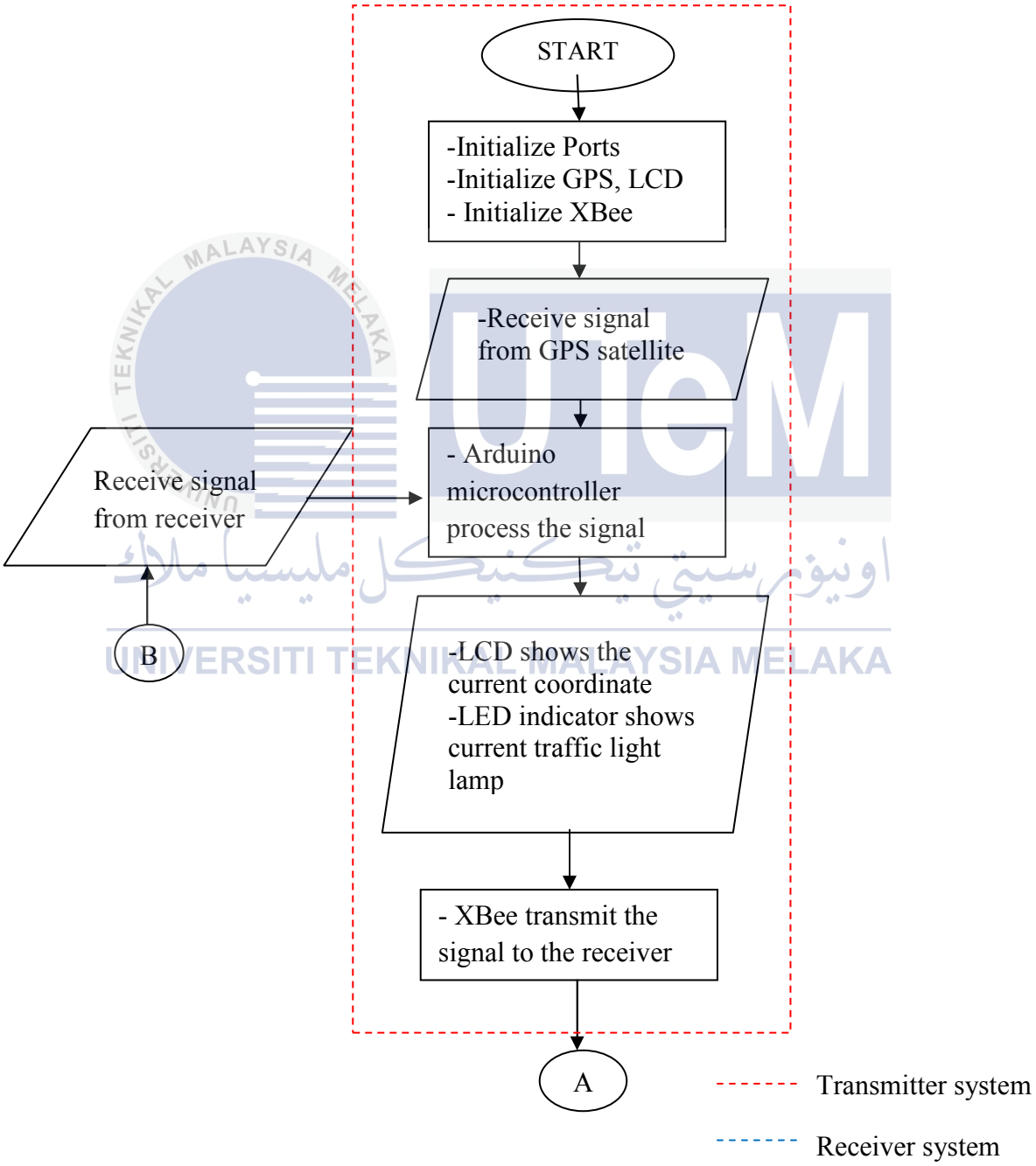

Figure 3.6 Flowchart Solar Power Smart Traffic Light System

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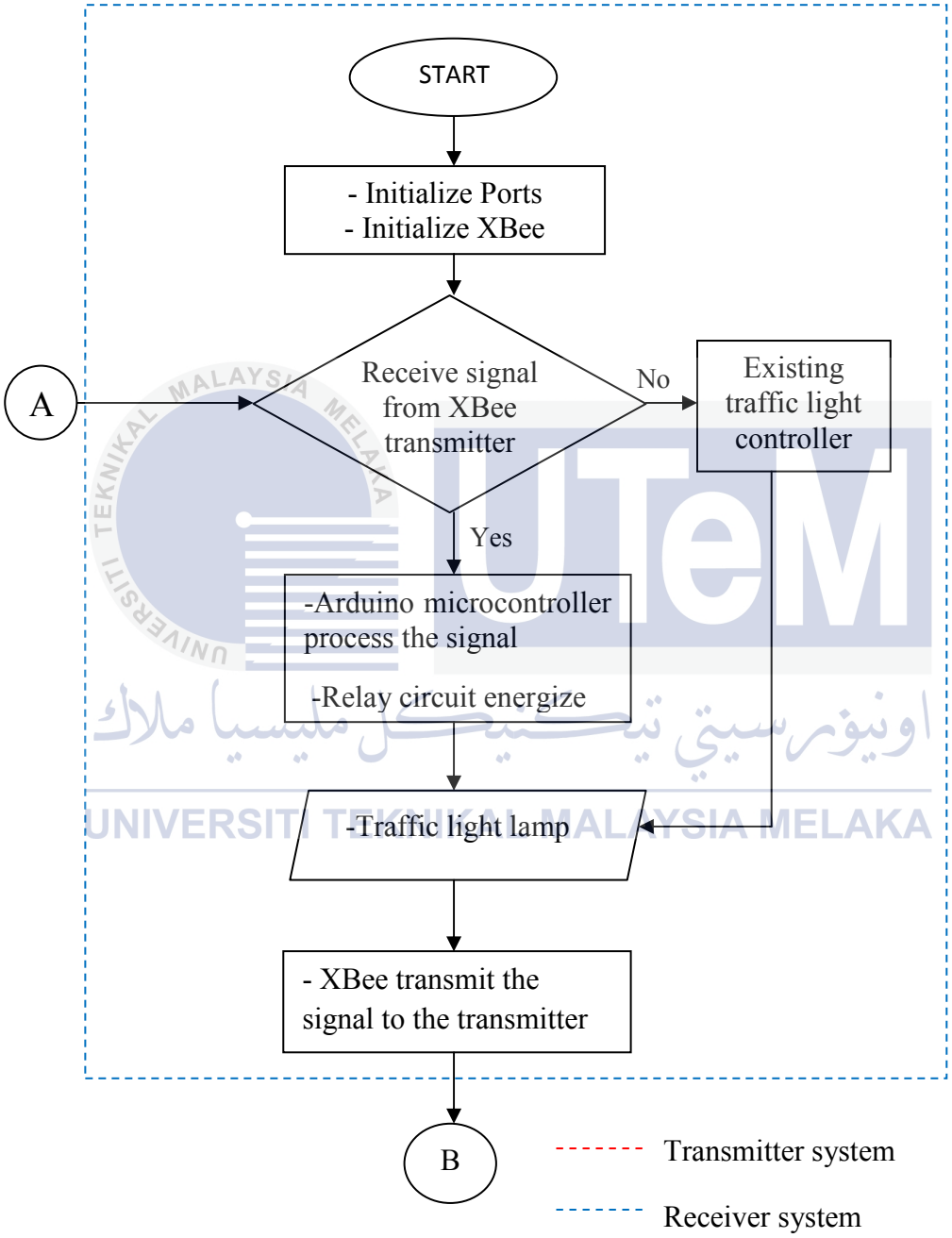

Figure 3.7 Flowchart Solar Power Smart Traffic Light System (continue).

3.4.2 Operation of Solar Power Smart Traffic Light System

The development of this project consists of two main systems which is transmitter and receiver system. Transmitter systems are installed inside emergency vehicle while the receiver systems are installed at traffic light controller. Roughly, the transmitter system consists of Arduino Uno as microcontroller, GPS module as detector of emergency vehicle location, three LED which are red, yellow and green as feedback indicator and last but not least XBee wireless communication as a transmitter devices. Inside receiver system, roughly consists of Arduino Uno as microcontroller and XBee wireless communication as a receiver. Figure 3.6 and 3.7 show the operation of transmitter and receiver system. Both of the system will communicate with each others.

When both of the systems are injected with power supply, all the components will be prepared to perform each task. GPS module will receive a coordinate signal from GPS satellite. This coordinate signal represents the location of emergency vehicle. An Arduino microcontroller at transmitter will process the data. After process the data, LCD display will show the current coordinate in term of latitude and longitude reading. Besides that, the XBee at transmitter will send the longitude and latitude data to the receiver system via XBee receiver.

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After Arduino microcontroller at receiver receive signal via XBee receiver, the longitude and latitude data will be processed. The data will be processed to determine the direction of emergency vehicle, and the distance between traffic light controller and the emergency vehicle. When the microcontroller detected the present of emergency vehicle, the microcontroller will bypass the system. This bypass system will give priority to emergency vehicle by change the traffic light lamp to green light. This change only occurs at the present of emergency vehicle lane. When the traffic light change to green, XBee receiver will send a signal to transmitter system as a feedback to inform the traffic light controller already bypass the existing controller. In second condition, when the XBee receiver are not receive signal

from XBee transmitter, bypass system are not activate therefore the traffic light will controlled by existing controller.

3.4.3 Development of transmitter system

Inside transmitter system there are six major elements or in other words six main systems. These six main systems will interact with each other to create a system called a transmitter system. The six system including of wireless communication system, GPS system, unit processing system, display system, boost bypass system, and last but not least the solar power system. Figure 3.8 shows the schematic diagram of combination all the system in formation a complete circuit for development of transmitter system.

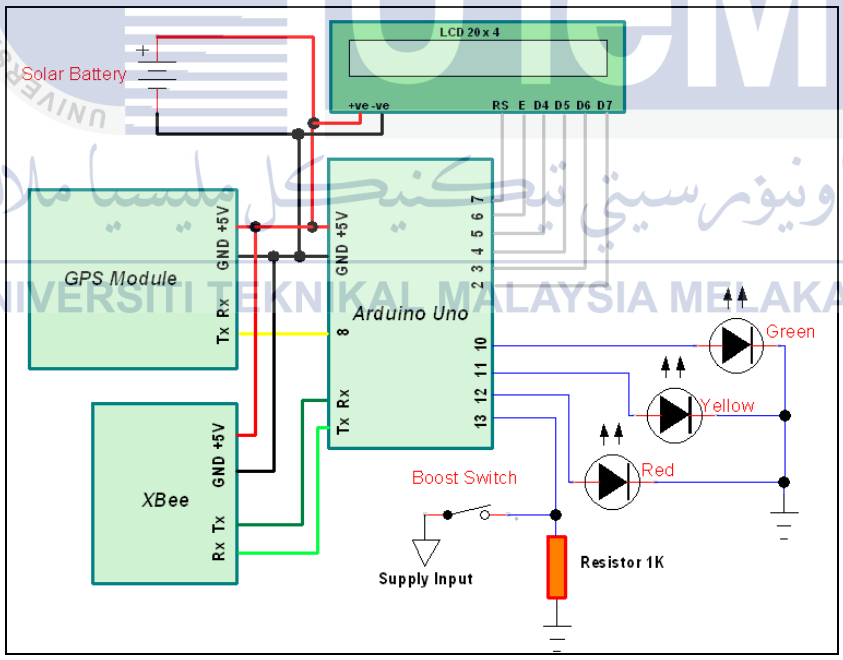

Figure 3.8: Schematic diagram of transmitter system

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3.4.4 Wireless communication system

Figure 3.9: XBee wireless

Nowadays, the application of wireless communication device is now very widely used. There are many types of wireless communication devices in the market which have the features and its own design. There are several types of wireless communication devices in the market such as ZigBee, WiFi, XBee and etc [11]. During selection of wireless communication devices, a few specifications or performance should be consider for example transmit range, transmit power output, sensitivity, supply voltage, operating frequency and so on. The entire criterion is based on application that will be used. Figure 3.9 will show several types of wireless communication devices with their specification

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Table 3.2 - Comparison wireless communication system [Appendix A]

Standard	Bluetooth	ZigBee	Wi-Fi	XBee
IEEE Spec.	802.15.1	802.15.4	802.11a/b/g	802.15.4
Frequency Band	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
Speed Rate	1 Mb/s	250 Kb/s	54 Mb/s	250 Kb/s
Nominal Range	10m	10m - 100m	100m	30m - 1600m
Tx Power Output	0 - 10 dBm	(-25) - 0 dBm	15 - 20 dBm	0 - 18 dBm
Data Protection	16-bit CRC	16-bit CRC	32-bit CRC	32-bit CRC
Application Focus	Cable Replacement	Monitoring and Control	Web, Video and Email	Monitoring and Control
Key Attribute	Cost, Convenience	Reliable, Low Power and Cost Effective	Speed and Flexibility	Flexible, User Friendly and Inexpensive

Table 3.2 above shows, some comparison in term of technical specification wireless communication system among Bluetooth, ZigBee, Wi-Fi and XBee. Therefore, the best choice in selection wireless communication devices is XBee. The selection of XBee is based on the costing is cheaper, the range for transmit very wide, user friendly and last but not least the coverage of XBee is variable and controllable. Refer appendix A for XBee specification data sheet.

In the development of this project, as all know there are two main systems including the transmitter and receiver system. Both each these systems have their own XBee devices which is transmitter, (***Tx)*** are located inside emergency vehicle and receiver (***Rx)*** is located at traffic light controller and also at emergency department such as hospital emergency department. For easier of understanding, Figure 3.10 shows the installation of a transmitter and receiver system in development of this project.

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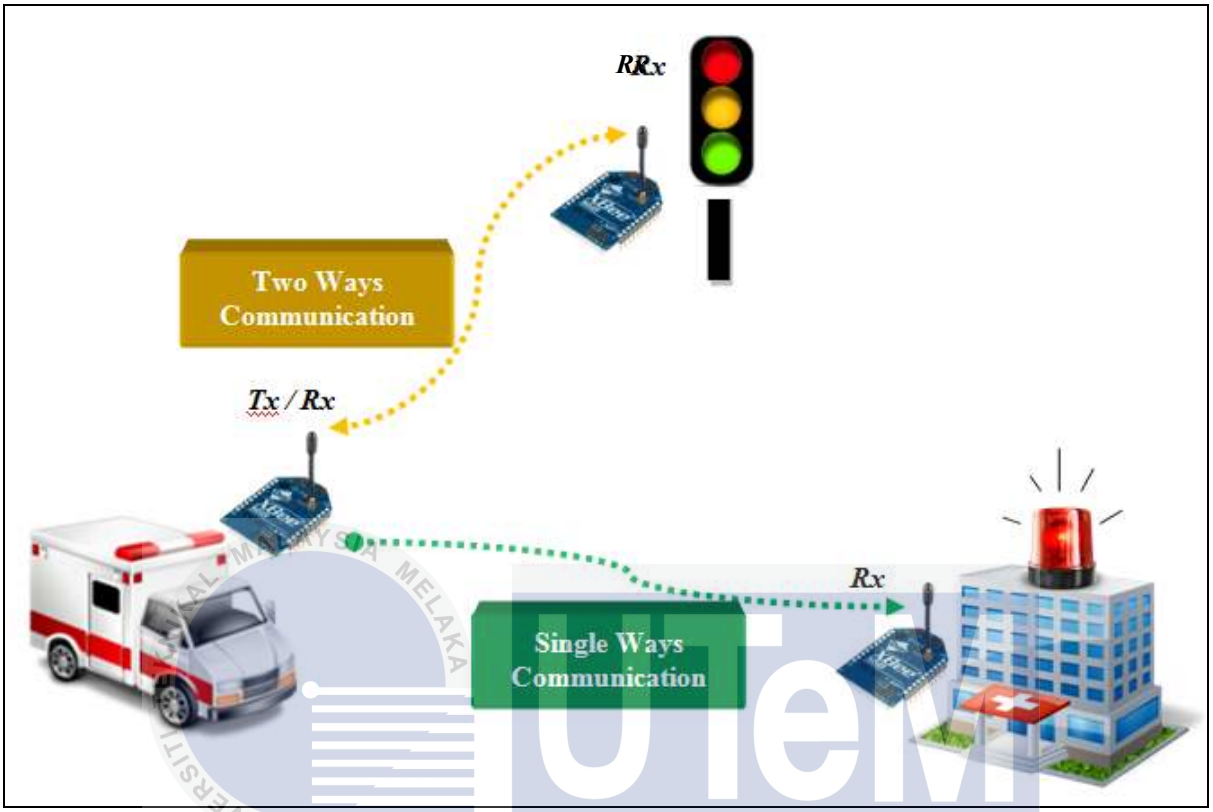

Figure 3.10 Installation for transmitter and receiver system

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From figure above, is illustrated the connection between transmitter and receiver system. Generally, XBee devices installed at emergency vehicle and traffic light controller can operate in two mode conditions which are the transmitter or receiver mode. In transmitter mode the emergency vehicle sends a signal to the traffic light controller. Whereas, the traffic light controller will gives a feedback by sending a signal to the emergency vehicle, in the receiver mode. Same condition occurs at the traffic light controller. For single way communication, the emergency lights at emergency department will blink when the emergency vehicle is approached an emergency department. In this situation, the emergency light at emergency department is in receiving mode.

3.4.5 GPS system

Figure 3.11: GPS Module

In the development of this project, this GPS system acts as a device to determine the location of emergency vehicles. The positioning emergency vehicle can be determined based on the coordinates of longitude and latitude readings. The positioning information can be received from global positioning satellite [12]. GPS receiving module can monitor the condition and collect position information of the emergency vehicle. In the development of this project, this GPS module is a very important component to ensure the receiver receives the correct coordinate information. This GPS module is capable to operate 24 hour per day and available to use in any weather condition. In order to get positioning information, GPS satellite circles the earth in its own orbit and at the same time it transmits signal information to earth. GPS receiver takes this information and microcontroller act as unit processing system will calculates to get the exact location of the user. After that, the microcontroller will determine the direction of emergency vehicles entered to the intersection. For ease of understanding, Figure 3.11 shows an overview of how GPS receivers receive data from GPS satellites and then the microcontroller process the data.

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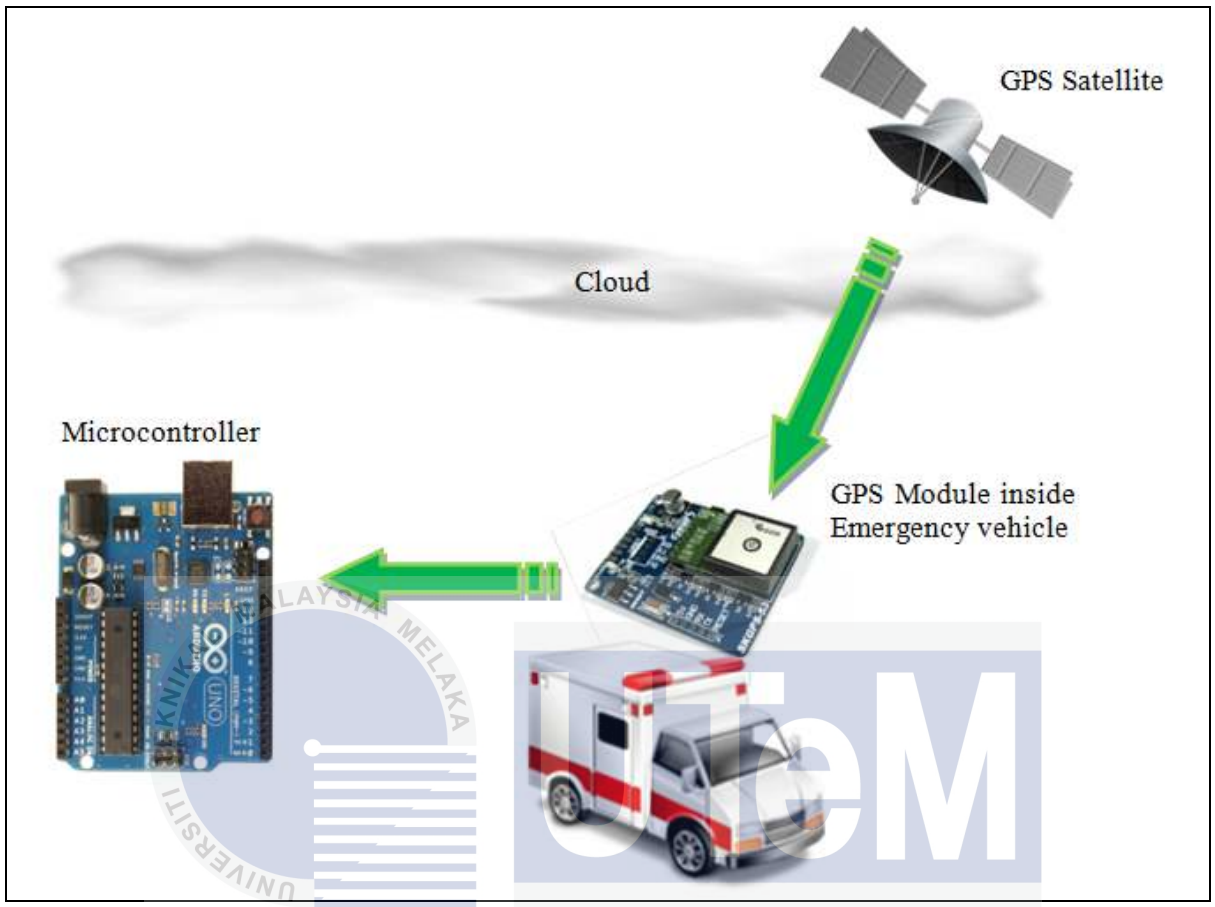

Figure 3.12 Overview GPS module receive positioning information

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Signal from the GPS satellite to the GPS receiver, traveled in a line of sight which means it can pass through cloud, plastic and glass but not for building or mountain. In this project, GPS Module Starter Kit (SKGPS-53) as shown in Figure 3.11 was selected as GPS receiver. Refer appendix B for GPS Module Starter Kit (SKGPS-53) specification data sheet [13]. Base on GPS module data sheet, this device can provide the good sensitivity of -165dBm. The module is characterized by low power, higher performance cost ratio and operation easy. The module communicates with microcontroller very straight forward with data line of *RXD* and *TXD* because of serial port communication adopted and according with NMEA-0183 protocol. Besides that, people are freely to use the GPS because there are no any fees or setup charges [13].

3.4.6 Unit processing system

Figure 3.13: Arduino Uno

Microcontroller processing unit is a device that is very important in the development of this project. Microcontroller serves in the processing and analyzing of the data. By manipulating the input received, multiple outputs can be generated. There are various types of microcontroller in the market which has its own advantages and disadvantages. Among the famous microcontroller is always used is PIC microcontroller and Arduino microcontroller. In the development of this project will use Arduino as a microcontroller. The selection of Arduino as a microcontroller because, Arduino microcontroller has been designed for those who are beginner in software or electronic experience[14]. Arduino microcontroller is capable to make an electronic project that can give output application that responding from input given. For example, Arduino can response to light intensity, sound, movement, touch and others by depending on sensor attach at the Arduino and from the input sensor, Arduino microcontroller also can carry out an output such as variable speed of dc motor, brightness of the LED, movement of robot and so on. There are various types of Arduino microcontroller such as Arduino Nano, Arduino Uno, Arduino Leornardo and etc. In the development of this project use Arduino Uno as a microcontroller because Arduino Uno has more input and output pin compare others Arduino. Figure 3.13 shows the design of Arduino Uno. As has been told, in the development of this project consist of two major divisions it is transmitter and receiver system. Both of these systems have their own microcontroller processing unit which is Arduino Uno as a microcontroller. Arduino Uno at transmitter system serves as a

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microcontroller that analyzes data received from input of GPS module. This Arduino Uno will extract the data to get the longitude and latitude of emergency vehicle. All this information is sent to the receiver system via XBee wireless communication. When Arduino Uno at receiver system receives the information, the Arduino Uno start to analyze the position of emergency vehicle base on latitude and longitude of emergency vehicle before enter the junction. By knowing the position of emergency vehicle, this Arduino Uno produced an output to control the sequence of the traffic lights.

$$\theta = \tan^{-1} \frac{|Y_1 - Y|}{|X_1 - X|} \tag{3.1}$$

By using formula shown in (3.1), the Arduino Uno microcontroller can determine the direction of emergency vehicle. The values of X and Y will represent the latitude and longitude of traffic light controller. The traffic light controller coordinate will set as a reference coordinate. While the values of X_1 and Y_1 will represent the coordinate of emergency vehicle. The coordinate of emergency vehicle are always change when approaches to the traffic light controller. By referring this two different coordinates, angles for each path can be determined.

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Figure 3.14: Division of intersection

Table 3.3: Division angle of each path

ANGLE	JUNCTION
(0° ≥ Θ ≥ 90°)	1
(90° ≥ Θ ≥ 180°)	2
(180° ≥ Θ ≥ 270°)	3
(270° ≥ Θ ≥ 360°)	4

Figure 3.14 and Table 3.3 shows the four division of intersection and the division an angle of each path. When the Arduino microcontroller define the angle between traffic light controller and emergency vehicle in range 0° to 90°, this condition show that the emergency vehicle comes from junction one. This operation to determine the direction of emergency vehicle are same with others junction.

3.4.7 Display system

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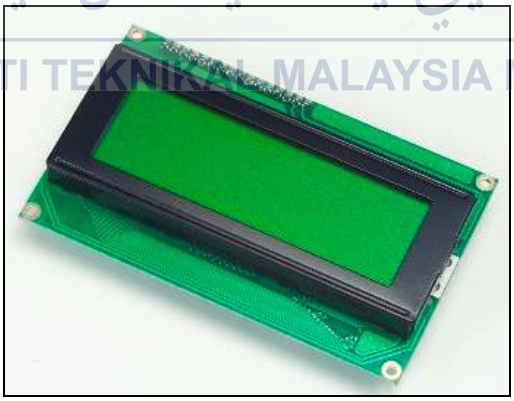

Figure 3.15: LCD display

In development of the transmitter system, LCD display is needed for displaying the position of emergency vehicle. This LCD display will show the latitude and longitude of emergency vehicle. They are various type of LCD display with a different dimension, color

and etc. The LCD the display has been selected size is 4 x 20. That means the LCD display has four columns vertical side and twenty numbers of rows for horizontal side. This size is enough to display the longitude and latitude coordinates. This LCD displays are powered by 4Vdc power supply. In addition, the LCD display serves to determine whether the GPS module connects and receives signals from satellites or not. If the GPS module is not connected with satellites, the LCD display does not show any values for longitude and latitude coordinate. Besides that, LCD display serves as indicator to monitor the power store inside battery. If energy store inside the batteries low, LCD display become dimmer. Figure 3.15 shows the construction of LCD display.

3.4.8 Boost bypass system

Figure 3.16: Boost bypass button

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Boost bypass system is designed to make it this system more advance. In original design, the transmitter will transmit signal to receiver in certain distance that has been set. In normal conditions, traffic congestion distance will not exceed the XBee transmitter coverage. Therefore when emergency vehicle enter the traffic congestion the microcontroller directly energize and control the whole traffic light system. The problem is when extreme traffic congestion occurs, the traffic congestion is very long distance exceeding the XBee transmitter coverage. So the emergency vehicles have to weather the traffic congestion until entered XBee transmitter coverage. This deficiency must be overcome to ensure the reliability of the system more betters. Therefore, the function of this system is able to overcome deficiencies. For further understanding of this system Figure 3.17 and Figure 3.18 will illustrate the normal condition and extreme traffic congestion condition

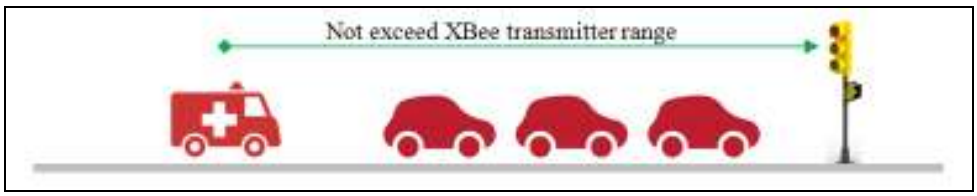

Figure 3.17: Normal traffic congestion

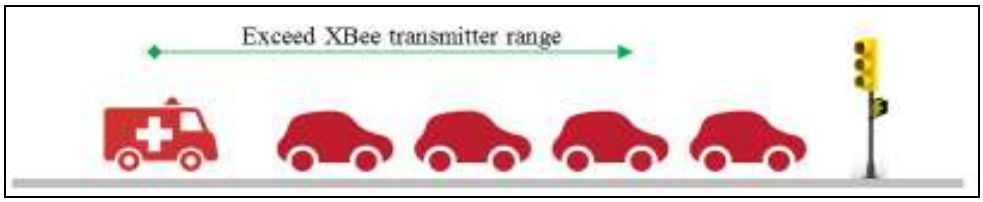

Figure 3.18: Extreme traffic congestion

Figure 3.16 shows a button that install on the transmitter device. This button is operating to activate this system. The operation of this system is, when this button is pressed manually it will inject more input voltage source to the XBee wireless. Therefore the XBee wireless gets more power and capable to transmit far away.

3.4.9 Solar power system

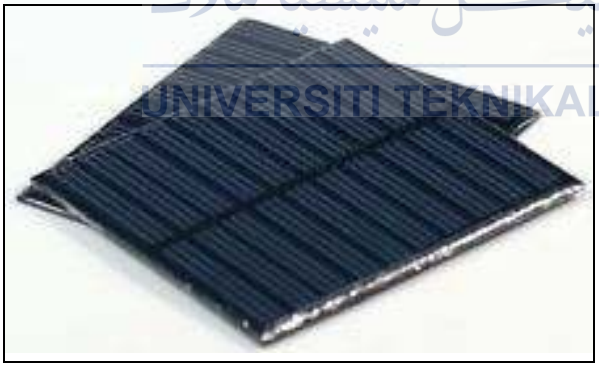

Figure 3.19: Solar panel

Figure 3.20: Lithium ion battery

Whole transmitter system is powered by lithium ion battery. This battery will be used to store the energy. At daytime solar panels will powered all component inside transmitter system and also charge the battery, therefore the battery will maintain its energy capacity so the transmitter system can operate by its own independent source. At night, transmitter system

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still can operate because transmitter systems are powered by energy store inside battery. Therefore this transmitter system will become portable system without worried about power source. Figure 3.19, 3.20 shows the solar panel and lithium ion battery and Table 3.4 below is the specifications of the solar power system:

Table 3.4: Solar panel specifications

Output Capacity	18.5Wh (5000mAH)
USB Output	5V, 1.5A
Input	5V, 1A
Max. Output Current	1.5A
Dimension	110 X 70 X 16mm

3.4.10 Development of receiver system

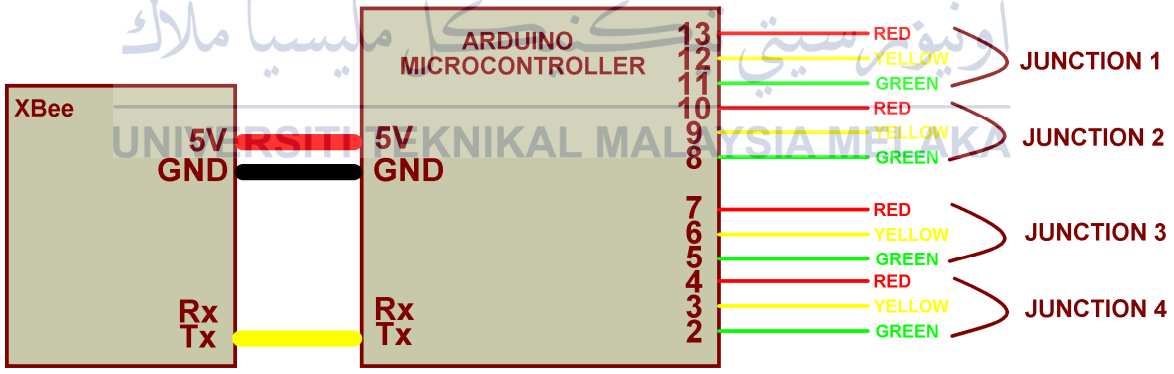

Figure 3.21: Receiver Circuit

This receiver system circuit show in Figure 3.21 is needed to install at traffic light controller system. In this system consist of XBee as wireless communication system, Arduino as a microcontroller system and relay controller system. The receiver will receive a coordinate signal from transmitter system within distance 100 meter. This distance has been set inside microcontroller programming. The advantage of this system, it can be installed at any existing

traffic light controller without disturbing the original controller. When the receiver system detected the presence of emergency vehicles, relay controller system will switch the traffic light controller from existing controller to bypass system controller. For ease understanding Figure 3.24 shows how the relays switch from existing traffic light controller to bypass system controller. Figure 3.22 and 3.24 show the existing traffic light controller circuit and existing traffic light controller attached with bypass controller.

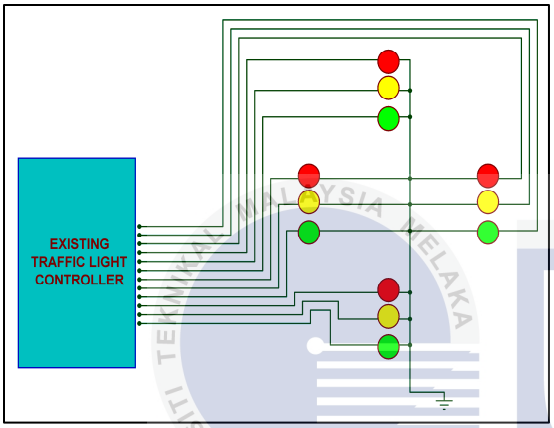

Figure 3.22: Existing Traffic Light controller

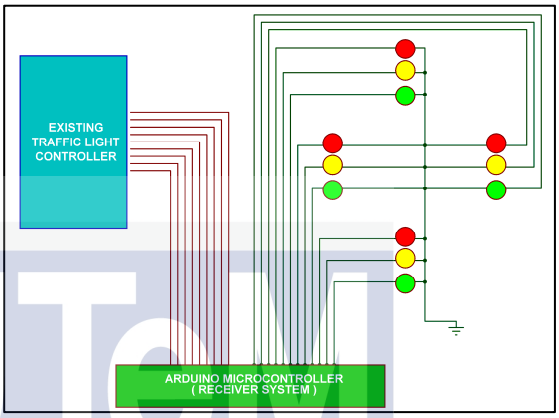

Figure 3.23: Bypass System

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3.4.11 Relay controller system

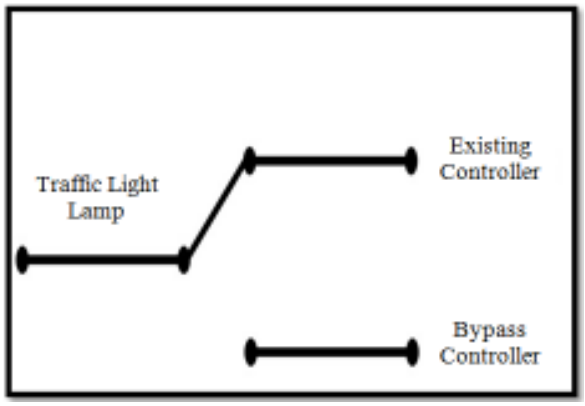

Figure 3.24: Relay controller system

Relay controller system is very importance parameter inside receiver system. As mention before, this system functioned to switch existing traffic light controller to bypass controller. When receiver system detect the present on emergency vehicle, the relay will select bypass controller to controller alls the traffic light lamp. As we know, relay devices consist of two main parts which is coil and contact. In normal condition, the common contact *C* will touch with normally close contact *NC*. While the coil is energized, common contact C will touch the normally open contact *NO*. By applying this principle, the bypass system can be developed.

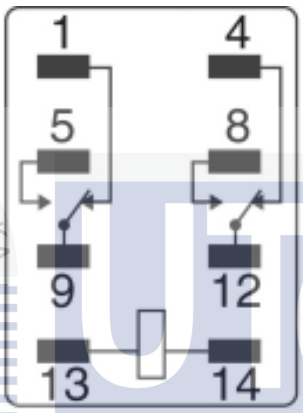

Figure 3.25: Relay double pole double through connection

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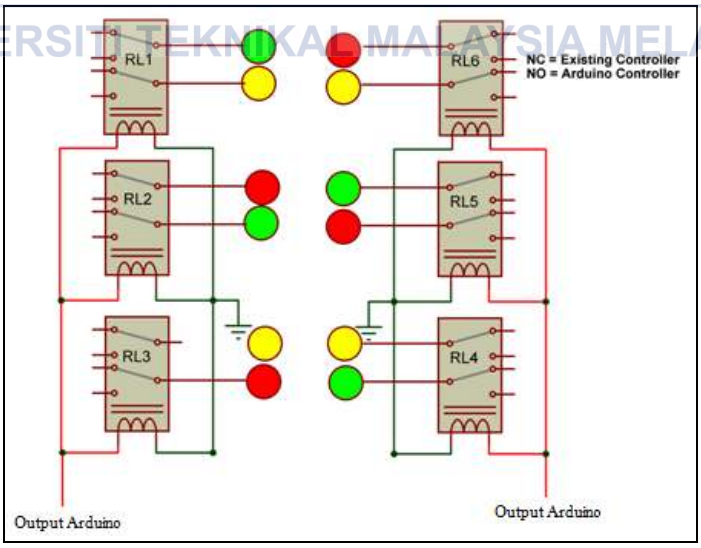

Figure 3.26: Relay controller circuit

The output from Arduino microcontroller are connected with normally open contact *NO*, this will represent of bypass controller. While the output from existing traffic light controller are connected with normally close contact *NC*, and the common contact relay will connected with traffic light lamp. Therefore in normal condition the traffic light lamp are controlled by existing controller. When the relay energized, the traffic lamp are controlled by bypass system. The relay controller system consists of six number of relay. This six relays will control twelfth traffic light lamp that represent four traffic light junction because the relay used double pole double through relay as shows in figure 3.25. Figure 3.26 shows full relay controller circuit.

3.4.12 Hardware Design

Figure 3.27, 3.28, and 3.29 shows the transmitter and receiver devices that have been designed. Both of this system functions as planned.

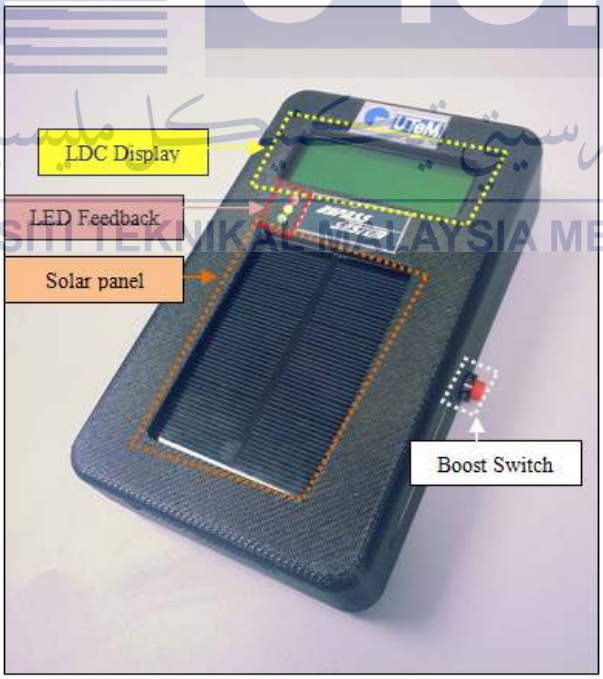

Figure 3.27: Transmitter devices

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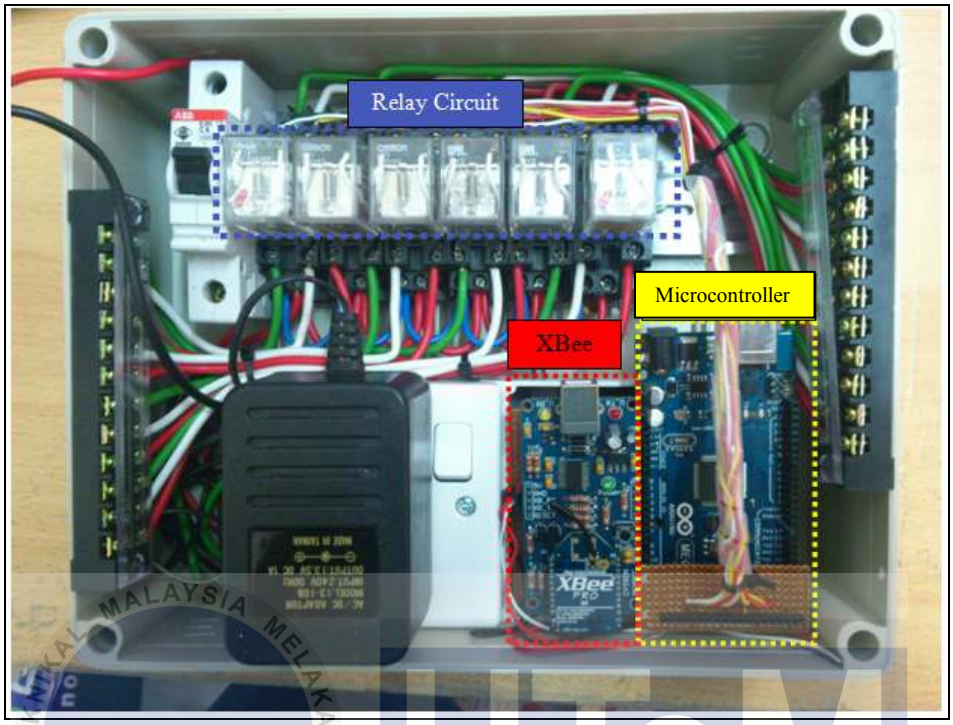

Figure 3.28: Receiver devices without cover

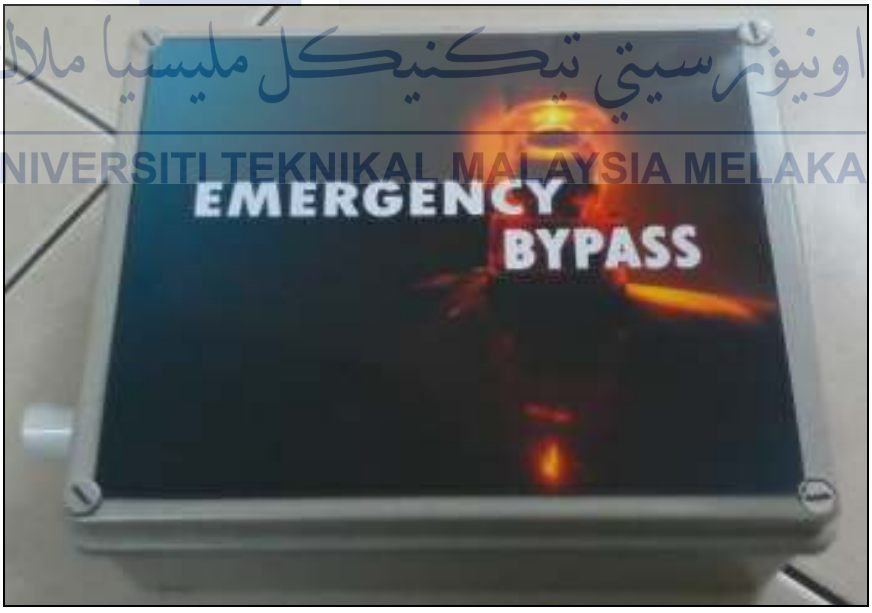

Figure 3.29: Receiver devices with cover

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CHAPTER 4

RESULT AND ANALYSIS

In the development of this project, a few testing have been done such as, range for an XBee wireless signal, validation of GPS coordinate, range for boost system, GPS satellite connection and last but not least battery charge and discharge.

4.1 GPS Validation Coordinate

GPS validation testing is very important to ensure that every coordinate reading displayed on the LCD display exactly by the coordinates of an area will be measured. The function of this coordinate is, to determine the direction of emergency vehicle and also to detect the distance of emergency vehicle.

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The testing was done to determine whether the reading displayed on the LCD shows an accurate reading or not. This testing has been done around FKE UTeM and the purpose of this testing is to compare the readings displayed on the LCD with readings displayed in the Google Earth software. Test results show the readings displayed by LCD are similar as shown in the Google Earth Software. Figure 4.4 and 4.5 show the reading displayed on LCD and Google Earth Software. As a conclusion, the GPS module is accurate and can be implemented in this project.

Figure 4.1: Coordinate displayed on LCD

Figure 4.2: Coordinate displayed on Google Earth Software

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4.2 XBee Wireless Communication Testing

This experiment was conducted to determine the effective distance of an XBee wireless to transmit a signal from transmitter to receiver. This testing has been done around FKE UTeM. Figures 4.3 and 4.4 show the locations of the testing that have been made but the emergency vehicle comes from different direction. Table 4.1 shows that there are seven data that have been recorded during this testing. After that, by using software Coordinate Distance Calculator shows in Figure 4.7, distance from transmitter to receiver can be determined based on coordinate for traffic light controller and emergency vehicle. In this case the coordinate for traffic light controller has been set as a reference coordinate which is lat: 2.31494 and lon: 102.319384.

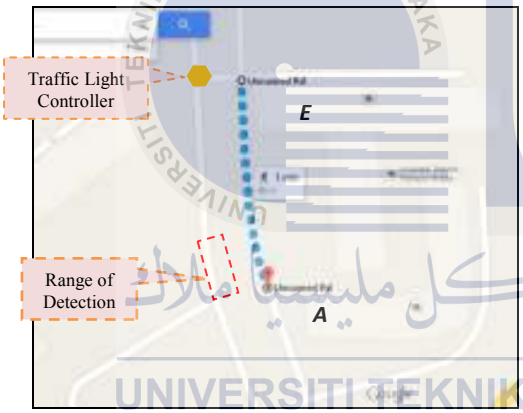

Figure 4.3: Emergency vehicle come from Block A to Block E

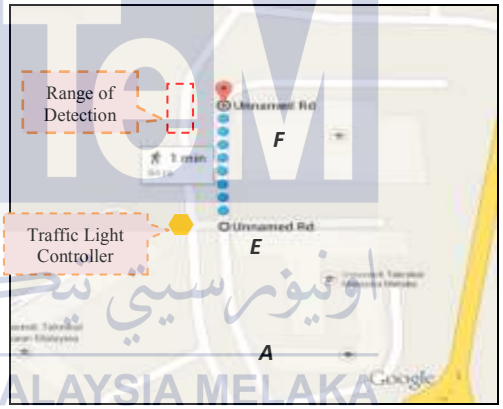

Figure 4.4: Emergency vehicle come from Block F to Block E

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Table 4.1: Normal condition effective range for XBee

Direction	Distance (m)	Coordinate reference Lat: 2.31494	Lon: 102.319384	Status
A-E	81	2.3142114	102.3194732	Detected
A-E	85	2.3141681	102.3194882	Detected
A-E	86	2.3141617	102.3194905	Detected
A-E	84	2.3141785	102.3194846	Detected
F-E	82	2.3156797	102.3193828	Detected
F-E	86	2.3157175	102.319388	Detected
F-E	84	2.315701	102.3193843	Detected

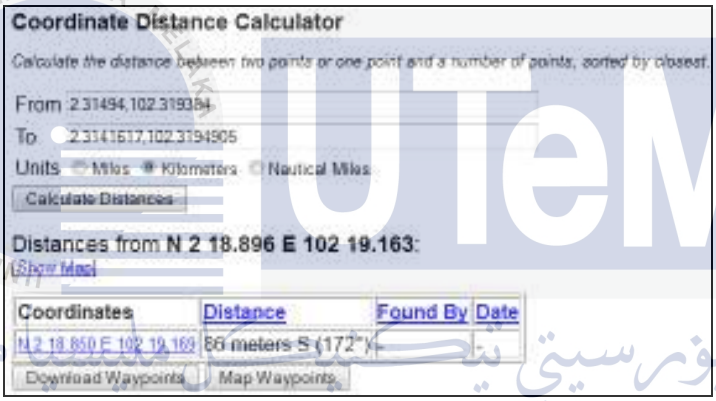

Figure 4.5: Coordinate distance calculator

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This testing has been done by moving emergency vehicle approaching to the traffic light controller. From table 4.1 shows that, the average effective distance for an XBee to transmit a signal to the receiver is in range of 86 meter. The most effecting range for an XBee in transmitting mode at distance 86 meters while the shorter distance are recorded at 81 meters. The difference between these two distances is depending on speed of emergency vehicle. When speed of emergency vehicles increase, the effective distances for XBee in transmitting mode become decreases. This is because, the microprocessor inside traffic light controller need a few of time to determine the direction of emergency vehicle.

4.3 Boost Bypass Testing

This testing was conducted to determine the effective distance of an XBee wireless to transmit a signal from transmitter to receiver in boost bypass condition. As mentioned before, the function of boost bypass system is to make effective range for XBee to transmit a signal with long range. Table 4.2 shows the results when this system is activated. The procedure to conduct this testing is same as the procedure for previous testing such as same location and emergency vehicle approaches to traffic light with two different direction.

Table 4.2: Boost condition effective range for XBee

Direction	Distance (m)	Coordinate reference Lat: 2.31494	Lon: 102.319384	Status
A-E	96	2.3140749	102.3195218	Detected
A-E	99	2.3140521	102.3195303	Detected
A-E	97	2.314072	102.3195228	Detected
A-E	98	2.3140983	102.3197242	Detected
F-E	96	2.3158089	102.3194557	Detected
F-E	97	2.3158152	102.3194688	Detected
F-E	98	2.3158207	102.3194842	Detected

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From table 4.2 shows that, the average effective range for this boost conditions is 99 meters which is further compare in normal condition. The most effective range for XBee in transmitting mode at distance 99 meter while the shorter distance are recorded at 96 meters. The different between these two measurements are effected by speed of emergency vehicle. This is because, the microprocessor inside traffic light controller need a couple of time to determine the direction of emergency vehicle.

4.4 GPS Satellite Connection Testing

In transmitter system, there are several components including GPS module. The use of this GPS module is to receive signal from GPS satellite. The GPS Satellite will send information signal such as current coordinate to the GPS module. However, to ensure communication between the GPS module and GPS satellite connected with each other, it required a couple of times. Table 4.3 shows the time required by a GPS module to communicate with GPS satellite. This testing was conducted for four days with certain times.

Table 4.3- Connecting time with GPS satellite

	Trial	Time	Time Response (s)
Day 1	1	9.00 AM	90
	2	12.00 AM	36
	3	5.00 PM	31
	4	8.00 PM	43
Day 2	5	9.00 AM	85
	6	12.00 AM	35
	7	5.00 PM	46
	8	8.00 PM	37
Day 3	9	9.00 AM	86
	10	12.00 AM	37
	11	5.00 PM	41
	12	8.00 PM	32
Day 4	13	9.00 AM	93
	14	12.00 AM	45
	16	5.00 PM	43
	16	8.00 PM	34

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Table 4.3 shows the time response to connect with GPS satellite. From the data, the longest response time is 93 second while the shortest response time is 31 second. The average time response for GPS module to connect with GPS satellite is 51 second. If examined the data that has been recorded, only in the morning the time response take a relatively long time compared to other times. This is because when refer GPS module starter kit SKGPS-53 data sheet state that slow communication speed between GPS satellite GPS satellite.

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4.5 Charge and discharge testing

In the development of this project, has been stated before consist of solar powered system. Inside this solar powered system consist of lithium ion battery as energy storage devices. This testing has been done to check the capability of charge and discharge condition. Charging testing means, the times required to make the battery fully charge. The discharging process is done by draining the battery from its full capacity until it is empty. Charging testing consist of two types of testing which is by using power supply and solar panel. While for discharge testing only measure the time required to fully discharge the lithium ion battery. Figure 4.6 and 4.7 shows the result for charging testing using power supply and solar panel while Figure 4.8 shows the result for discharging testing. All of these testing were performed for seven days.

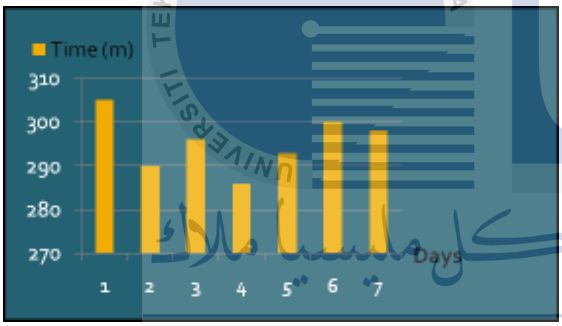

Figure 4.6: Charge by Power Supply

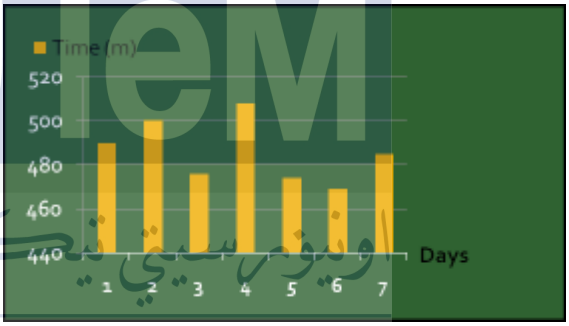

Figure 4.7: Charge by Solar Panel

Base on the graph shows in Figure 4.6, the average time required for charging using power supply is 4 hour and 55 minute. The fastest charging time recorded on the fourth day testing which is 4 hours and 46 minutes. While the longest charging time was recorded on the first days testing which are 5 hours and 5 minutes. The average charging time required using solar panel takes 8 hours and 5 minutes. The fastest charging time recorded on the day six which is 7 hours and 49 minutes. The longest charging time using solar panel shows on the fourth day testing which are 8 hours and 28 minutes.

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Based on charging testing with both condition using power supply and solar panel, the result shows that the time required by a solar panel to charge the battery takes longer than power supply. This is because, the solar panel charging characteristic always depend on weather condition. If the weather condition during testing is cloudy, the solar panels could not produce a maximum energy. Time taken for charging using power supply is faster than solar panel. This is because, current input for power supply more stable and constant. However, the development of this project focused on the solar powered system. Although it takes a long time to charge the battery, it still applicable for this system. During daytimes the solar panel will supply all components inside transmitter system and at the same time charged the battery. If in worst condition, the battery will be charge by using power supply.

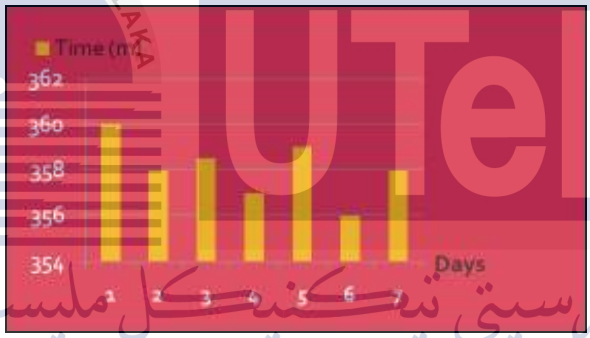

Figure 4.8: Batteries Discharge

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As mention before discharge process is done by draining the battery from its full capacity until it is empty. Figure 4.8 shows the result for discharging testing. The average time required for fully discharge the battery is 5 hour and 50 minute. At day six shows the fastest time discharge which is 5 hours and 56 minutes. While at days 1 shows the longest discharge time which is 6 hours. If examined the data that has been recorded, the different between the highest and the lowest time discharge only about 6 minutes. This indicates that the transmitter system is designed is very stable in terms of energy consumption. Besides that, form this testing will know that the battery capacity is applicable for this system. For real condition, these systems are not operating continuous for 6 hours. Therefore the battery capacity can powered the transmitter system at night.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Smart traffic light system is an important as it has huge contribution to emergency vehicles and to other road users. This system will provide a new alternative to existing traffic light systems with few improvements developed. This improvement can reduce time response of emergency vehicle and also provide high security level for emergency vehicle and also other road users.

This smart traffic light system has achieved its objectives as it can detect the location of emergency vehicle and display the coordinate in a form of latitude and longitude this system can also activate bypass system when emergency vehicle approaching the intersection. Besides that, this smart traffic light system can communicate in two ways communication between transmitter and receiver. The error shown that there is a difference between setting distance detection in programming and actual distance detection on side within an acceptable range since there is a tolerance in any system that have been developed. This error should be kept as minimum as possible in order to maintain its reliability to consumer and utilities. There is an issue need to be highlighted such as the security of the traffic light controller. As recommendations, this system can be improved by installing a device that can communicate with central control unit to monitor the movement of emergency vehicles. The central control unit of the hospital is able to monitor the movement of ambulances and its position. This system also needs an extra protection to avoid unreliable usage by other parties. Last but not least, the development of smart traffic light system managed to show its potential in contributing towards smart safety system by reducing risk an accident between emergency vehicle and other road user.

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APPENDIX A

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APPENDIX B

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APPENDIX C

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LIST OF TABLE

TABLE	TITLE	PAGE
2.1	Comparison between FLC, DP and Wireless technology systems	7
2.2	Comparison between Bluetooth, XBee and Wi-Fi	8
2.3	Advantages of Arduino	9
3.1	Project Gantt Charts	12
3.2	Comparison wireless communication system	22
3.3	Division angle of each path	29
3.4	Solar panel specifications	32
4.1	Normal condition effective range for XBee	40
4.2	Boost condition effective range for XBee	41
4.3	Connecting time with GPS satellite	42

UNIVERSITI TEKNIKAL MALAYSIA MELAKA