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ANDROID SMARTPHONE CONTROLLER MOBILE ROBOT

HARUN AMINURASYID BIN ABU BAKAR

A thesis submitted in partial fulfilment
of the requirement for the award of the degree of
Bachelor of Engineering (Electrical – Mechatronics)

Faculty of Electrical Engineering
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I declare that this thesis entitle “Android Smartphone Controller Mobile Robot” is the result of my own research except as cited in the reference. The thesis has not been accepted for any degree and it not concurrently submitted in the candidature of any other degree.

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Dedicated, in thankful appreciation for support, encouragement and inspired me throughout my journey of education to my beloved mother, brother, sister and my friends that has always been there for me.

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ABSTRACT

Smart phones have become very popular in recent years. There are a lot of benefits to having a smart phone, far more than most people realize. The truth is that few people actually get the full benefit out of their smart phone and use it primarily as a regular phone with a few extra features, there are so many other things that a smart phone can do. This gadget can do many task and activities as there are many type of sensors were provided inside the smartphones. The robot can be controlled more easily with smartphone since it is more flexible and has an extra function. We could see in the future, the engineers and operators will used their own smartphone to control the robot in industry. This project investigates the use of smartphone to control mobile robot via Bluetooth wireless. The mobile robot is build and was controlled by wireless with using the smartphone. Microchip PIC16F877A is used because it more powerful rather than other and it has a more pin that can do more function and task. The microchip will be programming by using MPLAB since it is commonly used and easier to program. The mobile robot and the smartphone are connected via Bluetooth by using SKXBEE devices. The smartphone is using an Android application. Android is an operating system for phone that widely used by the people around the world. The Android application for this project can be used by other Android smartphones and users to control their own mobile robot. This project shows the smartphone as a modern technology can be used to reduce the cost to replace the others mobile robot controller.

ABSTRAK

Sejak akhir-akhir ini telefon pintar menjadi semakin diminati ramai. Terdapat banyak faedah yang boleh diperolehi dengan memiliki telefon pintar. Ramai orang boleh mendapat manfaat sepenuhnya daripada telefon pintar mereka selain menggunakannya sebagai telefon biasa, dengan beberapa ciri-ciri tambahan terdapat banyak perkara-perkara lain yang telefon pintar boleh lakukan. Alat ini boleh melakukan tugas dan aktiviti yang banyak dengan pelbagai jeenis sensor yang telah disediakan di dalam telefon pintar. Robot boleh dikawal dengan lebih mudah dengan telefon pintar kerana lebih fleksibel dan mempunyai fungsi tambahan. Pada masa akan datang, jurutera dan pengendali akan menggunakan telefon pintar mereka sendiri untuk mengawal robot dalam industri. Projek ini mengkaji penggunaan telefon pintar untuk mengawal robot mudah alih melalui wayarles Bluetooth. Robot mudah alih membina dan dikawal oleh wayarles dengan menggunakan telefon pintar. Microchip PIC16F877A digunakan kerana ia lebih sesuai dan mempunyai pin yang lebih yang boleh melakukan fungsi dan tugas yang lebih banyak. Mikrocip pengaturcaraan akan menggunakan MPLAB kerana sesuai digunakan dan mudah untuk program. robot mudah alih dan telefon pintar yang menggunakan aplikasi Android dihubungkan melalui Bluetooth dengan menggunakan peranti SKXBEE. Android adalah sistem operasi untuk telefon yang digunakan secara meluas di seluruh dunia. Aplikasi Android untuk projek ini boleh digunakan oleh telefon pintar Android yang lain dan pengguna boleh mengawal robot mudah alih mereka sendiri. Projek ini membuktikan telefon pintar sebagai teknologi moden boleh digunakan untuk mengurangkan kos untuk menggantikan pengawal robot mudah alih yang lain.

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LIST OF ABBREVIATIONS

PIC	-	Programmable Intelligent Computer
PCB	-	Printed Circuit Board
GUI	-	Graphical User Interface
SDK	-	Software Development Kit
LED	-	Pulse Width Modulation
UART	-	Universal Asynchronous Receiver Transmitter
TX	-	Transmitter
RX	-	Receiver
ICSP	-	In-Circuit Serial Programming
OS	-	Operating System
PS2	-	Play Station 2
LiPo	-	Lithium Polymer
AC	-	Alternate Current
DC	-	Direct Current
LED	-	Light Emitting Diode

LIST OF APPEDINCES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, robot play an important role in industrial area since the capabilities to doing something or job that are impossible due to limited abilities of human. Robot are able to do the repetitive work with constant performance, do a dangerous thing that can risk to human and make a product faster with less rest time. Besides, robot is less cost when compare with worker salary. Refer to the International Standard Organization's definition of an industrial robot, mobile robot can be define as;

"A mobile robot is an autonomous system capable of traversing a terrain with natural or artificial obstacles. Its chassis is equipped with wheels/tacks or legs and possibly a manipulator setup mounted on the chassis for handling of work pieces, tools or special devices. Various preplanned operations are executed based on a preprogrammed navigation strategy taking into account the current status of the environment" [1].

In other words, any intelligent machine which moves with respect to environment within limited human interaction (autonomously) called “Mobile robot”.

According to Furat Barlas [2],”Mobile robots can be used in several applications. Dangerous area operations (Nuclear plants), planetary exploration and pipe investigation, extreme temperature and narrow field investigations (pyramid exploration robots). Moreover, floor cleaning robots and servant robots are common examples for indoor use. It is not a dream that, in near future robots will be a part of our daily life.”

The smartphone is defined as a mobile phone that has an open operating system where user can install new applications that can access directly the services of the phone. Smartphone existence because the user want the flexibility in term of mobile format as they used to with computer. The technical development in semiconductor industry has enabled the development of smart phones providing adequate computational capabilities and amount of memory in small and power efficient chips and this combination is desirable to more and more customers.

The industrial applications are mostly human interfaces of machine to machine communication which suitable with smartphone as it will more easily. The currently mostly used industrial applications can be divided as

- Monitoring
- Reporting
- Viewing of documents etc.
- Position and location based applications

Two-way data transfers can be used to send sensor information, video or other information for processing to other places where that information can be for example compared to databases and this analysis result can be send back to the smart

phone user. This similar information analysis based on database information can be done also using smart phones own processing and storage capabilities but of course in smaller scale [3].

Android operating system is an open source framework designed for Android devices such as smartphones and tablets. It is a comprehensive platform that features a Linux based operating system stack for managing devices, memory and processes. Google created the framework and made it to be available to Java Programmers through a Software Development Kit (SDK) that is known as Android SDK. The Android SDK provides libraries needed to interface with the hardware at a high level make Android applications [4].

Anyone can develop their application for free and install in their mobile phone. It has open marketplace which is called Google Play where developers can distribute, share and sell their application.

1.2 Objectives

The main objective of this project is to design and modified a communication mobile robot that can be controlled via wireless by smartphone through Bluetooth. Secondary objective is to developed Android software by using App Inventor for Android

1.3 Project Scope

This project involves both hardware and software. Hardware is mobile robot need to modify and software has two main parts which is programming the mobile robot and programming the Android application. The scope of the project involves:-

1. A mobile robot with PIC microcontroller
2. Android smartphone to install the Android application as a controller of mobile robot

1.4 Problem Statement

Nowadays, with the advancement of information technology, people tend to carry their mobile gadgets wherever they go, particularly the smartphones, as it is seen to become very important in their daily activities. As in near future robots will be a part of our daily life, it is better to build a program to control the robot with latest technology such smartphone since it user friendly and will be more easier carry the program anywhere.

Cost of the controller of robot is another subject. Since Android is a free application developer, it will cut the cost and replace robot controller such as PS2 controller and computer.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many relevant and similar projects that can be search around the world. In this chapter, a number of previous research projects of mobile robot are reviewed. The chapter also discusses on Android devices and briefly summarizes the application of Android devices in various fields. The research projects provide information such as the theories, techniques and designed applied.

For this chapter, there are 3 references are chosen as they are related to the current project which can be review as guideline and information to finish this project.

2.2 Computer Controlled Mobile Robot

This project was developed by UTM student, Mohd Bazli Bin Mohd Mokhar. In this project, Bazli used Graphical User Interface (GUI) as interface to mobile robot. The command given in order to control direction, speed, distance and degree of turn of the mobile robot by computer via wireless.

According to Bazli [5], "In this project, two wheel differential drive mobile robot is built. By using the computer, the mobile robot is control by wireless. Mobile robot control using computer is very common project in final year project. However, based from the previous projects, not all variable of mobile robot control was controlled. The common variable based on previous projects is to control the direction of the mobile robot. There are a little researches or projects that control other variable in mobile robot control such as distance or speed. So, in this project, direction, speed, distance and degree of turn of the mobile robot are control at the same time. In addition, a Graphical User Interface (GUI) is developed for controlling of mobile robot. Wireless communication between host computer and robot is established using Bluetooth Module."

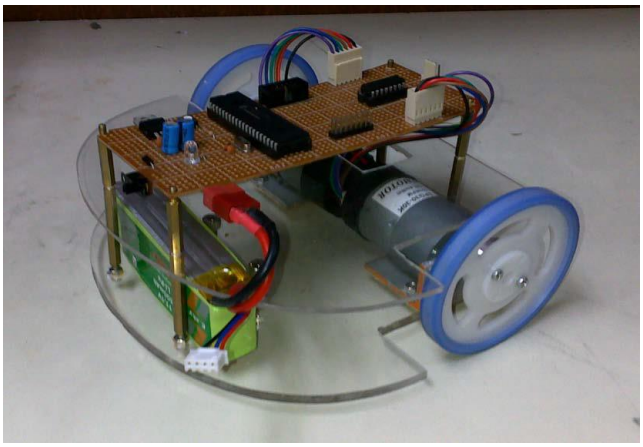

Figure 2.1 Two wheeled differential drive mobile robot

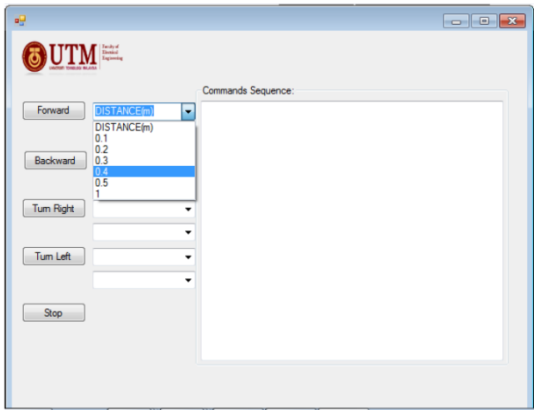

Figure 2.2: Layout of the GUI

2.3 Android E-NOSE

In 2012, a project named Android E-NOSE done by UTM student. This project used Android as the interface for E-NOSE application. The result of the data and type of gases detected by E-NOSE will be shown on the Android mobile phone screen.

According to Safwan [6], "The paper presents the design of an Android device as a platform to display data from an electronic nose. The Android E-Nose is developed using two different microcontrollers (Microchip DM240415 PIC24F Accessory Development Starter Kit for Android™ and IOIO for Android) which can be used separately to work with any (suitable) Android devices (smartphones or tablets). The proposed device is designed to be small, less expensive, portable and user friendly. The proposed portable Android E-Nose should be able to measure and discriminate between different types of gases with a user-friendly interface."

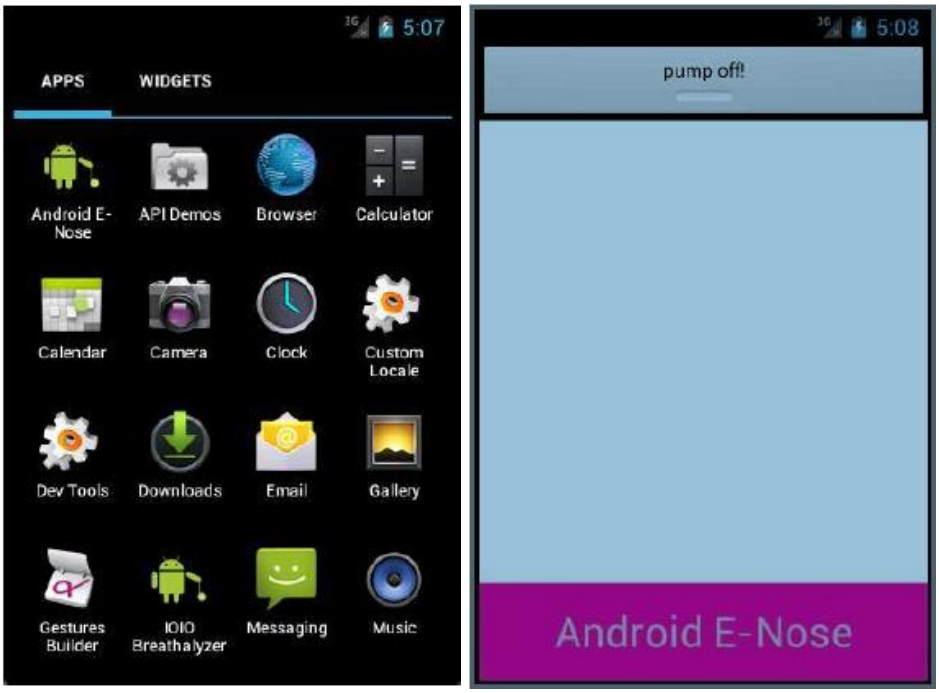

Figure 2.3: User interface of Android E-Nose application using IOIO board

Figure 2.4: User interface of the Android E-Nose application

2.4 Remote Home Surveillance Using Android Platform Phone Through TCP/IP

This project also is using Android operating system of mobile phone for their interface with the application remote home surveillance. This application shows live view of their home on Android phone by connected it with Internet. The people can check the condition of their home anywhere as long they have an Internet. User also can setting a password for this application for safety only user can access to this application.

According to Muhammad Affandy [7], "This project is concerned for this kind of situation and creating this program is easy by just purchasing an IP camera and the rich features of open source Android–platform phone. Just by using open source tools like JSF programming and Android client programming, one can create a software with ease with only sufficient knowledge about networking."

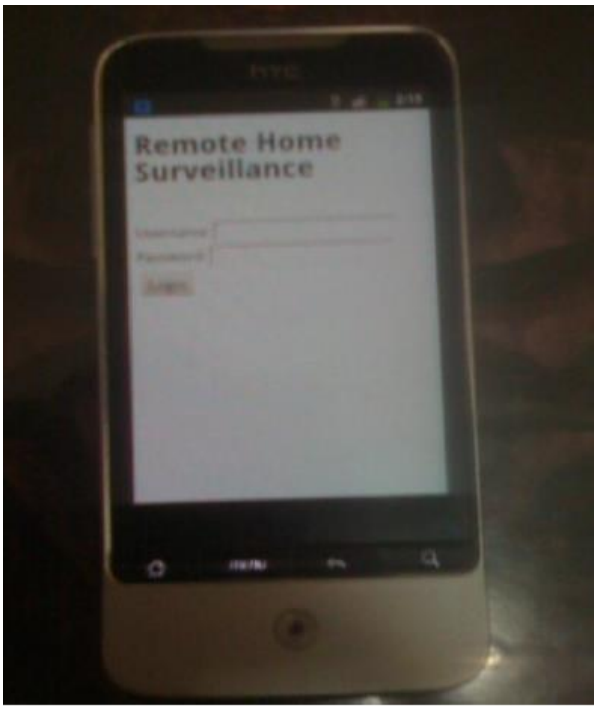

Figure 2.5: Remote Home Surveillance in Android phone

2.5 Summary of Chapter

These 3 projects and research have a part that related to this project which some of component and source code can be applied to improve the project. First project can be guidelines to design a mobile robot and develop communication Bluetooth wireless. Meanwhile, others 2 projects can be as references to develop Android application and connected it with Bluetooth wireless devices.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss about the methodology approach for solving the problem as mention on problem statement in the previous chapter. This chapter consists of work on planning, system design, hardware, software development and testing to make sure the flow of project development run smoothly and systematically.

3.2 Project Planning

Flowchart for project planning was done in order to complete this project. The first step is to propose this idea to supervisor. The second step is to do some research and literature review regarding this project which is based on the theory and application. Next, the mobile robot and wireless module were purchased and build as involved in designing the hardware part. The fourth step is to programming PIC of

mobile robot. After that, Android application will developed as mobile robot control. The sixth step is the integration of both software and hardware. The mobile robot will be testing by a simple command. As the communication between mobile robot and Android smartphone is establish, the programming to will be continue to increase the capabilities to control by smartphone. The last step is testing and troubleshooting of the software and the mobile robot. Figure 3.1 shows the flowchart of project planning.

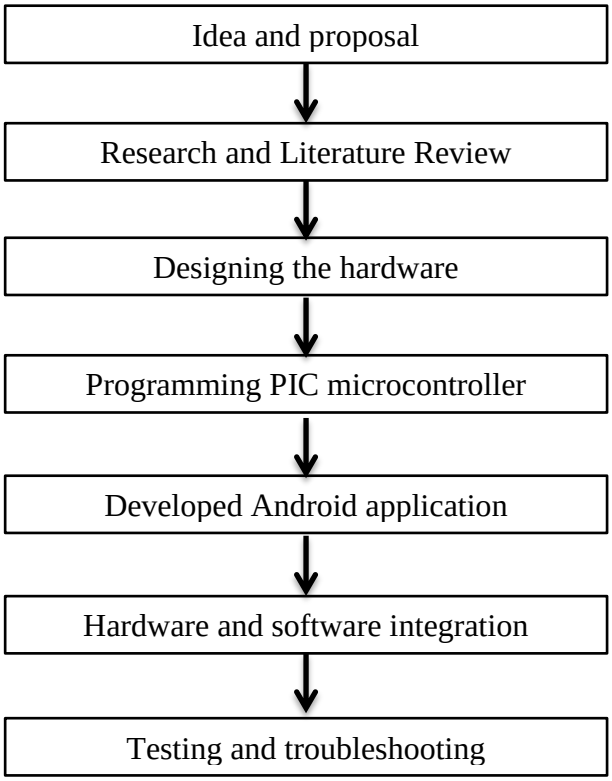

Figure 3.1: Flowchart of project planning

3.3 Hardware Part

The hardware parts consist of electric component and devices. This part also included with the mobile robot that will be used and modified for this project.

3.3.1 Mobile Robot

Figure 3.2: Cytron Multifunction Mobile Robot

Cytron DIY PIC microcontroller based project, PR23 (model) is designed for user to start develop mobile robot. The sample code provided showing few capability such as:

1. Line following
2. Obstacles detection using Ultrasonic Sensor
3. Obstacles detection using Analog Sensor
4. Control using XBee module
5. Control using PS2 controller

PR23 is an open source microcontroller Do It Yourself kit. This PIC microcontroller based project perfectly designed for user to start develop smart robot. It is a line following robot with optional add on gadget and capable of line following, distance measure, and control wirelessly. It also provides LCD (2X16 Character) and buzzer for user to indicate the condition or status of the robot that useful for debugging and testing.

This multifunction mobile robot is modified and designed to be able control its movement by Bluetooth wireless which connected with smartphone. The other function such as line following is removes because it is not appropriate with this project.

3.3.2 Voltage Regulator

The PIC microcontroller and this circuit required 5V voltage input to operate the circuit, thus this project are converts the higher input voltage to 5V by using voltage regulator LM7805. Figure 3.3 below shows circuit of voltage regulator LM7805.

Figure 3.3: Voltage regulator LM7805

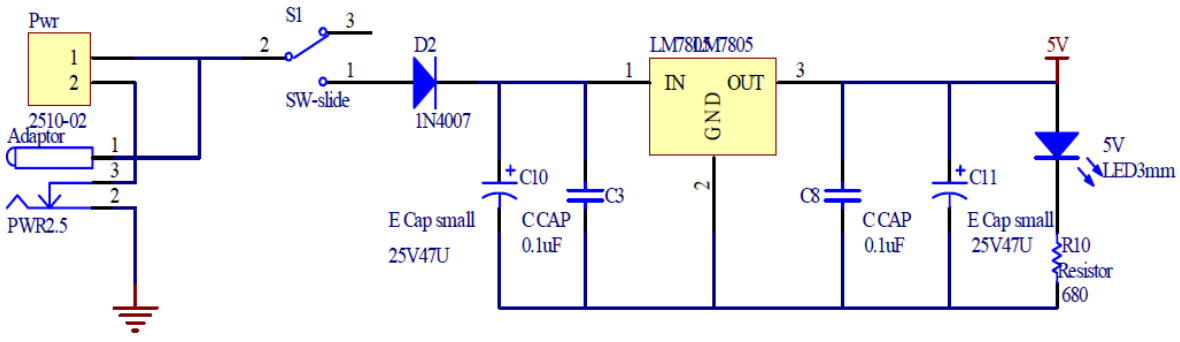

Figure 3.4: The circuit of voltage regulator LM7805

This circuit have 2 diferent type of power supply which can be used either AC to DC adaptor or 9V-12V battery to power up the circuit. Higher input voltage will produce more heat at LM7805 voltage regulator. Typical voltage is 12V.

Anyhow, LM7805 will still generate some heat at 12V. Diode D2 is use to protect the circuit from wrong polarity supply. Capacitor C3 and C10 is use to stabilize the voltage at the input side of the LM7805 voltage regulator, while the Capacitor C8 and C11 is use to stabilize the voltage at the output side of the LM7805 voltage supply. LED is a green LED to indicate the power status of the circuit. R10 is resistor to protect LED from over current that will burn the LED.

3.3.3 Power Source

Power supply is very important for each electronic circuit and devices inside the mobile robot. Without the properly regulated power supply it can affect the circuit and cause the robot malfunction. If the power supply for the circuit of mobile robot is less than required, the circuit will might not have enough energy and cause the problem such as LCD not displayed, LED not turn light and the microcontroller not receive the data from Bluetooth module. But if the exceeded current or voltage is supply, the circuit will damaged and malfunction as the microcontroller will burn. In this project, 5V is used to supply into microcontroller and other devices. The circuit is consisting of voltage regulator 5V to get the energy required. Meanwhile for servo motor is using 6V with separated voltage regulator 6V. For Bluetooth module BlueBee it should operate at 3.3V, however with the SKXBEE-Board it converts the voltage input 5V from PIC microcontroller to voltage input 3.3V. SKXBEE-Board will be equipped with Bluetooth module.

For all supply voltage of the mobile robot, the power source will be 11.1V Lithium Polymer (Lipo) Rechargeable Battery. This power supply should be enough for both microcontroller and servo motor of the mobile robot. The advantage of this battery beside rechargeable is small-size and lightweight when compare with other type of battery with the same capability. Figure 3.5 below show 11.1V Lipo battery.

Figure 3.5: Lipo battery 11.1V

Specification:

- Ordinary Voltage: 11.1V
- Fully-charge Voltage: 12.6V
- Capacity: 2200mAh
- Discharge rate: 30C
- Able to use for most of the 12V controllers, motors or any other appliances
- Must charge with designated LiPo Battery Charger

3.3.4 Microcontroller

Microcontroller 16F877A is chosen for this project. Below is some of the feature of this microcontroller:

• 256 bytes of EEPROM data memory

• self-programming

• 2 Comparators

• 8 channels of 10-bit Analog-to-Digital (A/D) converter

• 2 capture/compare/PWM functions

• synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus

• Universal Asynchronous Receiver Transmitter (UART)

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. It has many ports for input and output that suitable for multifunction mobile robot. Other than that, pin for receiving and transmitting data also included which is used for this project.

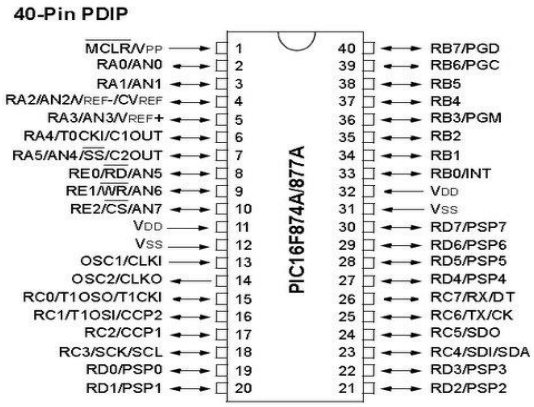

Figure 3.6: Pin diagram of PIC16F877A

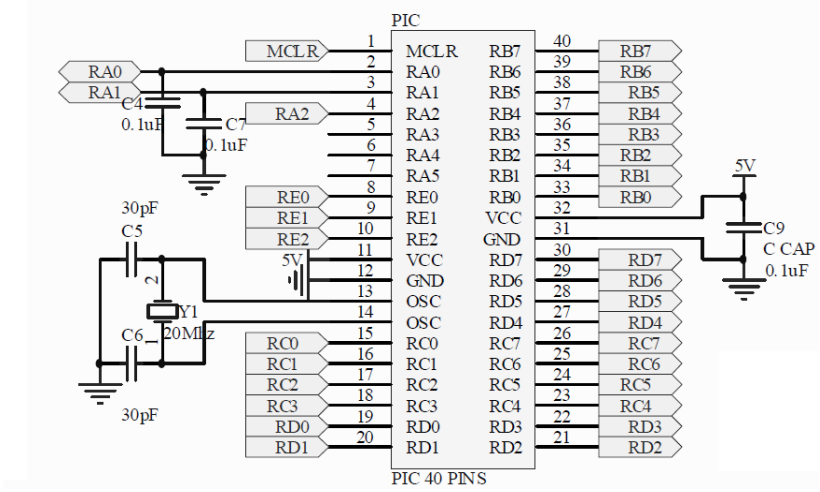

Figure 3.7: Circuit Connection of PIC16F877A

Microcontroller PIC16F877A is a 40 pins microcontroller which has five I/O ports. PIC16F877A is chosen to be used as the main processing unit for the mobile robot because it has high enough performance but with cheaper price, which is only

cost about RM20. Besides, this microcontroller has 2 PWM modules with 10 bits resolutions. The transmitter pin (TX) RC6 and receiver pin (RX) RC7 is used to communicate with wireless connection with smartphone by using Bluetooth Module. Four pins of the PIC16F877A are used to control the direction of two servo motors which is RC0, RC3, RC4 and RC5. Beside, an external crystal of 20Mhz is connected to the PIC18F4550 at pin 13 and 14 as shown in Figure to establish oscillation. For 20Mhz crystal, two 30pF capacitors are used for oscillator stability purpose.

3.3.5 Bluetooth Module

For this project, Bluetooth module BlueBee from Cytron Technologies is used. The main criteria Bluetooth wireless is chosen because the other wireless cannot be used with smartphone such as XBEE wireless because both devices have a different type of wireless and the XBEE wireless only can be connected between two XBEE modules. Since smartphone cannot connect directly with XBEE module, Bluetooth wireless is the efficient way to connect the smartphone with other devices. It also can reduce the cost as is only needed one Bluetooth module and its price is cheaper than XBEE module.

This BlueBee wireless module is new product from Cytron Technologies, utilizing the XBee form factor, BlueBee is compatible with XBee adapter such as SKXBee (without module), XBee breakout board and Arduino-XBee shield. Though the form factor (pin out) is compatible with XBee module, BlueBee uses Bluetooth Technologies. It has compact size, the pinout is compatible with XBee which is suitable for all kinds of microcontroller systems that have 3.3V power out, the module can use the AT commands to set baud rate.

The BlueBee module comes with an on-board antenna, the antenna provides better signal quality. It acts like a transparent serial port, which works with a variety of Bluetooth adapter and Bluetooth phone. It only provide SPP (Serial Port Profile)

where it becomes serial COM port once it establish connection with master Bluetooth.

BlueBee module's baudrate can modified using XBEE adapter. By using SKXBEE-BOARD or XBEE Arduino controller receives the base plug, enabling Bluetooth wireless control. Current version BlueBee Bluetooth module is only a slave module. Communication among two BlueBee is not possible. The connection must be initiated from Bluetooth Dongle (Laptop or computer), or handphone that have Bluetooth.

Specifications:

- Bluetooth chip: CSR BC04 Chipset
- Bluetooth protocol: Bluetooth Specification v2.0 + EDR
- Operating frequency: 2.4 ~ 2.48GHz unlicensed ISM band
- Modulation: GFSK (Gaussian Frequency Shift Keying)
- Transmit Power: ≤ 4dBm, Class 2
- Transmission distance: 20 ~ 30m in free space
- Sensitivity: ≤-84dBm at 0.1% BER
- Transfer rate: Asynchronous: 2.1Mbps (Max) / 160 kbps; Synchronous: 1Mbps/1Mbps
- Safety features: Authentication and encryption
- Support profiles: Bluetooth serial port
- Serial port settings: 1200 ~ 1382400 / N / 8 / 1
- Baud rate default: 9600 bps(Serial Port Profile, transparent mode)
- Baud rate default: 38400 bps in AT mode.
- Input Voltage: +3.3 DC/50mA
- Operating temperature: -20 ℃ ~ +55 ℃
- Module Size: 32 × 24 × 9mm

3.3.6 Interface LCD

Liquid crystal display (LCD) 2X16 character is using for the mobile robot. Table 3.1 shows connection pin and function of each pin is shown:

Pin	Name	Pin function	Connection
1	VSS	Ground	GND
2	VCC	Positive Supply for LCD	5V
3	VEE	Brightness Adjust	Connected to a preset to adjust brightness
4	RS	Select register, select instruction or data register	RB7
5	R/W	Select read or write	GND
6	E	Start data read or write	RB6
7	DB0	Data bus pin	RD0
8	DB0	Data bus pin	RD0
9	DB0	Data bus pin	RD0
10	DB0	Data bus pin	RD0
11	DB0	Data bus pin	RD0
12	DB0	Data bus pin	RD0
13	DB0	Data bus pin	RD0
14	DB0	Data bus pin	RD0
15	LED+	Backlight positive input	5V
16	LED-	Backlight negative input	RB5

Table 3.1: LCD Module Pin Description

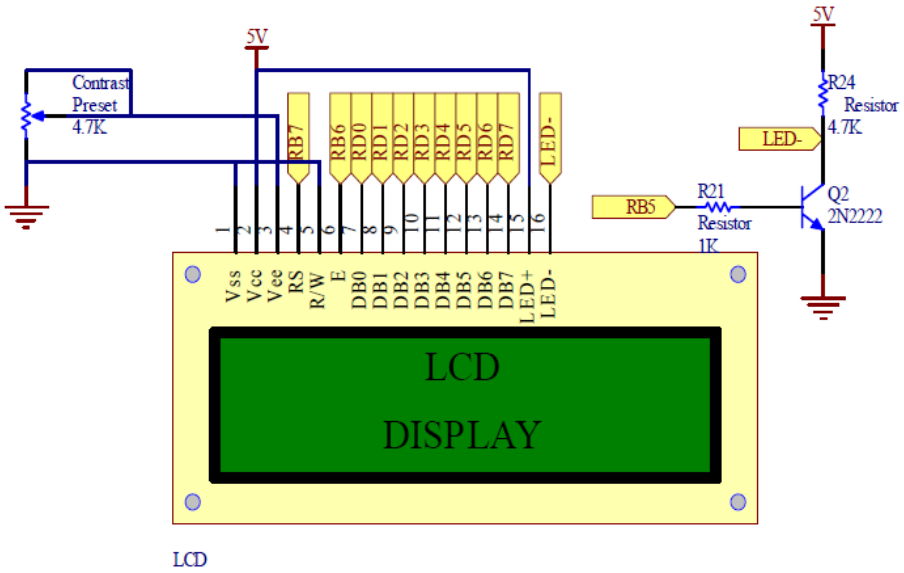

Figure 3.8: Circuit Connection of LCD

3.3.7 Servo Motor

This project is using two servo motor to control the movement of robot by control the motor direction whether clockwise or anti-clockwise. The type of servo motor is C36R from Cytron. This servo motor is modified so it is able to rotate 360 degree.

Figure 3.9: Servo Motor C36R Cytron

Specification:

- Plastic gears
- Speed (sec/60deg): 0.16/4.8V, 0.14/6.0V
- Torque (Kg-cm): 3.5/4.8V, 4.5/6.0V (Maximum 6.0V)
- Size (mm): 40.8x20.18x36.5
- Weight (g): 36
- Rotation angle: 180 degree
- Pulse width range: 0.546ms to 2.4ms (estimation)
- Designed for "closed feedback".
- Able to control the position of the motor
- C/W plastic servo horn and accessories

3.3.8 Printed Circuit Board

Printed circuit board is provided in PR23 mobile robot. This PCB will be soldering with electrical component to complete its circuit. Figure 3.10 below the PCB of mobile robot and their component area.

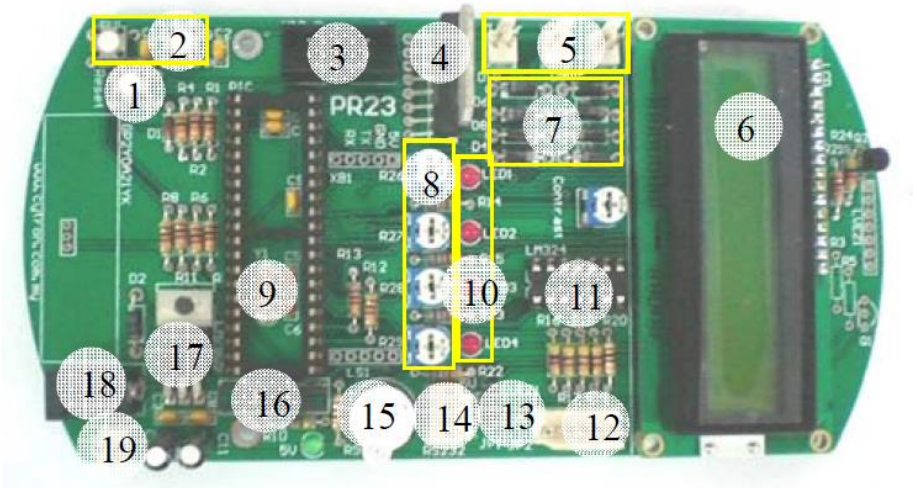

Figure 3.10: PCB of mobile robot

Component:

1. Reset button (to reset the microcontroller).
2. Push button.
3. UIC00A box header (connect to UIC00A programmer to load program).
4. L298N (Motor driver).
5. 2510-02 connector (motor connector).
6. Parallel LCD 2x16
7. 1N5819 (Clamping diode).
8. Preset (adjust sensitivity of IR sensor).
9. Crystal (20MHz).
10. LED (indicate status of sensor).
11. LM324 (comparator)
12. 2510-06 (connector for IR sensor)
13. Header 3x1 (To select ultrasonic or Communication).
14. 2510-04 connector, (UC00A connector).
15. Buzzer.
16. Slide switch (to ON or OFF the circuit).
17. LM7805 (voltage regulator, supply 5V for PIC).
18. AC-DC adaptor socket (to use power supply from AC-DC adaptor).
19. 2510-02 connector, (to use 11.1V of Li-on battery to power up the circuit).

3.4 Software Part

The software consist of 2 part which are the programming of PIC microcontroller and programming of the Android Application. This topic will discuss on software development and circuit debugging that essential for developing an embedded system.

3.4.1 Microcontroller Programming

The microcontroller has to be programmed to make the mobile robot behave as the designer want. There are a lot of software in market to develop the program such as MPLAB, MicroC and others. In this project MPLAB with C language has been choose as the software to program the microcontroller. This project used MPLAB IDE version 8.60. The MPLAB software already has the C compiler and assembler that can convert the programming code into the hex file. The hex file is the file that contains coded programming in hexadecimal number that can be loaded into the microcontroller using circuit debugging tools. Figure 3.11 shows the MPLAB software window interfaces.

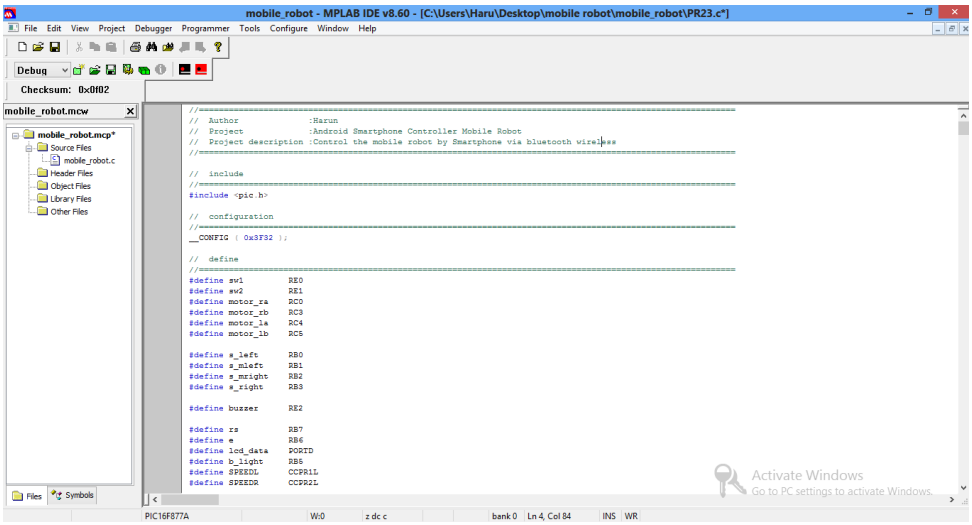

Figure 3.11 : MPLAB Window Interfaces

The converted hex file needs to load into the PIC microcontroller by using a programmer or debugger. Cytron's USB In Circuit Serial Programmer (ICSP) for PIC Microcontrollers UIC00B is used in this project as a programmer to load the source code into the PIC microcontroller. Figure 3.12 below shows the ICSP or the programmer that used in this project.

Figure 3.12: Cytron USB Programmer/In Serial Circuit Debugger (ICSP)

The software for the ICSP is PICkit 2 programmer. This software is to ensure the ICSP is connected with the PIC microcontroller and also to write the source code to PIC microcontroller or read the hex file from PIC microcontroller. Figure 3.13show the window interface of the software that used to load the program into the microcontroller.

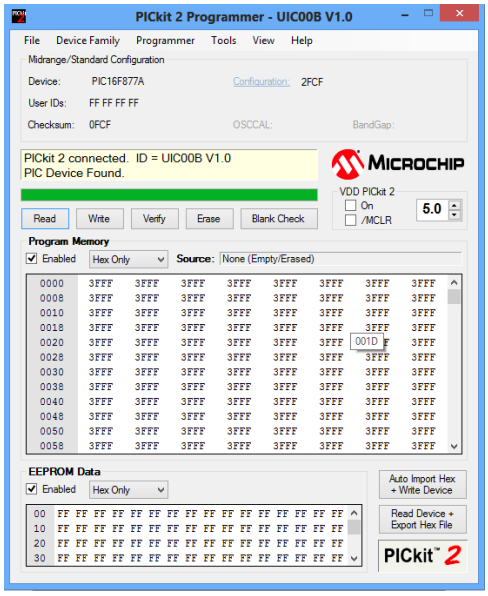

Figure 3.13: PIC Programmer interface window

3.4.2 Android Software

The Android Application can be developed by 2 different method and software. First method is by using Software Developed Kit (SDK) which using coding of Java Language and second method is by using an App Inventor for Android. For this project, second method is used to develop Android Application that can control the mobile robot with Bluetooth because this software is easier to use since not needed to use any coding.

3.4.3 App Inventor

App Inventor for Android is an application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). It allows anyone familiar with computer programming to create software applications for the Android operating system (OS). It uses a graphical interface that allows users to drag-and-drop visual objects to create an application that can run on the Android system, which runs on many mobile devices. To develop a program by this application, the Google mail and internet is required to save and modify the program.

This application has two software which are App Inventor Designer and App Inventor Blocks Editor. App Inventor Designer is to develop the interfaces of Android Application. There are many different type of palette can be added to interface such as button, image, label, slider and others. App Inventor Blocks Editor is using to program the Android Application without coding which programming it with drag and drop the blocks editor. Figure 3.14 below shows the developed of Android Application with Google App Inventor Servers.

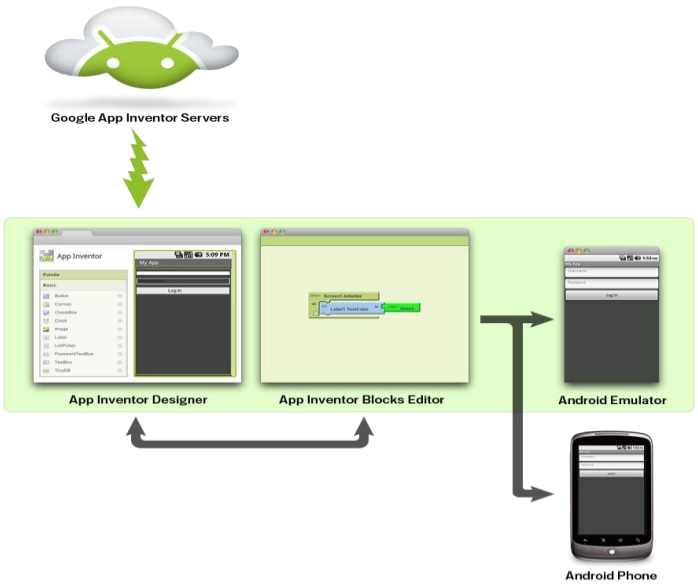

Figure 3.14: App Inventor for Android

The Bluetooth application needed to be used for this application to be able connected with the mobile robot. The Bluetooth connection is program with several options which will make this application is easier to use. For this project, the motion of accelerometer sensor will be using to control the movement of the mobile robot. The accelerometer will be accelerate in three axis which are x, y, and z axis when the smartphone is move its direction. The Android Application is programmed with accelerometer sensor by specific the value of accelerator of axis. When the accelerators meet the certain conditions the specific data will be send by smartphone to the mobile robot. Figure 3.15 below shows the Designer of Android Application of this project and figure 3.16 below show the Block Editors of Android Application with Bluetooth application and accelerometer sensors.

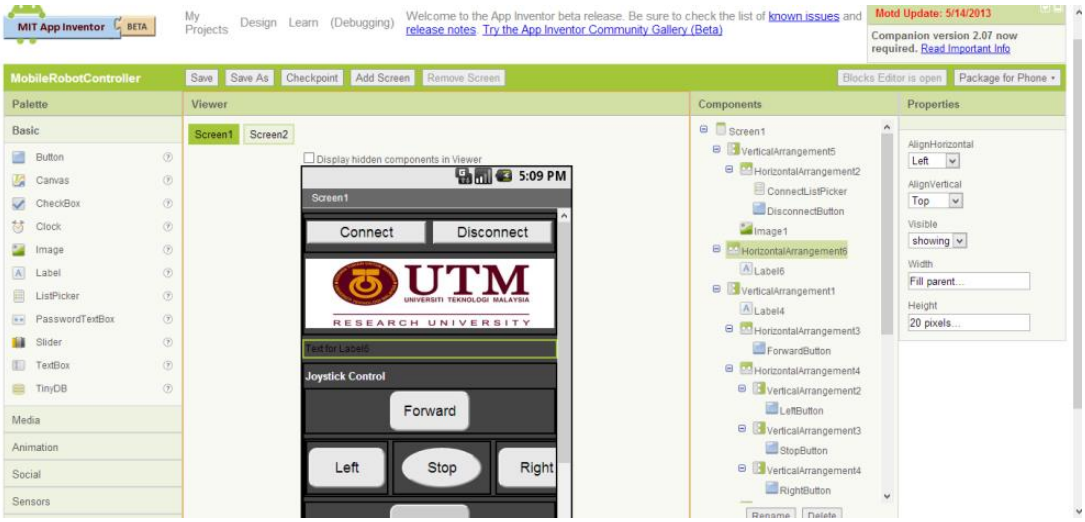

Figure 3.15: Designer of Android Application

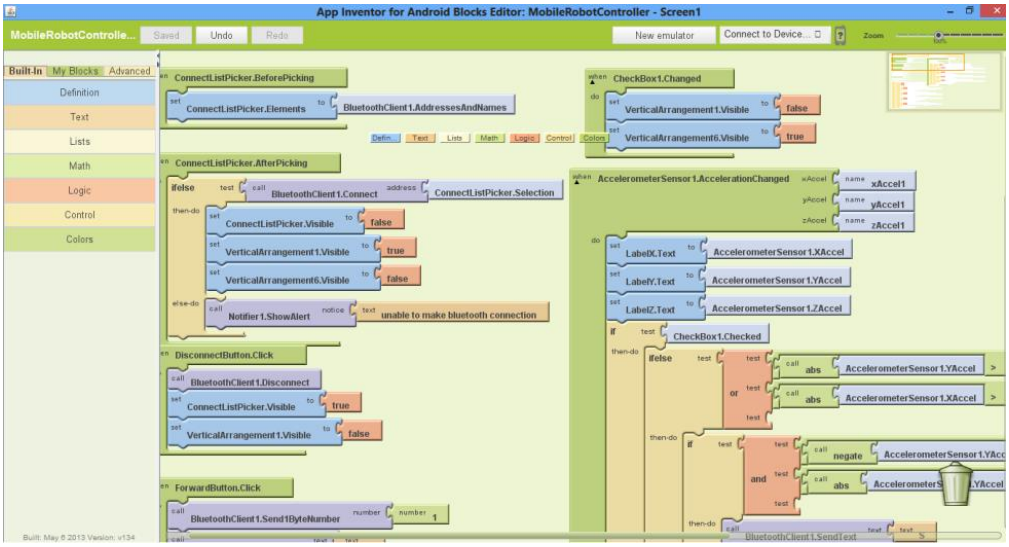

Figure 3.16: Block Editors of Android Application

After finished developed the application, the application can be installed into our Android Smartphone by download into our smartphone to able used it features. When the Bluetooth is connected, the data can be sending by this application to Bluetooth module of the mobile robot.

3.5 Flow Chart

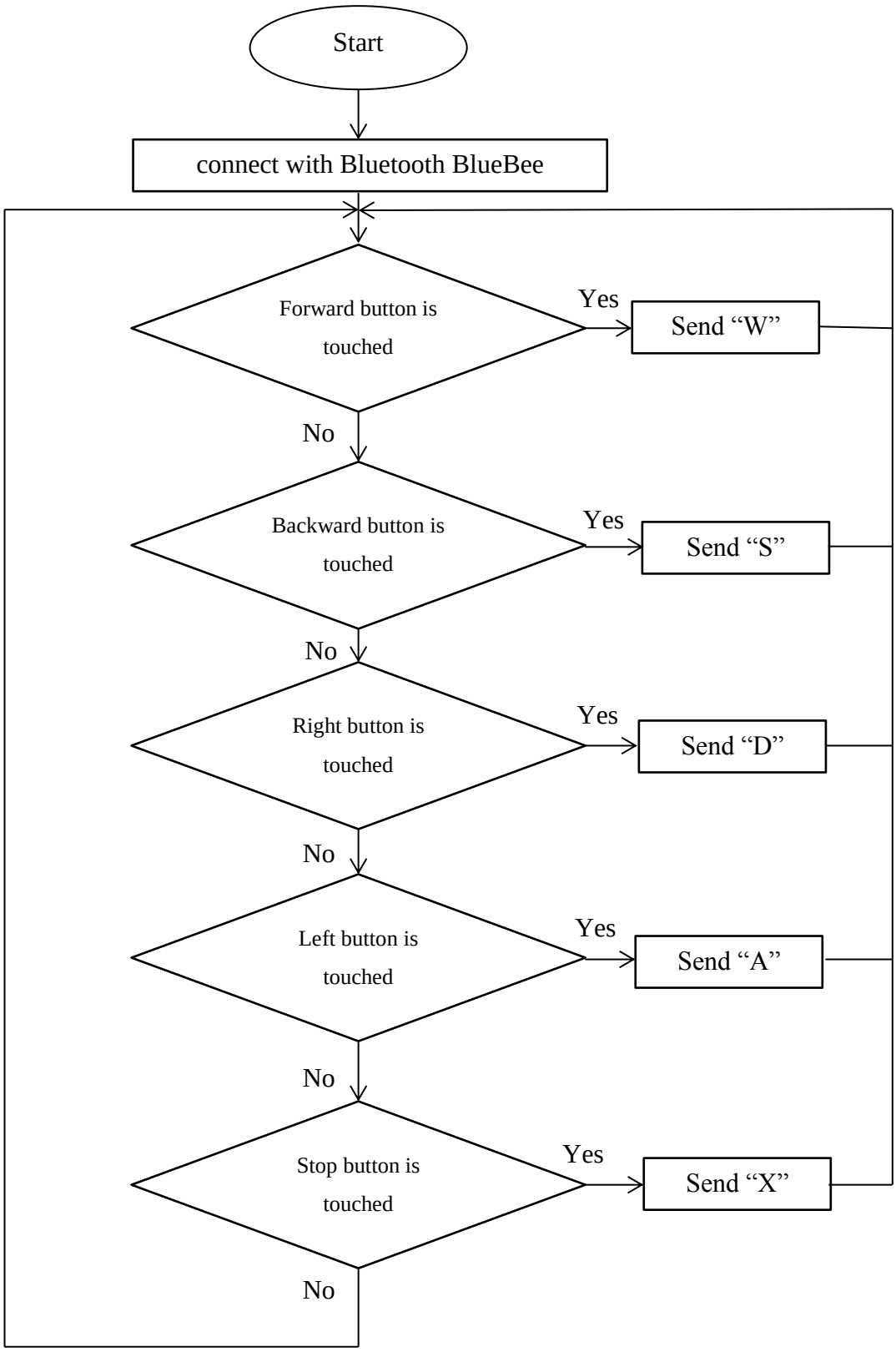

Figure 3.17: Flowchart of Android Application

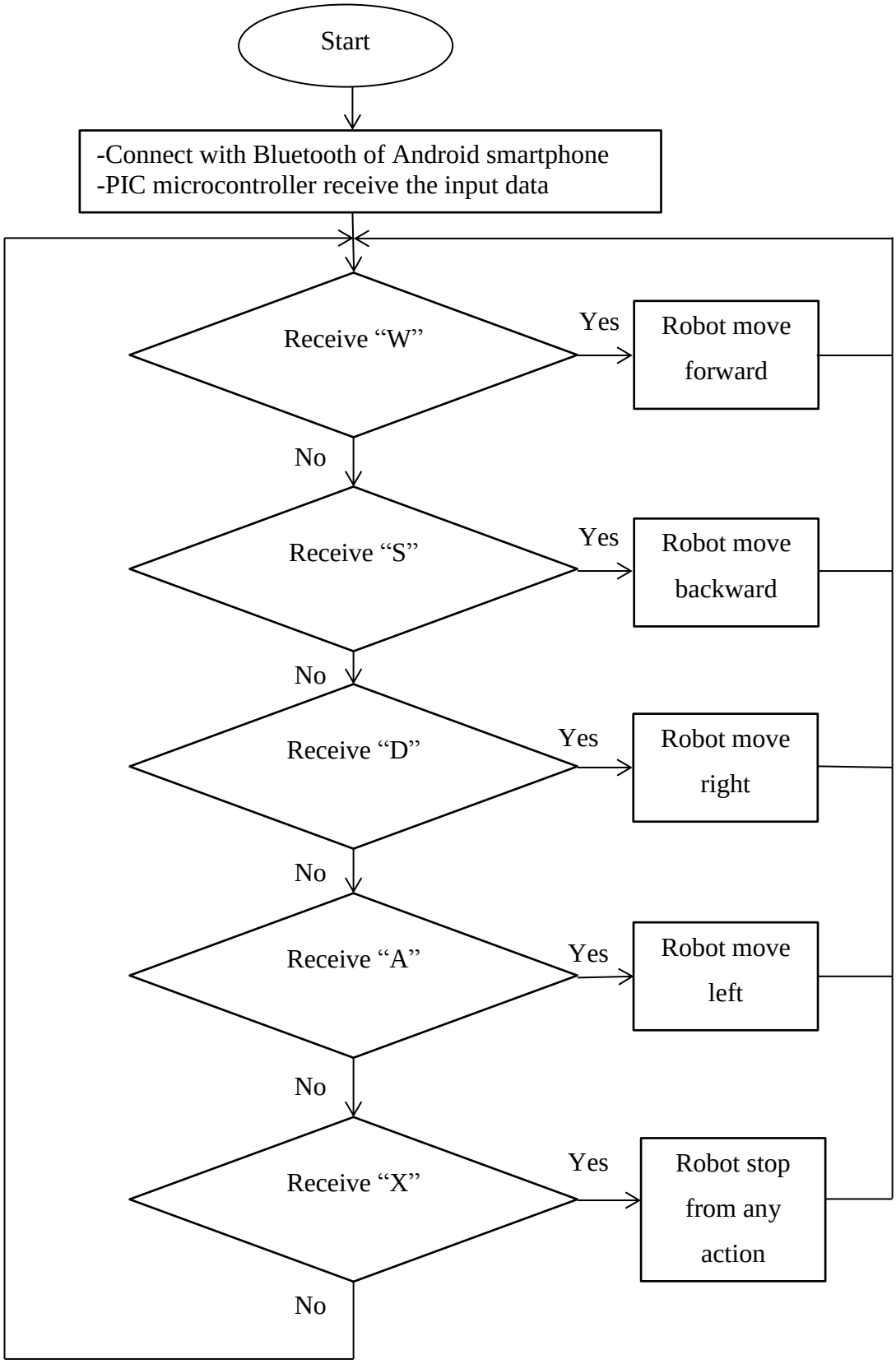

Figure 3.18: Flow chart of PIC microcontroller

Figure 3.17 shows the flowchart of Android Application and Figure 3.18 shows the flowchart of PIC microcontroller. The Bluetooth connection needs to be establishing to transmit and receive the input data. The Android application will send data to Bluebee Bluetooth module when the button of joystick control is touched. PIC microcontroller will receive the data from Bluetooth Module and determine the process that will take action depend on the input receive. The programs will always in infinite loop to search for the input until the Android application is closed the power of the module is turned off.

3.6 Testing and troubleshooting

Testing is important to determine the product reliability and functionality. Several testing already been done in this project to make sure the project is function and safe to use. After the circuit is complete soldered, testing is needed to make sure the circuit is free from short circuit. The after the circuit is connected with power source, the circuit also need to do testing and troubleshoot to check the circuit whether its component has enough voltage as specified needed. The communication Bluetooth also need to do some troubleshooting to make sure the data send is corrected when the receiver has receive the data and the data can be improved by reduce the noise from surrounding. The mobile robot is testing whether the action of robot is same as the data sent from smartphones.

3.7 Summary of Chapter

The progress of the project need to follow the project planning in order to make sure the project can be completed as expected time and to make the project more systematic with the correct way as this methodology will be implemented when plan the project work in industries. A different method with potential safety and more benefit need to be discovered and design to produce the good quality of the project. Then, the method with a more advantages and less disadvantages is chosen to complete the project.

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Introduction

This chapter discusses on the results obtained from experiments and the problems faced during the progression of this project. The results of the project include the develop communication wireless between the mobile robot with Android Smartphone to controlled the movement of mobile robot and the design of Android Application by using Application Inventor Servers.

4.2 Modified Mobile Robot

Two wheeled mobile robot is built as requirement of this project and equipped with a Bluetooth Module BlueBee to create a wireless connection between the mobile robot and Android smartphone. The mobile robot will receive an instruction from a smartphone Android Application and will do a specific task given. To control the mobile robot is mean to control its servo motor whether it will move

clockwise or anti-clockwise. Figure 4.1 shows the modified mobile robot which equipped with Bluetooth communication Module.

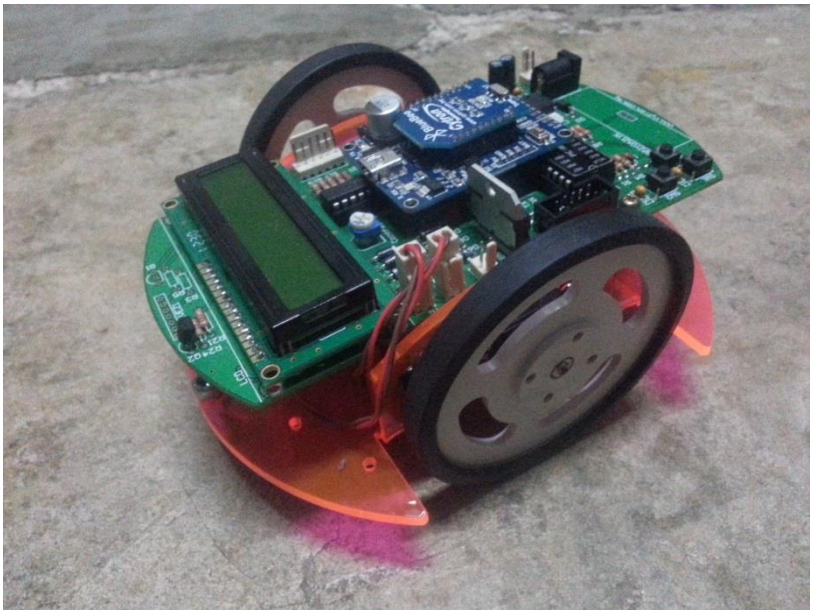

Figure 4.1: Mobile robot with Bluetooth communication

4.3 Android Application Mobile Robot Controller

The android application is developed as required for this project which was name as Mobile Robot Controller. The application was installed to Android smartphone and testing the feature and functionality of smartphone such as touch screen and sensors. It shows the application can be used successfully as expected from this project. Figure 4.2 shows the Android Application named as Mobile Robot Controller.

Figure 4.2: Android Application Mobile Robot Controller

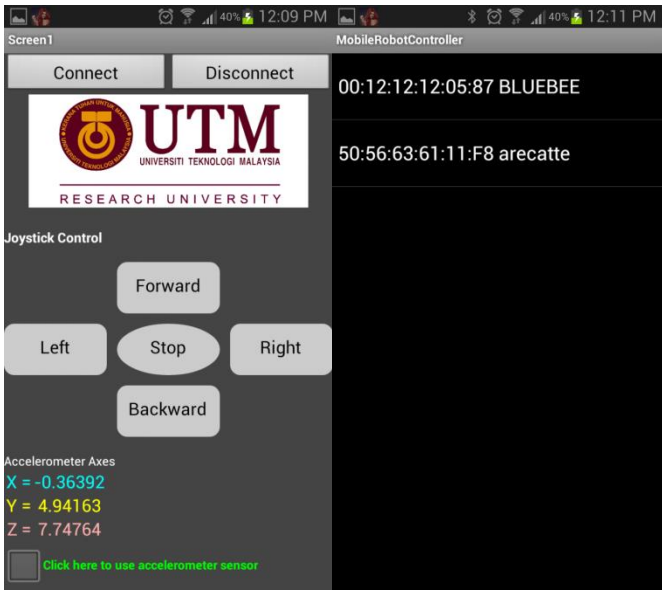

Figure 4.3: Interface of Android Appication

Figure 4.3 shows the interface of Android Application. This application can control the mobile robot through Bluetooth wireless whether by using keypad or accelerometer sensors inside of smartphone. The top of the screen shows connect and disconnect button. This button is used to create the Bluetooth connection with the paired device. For this project, BlueBee module is used and clicks the BlueBee to

connect it as shows at figure. The screen has joystick control part to control the mobile robot by touch the keypad. It is also show the accelerator axes for the motion accelerometer sensors. At the bottom position of screen has an option to choose use accelerometer sensors to control the mobile robot.

4.4 The movement response of mobile robot

The keypad button or joystick control consist of five instructions to the mobile robot where is the movement of the mobile robot which are forward, backward, right, left and stop as shown at figure above. When the forward button is touched, the application will send 'forward' instruction to the mobile robot through Bluetooth wireless and the mobile robot will receive the instruction and do the task given. It also same when other button is touched, the application will do send the data as stated in button layer.

Action	Robot Response
Touch the forward keypad	The robot is move forward
Touch the backward keypad	The robot is move forward
Touch the right keypad	The robot is turn right
Touch the left keypad	The robot is turn left
Touch the stop keypad	The robot is stop from doing any activities

Table 4.1: The result of using keypad

When the accelerometer sensors are activated by click at accelerometer sensors button, the keypad cannot be used and the motion of accelerometer sensors will be used to control the mobile robot. The motion of accelerometer sensors consist of x, y and z accelerate axis and the value will be responding when the smartphone move. When the accelerator axis reaches a certain value with a specific

condition, the application will send the data through Bluetooth to the mobile robot. The data send is same with the keypad before which are forward, backward, right, left and stop.

Action	Robot Response
When the smartphone move downward position	The robot is move forward
When the smartphone move upward position	The robot is move backward
When the smartphone move right position	The robot is turn right
When the smartphone move left position	The robot is turn left
When the smartphone at flat position	The robot is stop from doing any activities

Table 4.2: The result of using accelerometer sensors

Figure 4.4: The mobile robot controlled by smartphone

4.4 Discussions

After testing have been made rigorously, it is clear that the project achieve the objective of this project to develop a wireless switch, however a few challenges have been countered while developing this project.

The first challenge is the developing the communication wireless between the mobile robot and Android smartphones. Most of the wireless application based on previous project are using XBEE wireless for create a connection between two devices such as the robot and computer. However for the smartphone, it has a different wireless type with XBEE wireless which both cannot be connected directly. Furthermore, XBEE module is only can be connected with other XBEE module which is the smartphone needed XBEE module for itself as it will reduce the potential of smartphone since its need to move freely with the motion of the accelerometer sensors. This problem is solved by using the Bluetooth module as Bluetooth module and smartphone has the same type of Bluetooth wireless connection.

Second challenge is to develop an Android application for smartphones. At early stage, the application is developed by using Software Development Kit which will use java language to programming the application. However, the java coding is quite hard to understand and it takes more than expected time required. As the schedule goes on, the time is become limited for complete this project. After successful developed the application, the screen is not very clearly to see that might be because some of bad and wrong coding of programming. The application also could not connect with Bluetooth wireless due to missing statement requirement to establish the Bluetooth for smartphone. With using Application Inventor for Android, this problem does not occur and the application can be used as required for this project.

4.5 Summary of Chapter

The mobile robot is modified to able control it with Android Application that has been successfully developed. The instruction given can be understand by the mobile robot and process the data to do the task that were program in PIC microcontroller. Besides, the problems occur during this project is bring to minimum which not affected the output of the project.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter will explain about the conclusions of the project and recommendation that can make for future improvements and innovations.

5.2 Conclusions

` The first chapter stated that two objective need to be completed in order for this project to be success. First objective is to design a mobile robot with a communication wireless between the mobile robot and Android smartphone and second objective is to Developing an Android application which able to use accelerometer sensors inside smartphone to control movement of mobile robot via wireless

The mobile robot is completed built with PIC microcontrollers and Bluetooth Module, which the mobile robot can build the wireless connection with Android

smartphone. The Android application that be able to control the mobile robot also has been successfully developed with addition can used an accelerometer sensors as a controller. As a conclusion, this project is success as both objectives is managed to be completed at the end of the research and wireless controller has successfully been developed. Furthermore, the wireless controller by using Android application is freeware and can be used by other people without need to paying the application.

5.3 Recommendations

This project can be upgraded with several improvement and innovation to improve its functionality and more attractive .Thus, for future advancement and research improvement in this project, following recommendations can be made:

1. Increase the type of movement of the mobile robot that can be controlled to make its more functionality and attractive. This project has a potential as an attractive tools to kid and teenager which can be used as a games and toys for market business.
2. The application can be develop for other mobile operating system rather than Android such as iOS, Windows Phone and Blackberry. The other different type user of smartphone able to enjoy the application without needed to buy Android smartphones.
3. The application can be developed to control other wireless devices which not only robot, but electrical devices as well such as switch, computer and electrical doors. In future, the smartphone will be an important devices that must be own for everyone as it can control many other devices as the new technology is focus to using less wire and more wireless devices because it is more cheaper, easy to use and can save more space.

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APPENDIX A

GANT CHART

FYP 1

No	Activities	Week															
	FYP 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Project Research																
3	Project proposal																
4	Literature Review																
5	Parts/components purchasing																
6	Circuit Design/Basic programming																
7	Software Learning																
8	Presentation																
9	Report Writing																
10	FYP1 report submission																

FYP 2

No	Activities	Week															
	FYP 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Hardware Construction																
2	Software Development																
3	Hardware and Software integration																
4	Testing and Troubleshooting																
5	Analysis and Result																
6	FYP 2 demo and presentation																
7	Final thesis writing																
8	Thesis submission																

APPENDIX B

SOURCE CODE OF PIC MICROCONTROLLER

```
//================================================================================
//     Author                      :Harun Aminurasyid Bin Abu Bakar
//     Project                     :Mobile Robot Controlled Android Smartphone
//     Version                     :v1.00
//     Date                        :May 2013
//================================================================================

//     include
//================================================================================
#include <pic.h>

//     configuration
//================================================================================
__CONFIG ( 0x3F32 );

//     define
//================================================================================
#define sw1          RE0
#define sw2          RE1
#define motor_ra     RC0
#define motor_rb     RC3
#define motor_la     RC4
#define motor_lb     RC5

#define s_left              RB0
#define s_mleft             RB1
#define s_mright            RB2
#define s_right             RB3

#define buzzer              RE2

#define rs                  RB7
#define e                   RB6
#define lcd_data            PORTD
#define b_light             RB5
#define SPEEDL              CCPR1L
#define SPEEDR              CCPR2L

#define RX_PIN              RC7
#define TX_PIN              RA2
#define BOT_ADD             100



//     global variable
//================================================================================
==================
unsigned int result;
unsigned int To=0,T=0,TH=0;
unsigned char REC;
unsigned char i=0,raw;

unsigned int us_value (unsigned char mode);

//     function prototype
//================================================================================
==================
void init(void);
void delay(unsigned long data);
void send_config(unsigned char data);
void send_char(unsigned char data);
void e_pulse(void);
```

```
void lcd_goto(unsigned char data);
void lcd_clr(void);
void send_string(const char *s);
void dis_num(unsigned long data);

void wireless_bluebee(void);

void forward(void);
void stop (void);
void backward (void);
void reverse (void);
void left(void);
void right(void);

void uart_send(unsigned char data);
unsigned char uart_rec(void);
void read_adc(char config);


//     interrupt prototype
//=============================================================================
=================
static void interrupt isr(void)
{
       if (TMR0IF)                          // TMR0 is overflow
       {
              TMR0IF = 0;                   // clear flag bit
              To +=0x100;                   // count number of TMR0 overflow

       if(RBIF)                             // there is change bit on RB4-RB7
       {
              RBIF = 0;
              if (RB4)                      // Rb4 is 1 mean is rising form 0
              {
                     TMR0 = 0;              // clear all counter involved, start
new count for period of RB4 high
                     To = 0;
              }


              else TH = TMR0 + To;          // RB4 is 0 mean is falling form 1
            // save TH, RB4 high period
       }

       if(RCIF)
       {
              RCIF = 0;                                 // clear flag bit

              if (RCREG == 'R') data[i=0]= RCREG;       // check if start byte
'R' is met
              else if (RCREG == 100) data[i=0]= RCREG;        // check if
start byte 'd'(decimal 100) is met
              if ((data[0] == 'R'))data [i++] = RCREG;        // save the data
in data array
              if (i>4) i = 4;
              // if the data array reached max, set the index to 4
       }
}


//     main function
//=============================================================================
```

```
void main(void)
{

	unsigned char m=0,i =0;
	delay(20000);
	init();			// initiate cnfiguration and initial condition
	buzzer = 1;		// inditcate the circuit is on with beep
	lcd_clr();		// clear the LCD screen
	send_string("Press switch 1 ");		// display "select mode"
	lcd_goto(20);				// move to 2nd line
	send_string("to start");	// display string according to the mode
	buzzer = 0;				// stop beep

	while(1)				// loop
	{

		if (!sw1)		// if button SW2is pressed
		{
			while(!sw1);		// wait until button is released
			switch(m)
			{

				case 0 :wireless_bluebee(); // bluetooth wireless
bluebee mode
				break;

				default :	;
			}
		}
	}
}

//=========================================================================
// Initailization
// Description : Initialize the microcontroller
//=========================================================================
void init()
{
	// ADC configuration
	ADCON1 = 0b10000100; //set RA0 and RA1 as Analog Input, left justified

	// setup for capture pwm
	RBIE = 1;			// enable interrupt on change of port B
					// motor PWM configuration
	PR2 = 255;				// set period register
	T2CON =		0b00000100;		//
	CCP1CON =	0b00001100;		// config for RC1 to generate PWM
	CCP2CON =	0b00001100;		// config for RC2 to generate PWM

	// Tris configuration (input or output)
	TRISA = 0b00000011;  //set RA0 and RA2 pin as input,other as output
	TRISB = 0b00011111;  //set RB0-RB4 pin as input, other as output
	TRISC = 0b10000000;  //set PORTC pin as output
	TRISD = 0b00000000;  //set all PORTD pin as output
	TRISE = 0b00000011;

	// TMR 0 configuation
	T0CS = 0;
	PSA = 0;
	PS2 = 1;					// prescale 1:32
	PS1 = 1;					//
	PS0 = 1;					//
```

```
        TMR0IE = 1;                                     // TMR0 Interrupt
        TMR0 = 0;

        //setup UART
        SPBRG = 0x81;               //set baud rate to 9600 for 20Mhz
        BRGH = 1;                   //baud rate high speed option
        TXEN = 1;                   //enable transmission
        TX9 = 0;
        CREN = 1;                   //enable reception
        SPEN = 1;                   //enable serial port
        RX9 = 0;
        RCIE = 1;                   //enable interrupt on eachdata received

        // enable all unmasked interrupt
        GIE = 1;
        PEIE = 1;

        // LCD configuration
        send_config(0b00000001);          //clear display at lcd
        send_config(0b00000010);          //Lcd Return to home
        send_config(0b00000110);          //entry mode-cursor increase 1
        send_config(0b00001100);    //diplay on, cursor off and cursor blink off
        send_config(0b00111000);          //function

        TX_PIN = 1;
        b_light = 0;
        buzzer = 0;
        stop();

}

//=============================================================================
//  Bluetooth wireless
// Description : Control the robot using UART (BlueBee Bluetooth Module)
//=============================================================================
void wireless_bluebee (void)
{
        lcd_clr();
        lcd_goto (0);
                    // clear the lcd
        RCIF = 0;
                    SPEEDL = 255;
                    // set the motor speed
                    SPEEDR = 255;
                    while(1)
                    {
                            lcd_goto(20);
                            if (RCREG == 'W')
              // if character 'W' is detected, the robot move forward
                            {
                                    forward();
                                    send_string("FORWARD        ");
                            }

                            else if (RCREG == 'S')
              // if character 'S' is detected, the robot move backward
                            {
                                    backward();
                                    send_string("BACKWARD        ");
                            }
                            else if (RCREG == 'D' )
              // if character 'D' is detected, the robot turn right
```

```
                        {
                                right();
                                send_string("TURN RIGHT      ");
                        }

                        else if (RCREG == 'A')
                // if character 'A' is detected, the robot turn left
                        {
                                left();
                                send_string("TURN LEFT       ");
                        }

                        else if (RCREG == 'X')
                // if character 'X' is detected, then stop the robot
                        {
                                stop();
                                send_string("STOP  ");
                        }
                        else                    // else then stop the robot
                        {
                                stop();
                                send_string("INSERT COMMAND  ");
                        }



        }
}



//=============================================================================
// Motor control function
// Description : subroutine to set the robot moving direction
//=============================================================================
void forward ()
{
        motor_ra = 0;
        motor_rb = 1;
        motor_la = 0;
        motor_lb = 1;
}

void backward ()
{
        motor_ra = 1;
        motor_rb = 0;
        motor_la = 1;
        motor_lb = 0;
}

void left()
{
        motor_la = 1;
        motor_lb = 0;
        motor_ra = 0;
        motor_rb = 1;
}
void right()
{
        motor_la = 0;
        motor_lb = 1;
```

```
	motor_ra = 1;
	motor_rb = 0;
}

void stop()
{
	motor_la = 1;
	motor_lb = 1;
	motor_ra = 1;
	motor_rb = 1;
}

//=============================================================================
//	LCD	functions
//=============================================================================
void delay(unsigned long data)	//delay function, the delay time
{
	for( ;data>0;data-=1);	//depend on the given value
}

void send_config(unsigned char data)	//send lcd configuration
{
	rs=0;				//set lcd to config mode
	lcd_data=data;			//lcd data port = data
	delay(400);
	e_pulse();			//pulse e to confirm the data
}

void send_char(unsigned char data)		//send lcd character
{
	rs=1;				//set lcd to display mode
	lcd_data=data;			//lcd data port = data
	delay(400);
	e_pulse();			//pulse e to confirm the data
}

void e_pulse(void)			//pulse e to confirm the data
{
	e=1;
	delay(300);
	e=0;
	delay(300);
}

void lcd_goto(unsigned char data)	//set the location of the lcd cursor
{
	if(data<16)			//if the given value is (0-15) the
	{				//cursor will be at the upper line
		send_config(0x80+data);
	}
	else			//if the given value is (20-35) the
	{			//cursor will be at the lower line
		data=data-20;	//location of the lcd cursor(2X16):
		send_config(0xc0+data);				// ------
----------------------------------------------
	}
	// | |00|01|02|03|04|05|06|07|08|09|10|11|12|13|14|15| |
}
	// | |20|21|22|23|24|25|26|27|28|29|30|31|32|33|34|35| |

	// ------------------------------------------------
```

```
void lcd_clr(void)                              //clear the lcd
{
       send_config(0x01);
       delay(350);
}

void send_string(const char *s)          //send a string to display in the lcd
{
       while (s && *s)send_char (*s++);
}

void dis_num(unsigned long data)
{
       unsigned char hundred_thousand;
       unsigned char ten_thousand;
       unsigned char thousand;
       unsigned char hundred;
       unsigned char tenth;

       hundred_thousand = data/100000;    // devide to get the numerator
              eg: 5234/1000 = 5
       data = data % 100000;       // modulas to get the remainder
              eg: 5234%1000 = 234
       ten_thousand = data/10000;
       data = data % 10000;
       thousand = data / 1000;
       data = data % 1000;
       hundred = data / 100;
       data = data % 100;
       tenth = data / 10;
       data = data % 10;

       send_char(hundred_thousand + 0x30);             //0x30 added to become
ASCII code char '0' to '9'
       send_char(ten_thousand + 0x30);
       send_char(thousand + 0x30);
       send_char(hundred + 0x30);
       send_char(tenth + 0x30);
       send_char(data + 0x30);
}

//================================================================================
// uart function
//================================================================================
void uart_send(unsigned char data) //function to send out a byte via uart
{
       while(TXIF==0);             //wait for previous data to finish send out
       TXREG=data;                         //send new data
}

unsigned char uart_rec(void)//function to wait for a byte receive from uart
{
       unsigned char temp;
       while(RCIF==0);                     //wait for data to received
       temp=RCREG;
       return temp;                        //return the received data
}
```