Car Key Lock Reminder

(XBee Wireless Module Implementation)

By

ZAINOL AMIR HAFIZUDDIN BIN ZAINOL ABIDIN

Dissertation Report

Submitted to the Electrical & Electronics Engineering Programme

in Partial Fulfilment of the Requirements for the Degree

Bachelor of Engineering (Hons)

(Electrical & Electronics Engineering)

DECEMBER 2010

UNIVERSITI TEKNOLOGI PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

This page is intentionally left blank

CERTIFICATION OF APPROVAL

Car Key Lock Reminder

By

ZAINOL AMIR HAFIZUDDIN BIN ZAINOL ABIDIN

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL AND ELECTRONICS ENGINEERING)

Approved by,

____

(Dr. FAWNIZU AZMADI HUSSIN)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
DECEMBER 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and the original work contained herein have not been undertaken or done unspecified sources or persons.

(ZAINOL AMIR HAFIZUDDIN ZAINOL ABIDIN)

ACKNOWLEDGEMENT

The author would like to express his deepest gratitude to the all mighty God for His guidance and blessing throughout the completion this report.

For most of the appreciation, the author would like to address to Dr. Fawnizu Azmadi Hussin, the project supervisor, for his willingness to share the idea with the author. For his time spent and understanding of the nature. For flexibility of work he offered. Not to mentioned, his effort in supervising, mentoring and delivering many precious lessons to the author on both technical and non-technical matters. Thank you.

To Kak Hawa, for giving a clear guidance on task given and share valuable knowledge and experience Thanks to all UTP staffs, technician in Electrical and Electronics Department, especially printed circuit board lab technician, for giving assistance, supporting and guidance within these 5 years and making it seems to be too short to spend here.

The appreciation would be incomplete without acknowledging of the university, for every possibilities and chances they provided.

In addition to that, the author would like to thank his supportive family members and the love one for their unyielding support, understanding, love and encouragement every single day, even though the project really took a lot of time away from them.

Last but not least, to those who are involved in the completion of this Final Year Project, whether directly or indirectly.

ABSTRACT

In today's world scenario, innovation is the key element where we believed that economy growth will be fuelled by innovation technology and reliance on this technology is predicted to be more than before in order to increase productivity especially when we are facing this recession period [1]. More effort and investment will be put on financial, safety and security because of increasing wave of concern towards these three critical issues. Among the expensive assets besides home property, car is one of the luxuries item and it slowly becomes a basic necessity item to major of people living, especially to people who rely on transport to go to work. Because of the concern on financial, safety and security, Car Key Lock Reminder is invented. Car Key Lock Reminder is a conceptual system that reminds the user to lock their vehicle based on the current vehicle's condition. The system calculates proximity distance between user and vehicle to determine whether the user is leaving the vehicle or not, before the system started to remind the user. Eventually, prevent the vehicle from stolen or hijacked. The system utilizes well-know link quality estimation, Received Strength Signal Indicator (RSSI), which indicates received power should be a function of distance with assumption of ideal environment. The system consists of two set of microcontrollers and XBee 802.15.4 RF Wireless modules, which one set is placed in the vehicle and one set is a handheld device.

Table of Content

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

From military to healthcare, various wireless communication applications have been developed as wireless communication has become more popular over the last decade. This rapid pace in technology advancement has produced a lot of wireless modules to fit various applications from high-end wireless modules to low-power consumption wireless modules.

Regardless advancement in technology, the innovation invented still lack of interaction between human and machine. According to a paper, *Social Defence Mechanisms: Tools for Reclaiming Our Personal Space* [2] *by Limor Fried,* improving human-machine interaction is next level technology in the future, which the main focus is to investigate how the engineers can refigure technology to address the full range of human experience. In the paper, she also pointed out questions regarding the difference between technology and what is actually consumer need.

The author agreed with *Limor Fried's* idea and absorbed the idea into the project, for example in this context, vehicle locking system. The author believed that innovation technology should integrate human interaction in making decision, by not granting full privilege of decision making to the technology. Instead, the technology should communicate to human, assisting them in making decision. This major difference between the products in the market and this concept would make it standout from the rest and improve human experience.

Car Key Lock Reminder is invented based on this idea as an additional feature to commercial car locking system such as central locking system. Car Key Lock Reminder eliminates the need for a timer in car locking system that will make decision to lock the vehicle after certain interval of time. The system aims to assist user in making decision. It communicates to user by sending alert to user if the vehicle is not locked. The system can determine relative distance between user and vehicle in order to detect whether user is leaving their vehicle before sending alert to user.

The author believed that Received Strength Signal Indicator (RSSI) can be used for evaluating distances between two wireless devices with assumption that the condition is in the open field [2]. Because based on fact that reflection, scattering and other physical properties have extreme impact in RSSI measurement within closed field such as in building and underground parking lot. With this assumption, we can relate RSSI in function of distance based on the relative power received.

Car Key Lock Reminder integrates 802.15.4 Wireless Personal Area Network (WPAN) between vehicle and user to mutually communicate to each other wirelessly by using small-range wireless modules.

1.2 Problem Statement

As the consumer becomes more and more concern about their financial, safety and security, especially in facing the current economy downturn, more investment are invested in these three critical element, in order to reduce losses and impacts upon the failure of the elements. Demand for such technology that can enhance efficient and productivity is very critical. Among the expensive assets besides home property, car is one of the luxuries item and it slowly becomes a basic necessity item to major of people living, especially to people who rely on transport to go to work

Car safety and security system is very important and many vehicle manufacturers have came up with various methodology related to this issue, in order to eliminate car theft incident. There are many factors that contribute to the theft cases and one of them is accidentally forget to lock when leaving the car because of human nature tendency under certain circumstances such as tired, stress and emotionally unstable.

For example, given a scenario when we are transferring a pile of luggage from a car into the house in the evening, we have to frequently travel to and from the car without locking the car. This activity may cause the user finally forgot to lock the car during the final trip and left the car unlocked for the whole night. Second scenario, we parked the car at gas station and left other passenger inside the car. The conventional locking system that mostly used timer will lock the door if the user did not open the door some time after the unlocking is triggered. During emergency cases, this can be hazardous because the passenger is trapped inside the car. Therefore, there is a need to come up with an invention that will give user total control over their vehicle and remind them whenever they have forgotten.

1.3 Objectives and Scope of Study

The project main objective is to construct a conceptual system for Car Key Lock Reminder and to come up with documentation of the whole prototype design process from the beginning to the completion of the prototype. The project outcome is to be able to produce a physical prototype that can demonstrate two main system criteria as the following:

- A static node which will be placed in the vehicle
- A handheld node will be able to alert user if user exceed a predefined distance while the car is still unlocked.

Throughout the project completion, there are three scopes of studies as the following; RSSI Approximation, Wireless Communication and Microcontroller Utilization. Throughout the project, Received Strength Indicator (RSSI) approximation is studied and their behaviours are recorded. The RSSI is extracted from XBee Wireless module is being monitor in order to achieve the best performance and simplest solution.

Mostly, the project involved in the hardware design process of the prototype from operation and configuration of wireless modules to be able to establish communication and to transfer specific data wirelessly to each other by utilizing microcontroller capability. Apart from that, the project involved in software design process in C language, which is used to utilize the hardware.

CHAPTER 2

LITERATURE REVIEW AND THEORY

Research and survey showed that there is no exact device or system in the market that shared the similar objective with the project. However some of the devices in the market shared useful information in order to understand the nature of the car lock system with different approaches. There are four related research and survey papers featured in this chapter. These researches and survey papers are the main elements in the project.

2.1 Passive Keyless Entry System

Passive Keyless Entry System (PKES) proposal was first appeared in 1990 [4] and the authors proposed that a system that automatically unlocks the vehicle when the user carrying the key approaches the vehicle and locks the vehicle when the user move away from the vehicle. The system is referred as "*passive* "as it does not require any action from the user. The communication between the key and car is characterized by a magnetically coupled radio frequency signal. In this system, the car concludes that the key is in the close proximity when it is in the car's communication range.

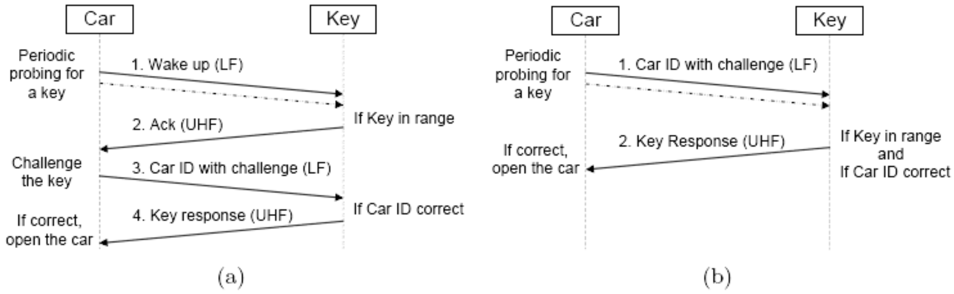
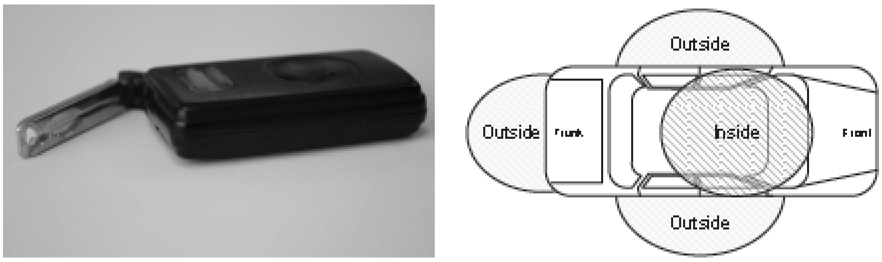


Figure 1: The example of Passive Keyless Entry System protocol realization.

(a) The car periodically probes the channel for the presence of the key with short beacons. If the key is in range, a challenge-response protocol between the car and key follows to grant or deny access. This is energy efficient given that key detection relies in very short beacons. (b) The car periodically probes the channel directly with larger challenge beacons that contain the car identifier. If the key is in range, it directly responds to the challenge.

The system uses LF RFID tag that provides short range communication (few centimetres) and a fully-fledge UHF transceiver for long range communication (10-100 m). The LF RFID is used to detect if the key is inside or outside of the car. The manufacturer usually embedded physical key within the key (fob) to open the car in backup mode when the battery is exhausted [4].



(a) A PKES Key and it's backup physical key.

(b) Car LF coverage.

Figure 2: (a) Backup key and (b) low frequency (LF) coverage region

Table 1: PKES access summary

Key position	Authorization	Medium used	
		Car ⇒ Key	Key ⇒ Car
Normal mode: when the internal battery is present			
Remote	Active open/close	None	UHF
Outside	Passive open/close	LF	UHF
Inside	Passive start	LF	UHF
Backup mode: when the internal battery is exhausted			
Remote	Open/close	Impossible	
Outside	Open/close	With physical key	
Inside	Start	LF	LF

2.2 Remote Keyless Entry System

Remote Keyless System is usually integrated with power door locks or central locking, is a common automotive locking system nowadays. The keys have button to open the door remotely. This functionality requires the presence of the battery and depends on UHF (315 or 433 MHz) communication [4]. The doors can be locked and unlocked by pressing a switch on key holder like transmitter. The vehicle equipped with central locking, will be automatically locked as the braking system is activated and some central locking system will automatically lock the vehicle if the door is not opened in certain interval after it is being unlocked by using transmitter. Nowadays, most of vehicles are equipped with this locking system as default or at least, as optional and added with some other functional such as alarm trigger. However the system can not determined the location of transmitter, whether it is inside or outside of the car. In case the user has forgotten to lock their car, the central locking system is exposed to any vulnerability of such as car theft, before the user realized the situation.

2.3 Keys with Immobilizers

Immobilizer or often called *transponder key* consists of embedded RFID chips. When the key blade is inserted in the ignition lock, the RFID tag will be queried by the car to verify if the key is authorized. This system are designed to prevent the physically the key as well as stealing the car by bypassing the lock [4]. The system mainly consists of transmitter-receiver for receiving a code of the unique key assigned to a user. The unique key code that received by the receiver placed in the car, will be verified by engine control unit (ECU) before permission to start the engine is granted. Therefore, if the unique key code provided is wrong or any attempt to ignite the engine forcefully, the ECU will cooperate with immobilizer to physically locks the wheels from being towed away.

2.4 Received Signal Strength Indicator (RSSI)

RSSI is a measurement of the energy present in a received radio signal in a period of time and is well-known for link quality estimation. It implemented mostly in 802.11 standards. RSSI usually related to 802.11 wireless networking families for example Wi-Fi, XBee module and Cisco systems card. Received power should be a function of distance with respect to wireless channel models [3] with assumption of ideal environment. Assumption of free space propagation model is built in the assumption that the transmitter and receiver are in the line of sight and there are no obstacles between them [5]. Obstacles such as reflection, scattering and other physical properties have an extreme impact on RSSI measurement. The following is the free space propagation model equation:

$$P_r(d) = C_f \frac{P_t}{d^2}$$

Figure 3: Free space propagation model where Pr is the received power Cf is constant depending on a transceiver, Pt is transmitting power and d is distance.

One of the wireless modules that the project will be using is XBee 802.15.4 RF Wireless module. The decision of choosing this wireless module will be discussed further in the methodology chapter. In XBee Wireless module (XB24) RSSI measurement is plotted from 0 to 255 which quantify the quality of signal strength into 256 threshold levels and the AD value extracted from the module is in hexadecimal. RSSI value can either be obtained through XBee pin number 6, AT command line mode and API (Application Programming Language) mode.

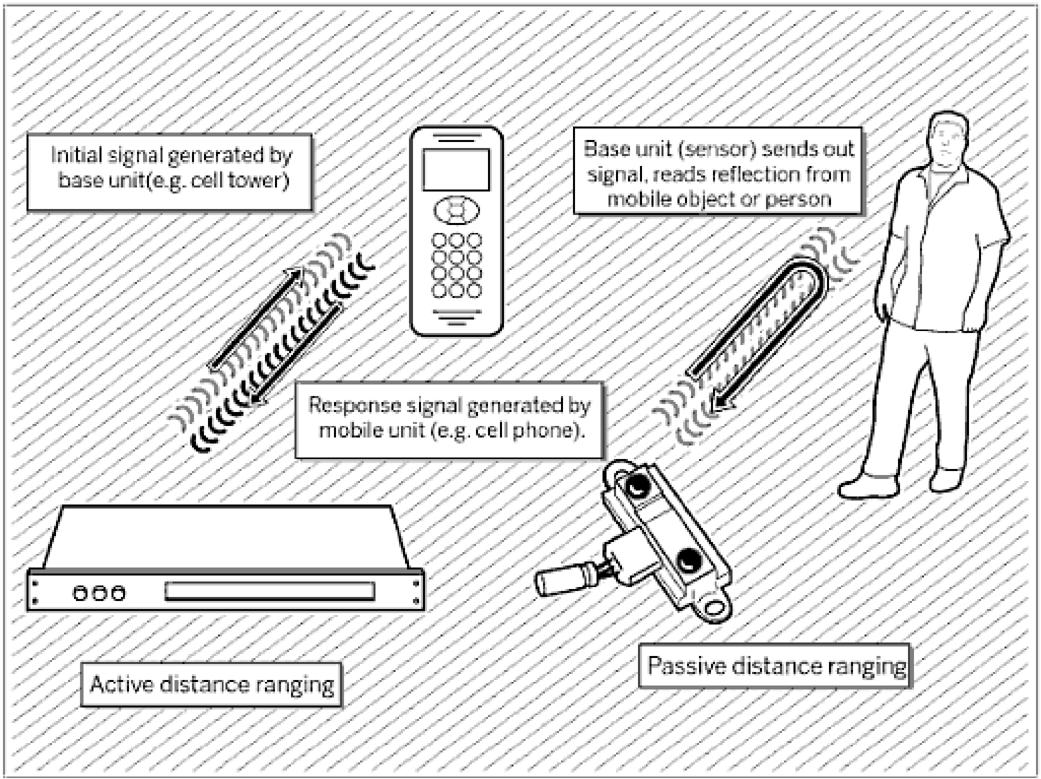


Figure 4: Explanation the passive and active distance ranging from M*aking Things Talk by Tom Igoe.*

According to *Tom Igoe in his book Making Things Talk*, in determining the distance approximation, we does not really have to know the real distance but it is sufficient to know how relatively near or far the person or object to another. In his example, if we are making a pet door lock that opens in response to the pet, you could imagine a Bluetooth beacon on the pet's collar, and a receiver on the door lock. When the signal strength from the pet's collar is strong enough, the door lock opens. In this case, and others like it, there is no need to know the actual distance_[7].

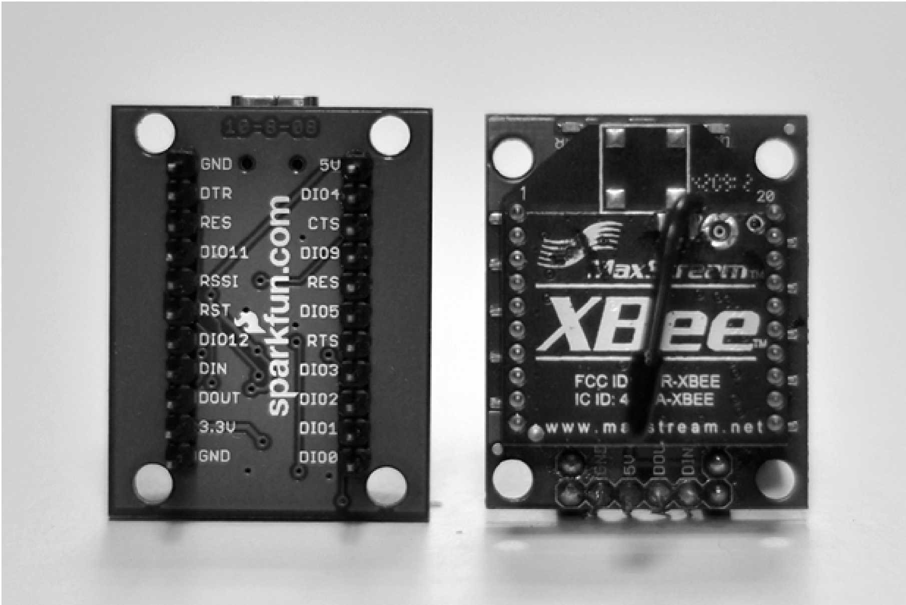


Figure 5: XBee 802.4.14 RF Wireless modules. On the left pins row, Received Strength Signal Indicator (RSSI) pin is the 6th pin from above

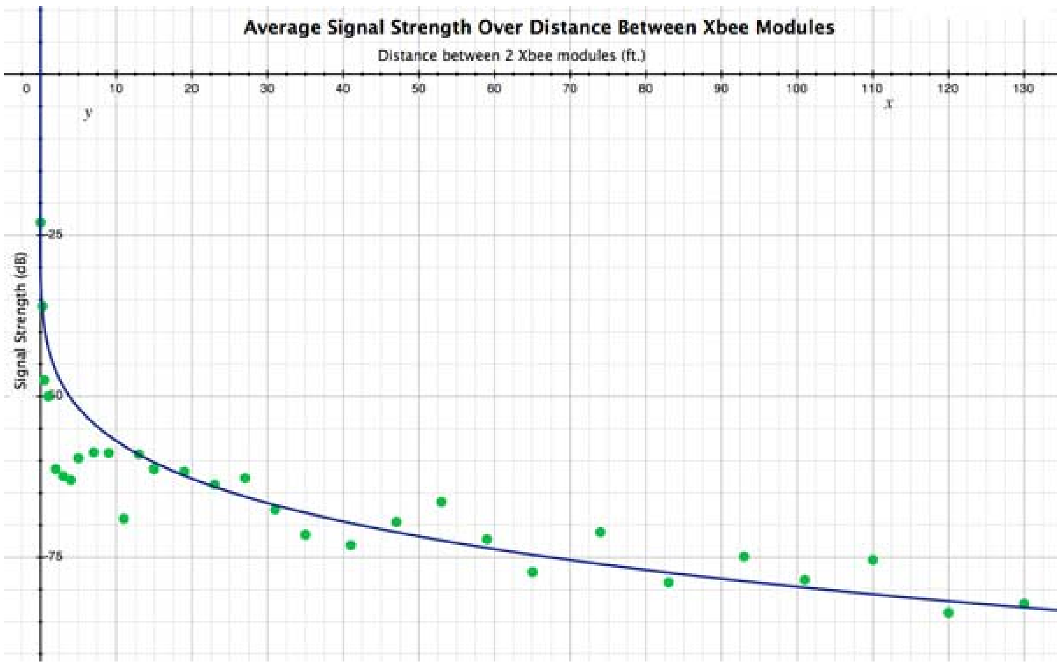


Figure 6: Average signal strength over distance between XBee modules experiment [6], conducted by Brain Clark in his *Social Pint Project*, shows that the scattering effect is highly affecting RSSI in close distance (below 10 feet)

CHAPTER 3

METHODOLOGY

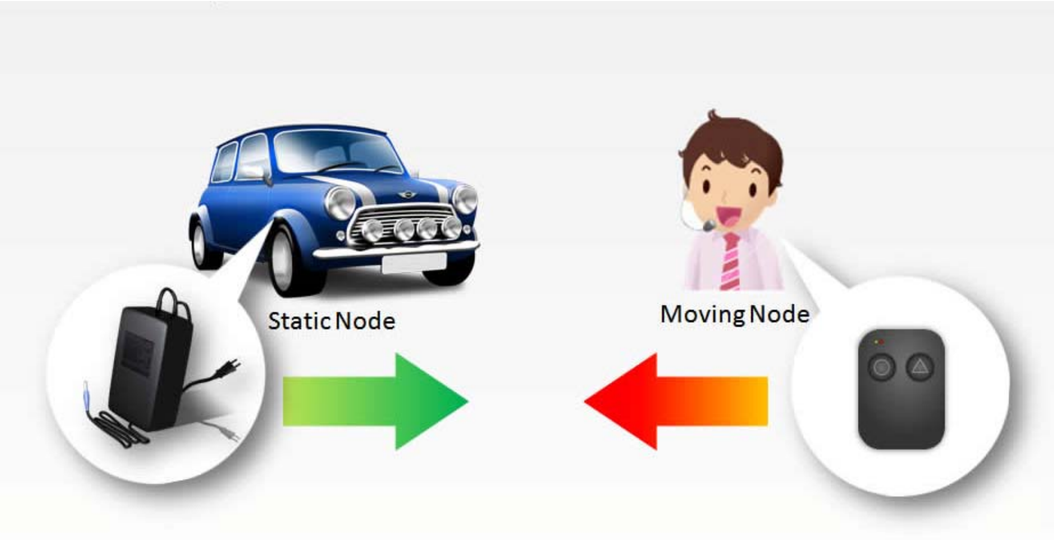


Figure 7: The author's Car Key Lock Reminder Concept illustration

The objective of the project is to develop a conceptual system for Car Key Lock Reminder and to come up with documentation of the whole prototype design process from the beginning to the completion of the prototype. By applying the concept, a transceiver will act as a static node placed in vehicle and another transceiver as a moving node. Both transceivers will establish a communication between themselves when in certain range specified. Then, static node and moving node measure their distance between each other. If it is in the range, static node will transmit the specific vehicle condition data to moving node to alert user or not. This concept is illustrated in the figure 7 above.

3.1 Procedure Identification

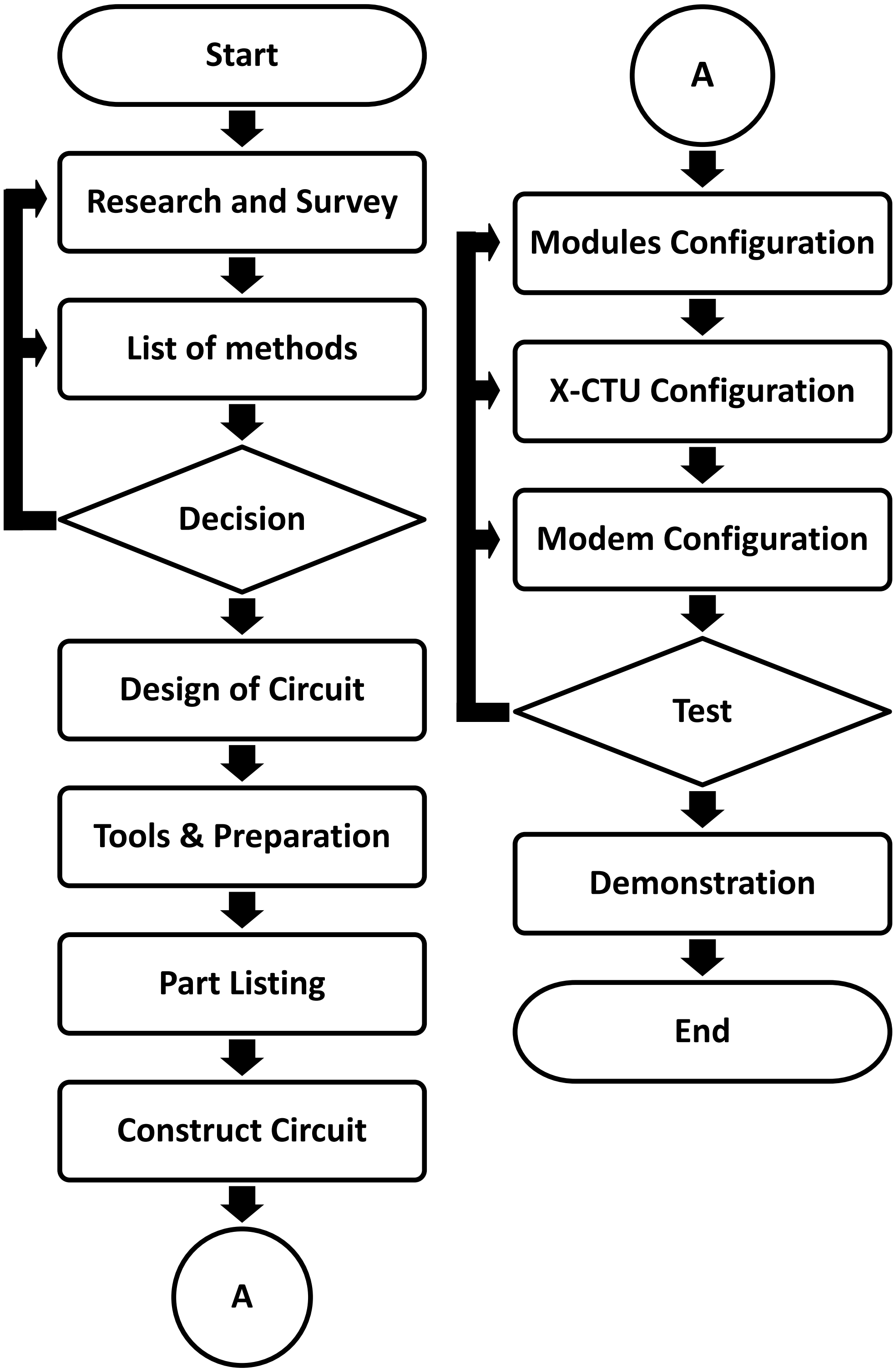


Figure 8: Flow Chart of Project

3.2 List of Methods

The list of methods in this project is the option of methods for developing the prototype and this section is divided into two major decisions.

3.2.1 Microcontroller

There are three types of approach in implementation in order to utilize the wireless modules to perform task such as wireless communication. The methods are the following:

- PIC microcontroller
- Atmel (Arduino)
- Make Controller

Based list of methods research conducted, a comparison table is created to justify which method is practically the best solution with balance of performance and cost factor. Few criteria have been selected in order to choose the methods:

- Ability to complete the task
- Complexity of system
- Cost

All the methods available have the ability to complete the task thus allowing all of them to be qualified. However, complexity of the methods proposed are varying, the most complex method is PIC (assembler), followed by Make Controller(C/C++) and the least complex is Arduino (Arduino-specific C/C++). This is based on the difficulty degree of languages that being used by each of the methods. However, PIC is the popular method available and the support for the PIC is wider in Malaysia, specifically. The final consideration and the most crucial is the cost factor. After taking account of these factors, the decision is to choose to use PIC method over the other despite of being it is in assembly language. Table 2 below shows the comparison between methods available.

Table 2: Comparison of Microcontrollers

Feature	**PIC**	**Arduino**	**Make Controller**
Price	RM27.62	RM92.59	RM262.35
Digital IO	33 general purpose IO pins	14 general purpose IO pins.	4 dedicated analogue ins and 35 general purpose IOs.
Analogue Inputs	8 analog inputs with 10-bit resolution	6 analog inputs with 10-bit resolution.	8 analog ins with 10-bit resolution.
PWM Channels	2/4 PWM channels	6 PWM channels.	4 PWM channels.
Serial Ports	USART RX or TX (Synchronous Slave mode).	1 UART, shared with the USB connection.	2.5 - 2 full UARTs and a debug port, which has no hardware handshaking.
Processor / Memory	8K RAM	8-bit AVR. 2K RAM, 32K Flash.	32-bit ARM7. 64K RAM, 256K Flash.
Tools Support	MPLAB	Arduino IDE - cross-platform easy to use editor, compiler and uploader.	mcbuilder - cross-platform, easy to use editor, compiler, and uploader.
Programming Language	Assembler	Arduino-specific C/C++	Standard C/C++

3.2.2 Wireless Modules Comparison

Few choosing criteria are listed in order to select the right wireless modules that will be used in this project. There are several wireless modules available in the market considered but focus is given on the XBee modules since we are equipped the wireless modules. Furthermore, the XBee is the most reliable low cost and low power consumption wireless modules ever built.

3.3 Design of Circuit

After the process of method selection, the progress proceeds with the design of overall circuit. This design is basically will trigger communication between two XBee modules by sending a command to make action at another XBee modules. The circuits for Transmitter and Receiver are design in ExpressPCB and Eagle. (Please refer to Appendix A, B, C and D).

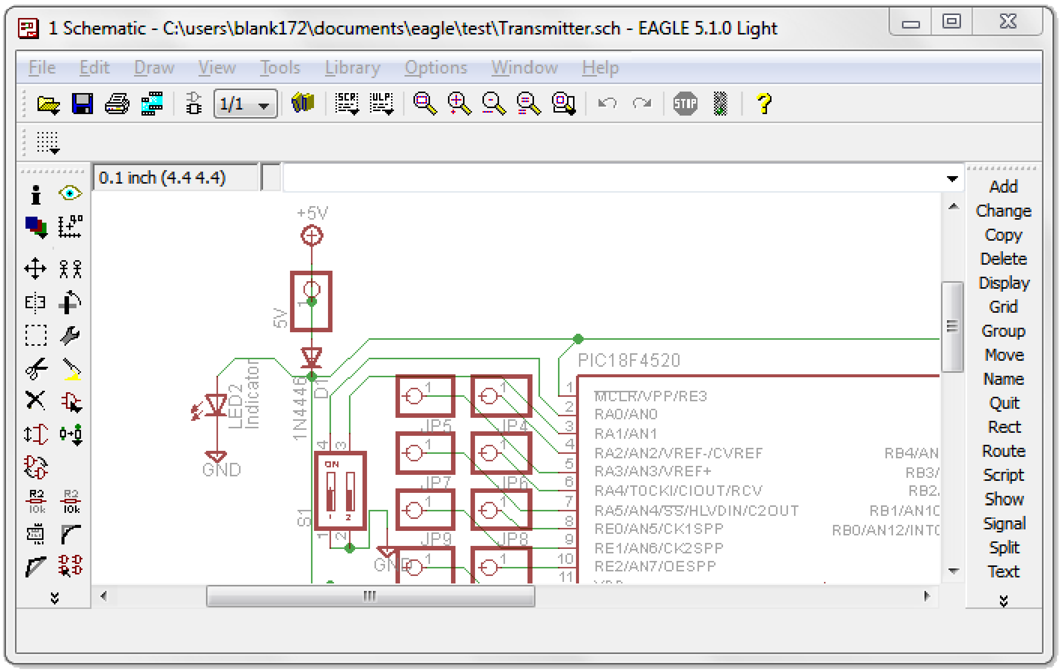


Figure 9: Designing circuit schematic in Eagle.

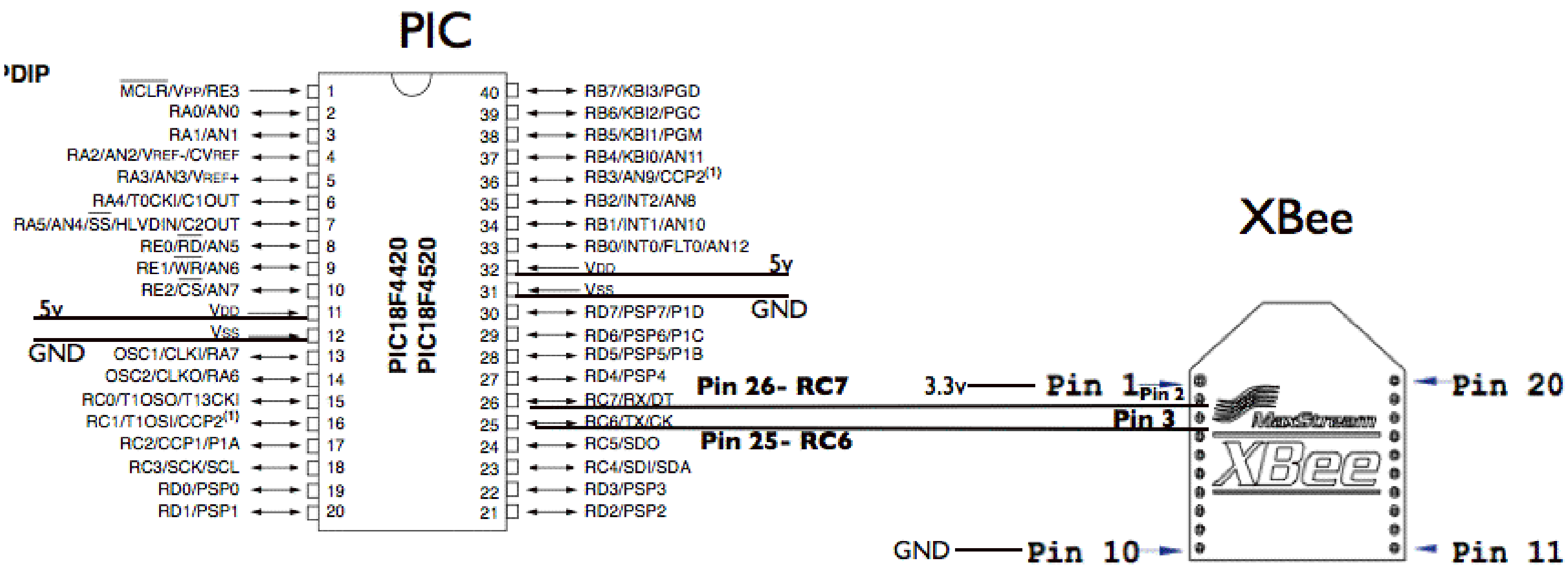


Figure 10: Connection from PIC microcontroller to XBee Wireless modules *(Photo Courtesy of http://hades.mech.northwestern.edu)*

3.4 Tools and Preparation

Understanding the requirement and priority of each tool is useful for project preparation. Table 1 shows the list of the required tools which will be used in project construction.

Table 3: Tools and Preparation

Tools	**Description**
Soldering Iron	One with temperature control and a stand is best. A conical or small 'screwdriver' tip is good, almost all irons come with one of these
Solder	Rosin core 60/40. Incompatible solder leads to bridging and cold solder joints which can be tough to find.
Multimeter	A meter is helpful to check voltages and continuity.
Diagonal Cutter	Essential for cutting leads close to the PCB
Desoldering tool	To prone to incorrectly soldering parts.
X-CTU	A program provided by Maxstream to all XBee supported product
MPLAB	A program that will be used to program PIC
Breadboard	To construct mock circuit

3.5 Part Listing

Analyzing the requirement and priority of each part and material used are useful for project preparation. Table 5 shows the list of the required components and material which will be used in project construction.

Table 4: Part Listing

Name	**Description**
XBee Modules	XBee 1mW 802.15.4 modules with a chip antenna part. WRL-08665
XBee Regulator Board	Small regulated board for 3.3V supply to XBee module.
USB Explorer	USB to serial base unit for the XBee module. Direct access to serial and programming pins on XBee unit.
Enhanced 40 pins PIC Start-Up Kit	Able to utilize the function of PIC by directly plugging in the I/O components in whatever way that is convenient to user
PIC	Microchip's 18F4520 8. Runs up to 20MHz with external crystal.
Clock	To set the PIC clock rate usually 20Mhz
LED	As an indicator

3.6 Construct the Circuit

The construction of circuit is divided into two process; development circuit board and final circuit board. First, the project proceeds with the construction of circuit based on the circuit design specified earlier. The circuit is constructed on the breadboard first and tested in the next section. After the circuit passed the test, the schematic design is converted into board design in Eagle software, in order to prepare for Printed Circuit Board (PCB) etching process. The board design is sent to the PCB lab in and approximately 2 weeks the PCB is completed. Another set of components are requested for the final circuit construction. For the demonstration, it is decided to construct scalable model of handheld transmitter that will interact with the system embedded in the car. The following is the sketch of project prototype. The functions of the switches are to simulate the common key fob’s function to open and close the door. If the open button is pressed, the Car Key Lock Reminder will wake up and keep reading transmission from static node in the vehicle. Meanwhile, if the close button is pressed, the Car Key Lock Reminder will sleep and stop reading transmission from static node to preserve the battery.

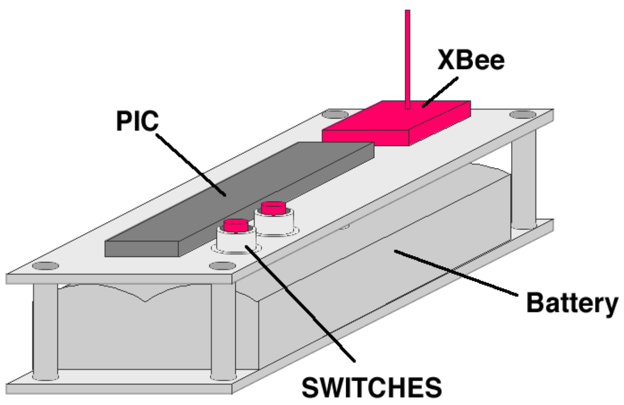


Figure 11 : Early sketch of the Car Reminder

3.7 Module Configuration

Understanding of the XBee wireless module is a very important aspect. In this project, the ability of XBee module transmitting data between each other will be tested. XBee modules have two modes of operation:

1. Transparent serial mode
   - Data will be sent to a serial port and it will act as a wireless serial connection between two XBee modules.
2. Packet mode
   - Two most important packets that we are dealing with is IO packets and command packets. In packet mode we can retrieve important information about each packet such as signal strength which is very important to in the investigation of strength signal measurement.

In order to use XBee, the module configuration has to be specified before proceeding with the next step. This is to ensure that the obtained XBee is in good condition and to apply setting to XBee module such as rename each XBee modules, setting its baud rate and channel that will be use for the communication. Below are the basic features of XBee modules:

Table 5: XBee Modules Features

XBee 802.15.4 RF Wireless Modules Features	
• 3.3V @ 50mA • 250kbps Max data rate • 1mW output (+0dBm) • 300ft (100m) range • Built-in antenna • Fully FCC certified • 6 10-bit ADC input pins • 8 digital IO pins • 128-bit encryption	• Local or over-air configuration • AT or API command set • Indoor/Urban: up to 133' (40 m) • Outdoor line-of-sight: up to 400' (120 m) • Receiver Sensitivity: -96 dBm • RF communications AT and API Command Modes

XBee modems are one of the easiest ways to create a wireless point-to-point or mesh network. The wireless module has error correction, configured with AT commands, come in multiple types and can create a wireless serial link out of the box. Below are the pin assignments for the XBee Wireless Modules used in this project:

Table 6: Pin Assignments for the XBee 2.4 DigiMesh Modules.

Pin #	Name	Direction	Description
1	VCC	-	Power supply
2	DOUT	Output	UART Data Out
3	DIN / **CONFIG**	Input	UART Data In
4	DO8*	Output	Digital Output 8
5	**RESET**	Input	Module Reset (reset pulse must be at least 200 ns)
6	PWM0 / RSSI	Output	PWM Output 0 / RX Signal Strength Indicator
7	PWM1	Output	PWM Output 1
8	[reserved]	-	Do not connect
9	DTR / SLEEP_RQ / DI8	Input	Pin Sleep Control Line or Digital Input 8
10	GND	-	Ground
11	AD4 / DIO4	Either	Analog Input 4 or Digital I/O 4
12	**CTS** / DIO7	Either	Clear-to-Send Flow Control or Digital I/O 7
13	ON / **SLEEP**	Output	Module Status Indicator
14	VREF	Input	Voltage Reference for A/D Inputs
15	Associate / AD5 / DIO5	Either	Associated Indicator, Analog Input 5 or Digital I/O 5
16	**RTS** / AD6 / DIO6	Either	Request-to-Send Flow Control, Analog Input 6 or Digital I/O 6
17	AD3 / DIO3	Either	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Either	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Either	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0	Either	Analog Input 0 or Digital I/O 0

3.8 X-CTU Configuration

XBee must be connected to computer by using XBee USB Explorer. Changing settings in your XBee is vital when working in certain environments, and with specific projects. This is important if certain components of the project require a different baud rate than 9600. The changing the default channel is so important in order to make a completely separate communication channel thus avoiding interference of if the channel is being used.

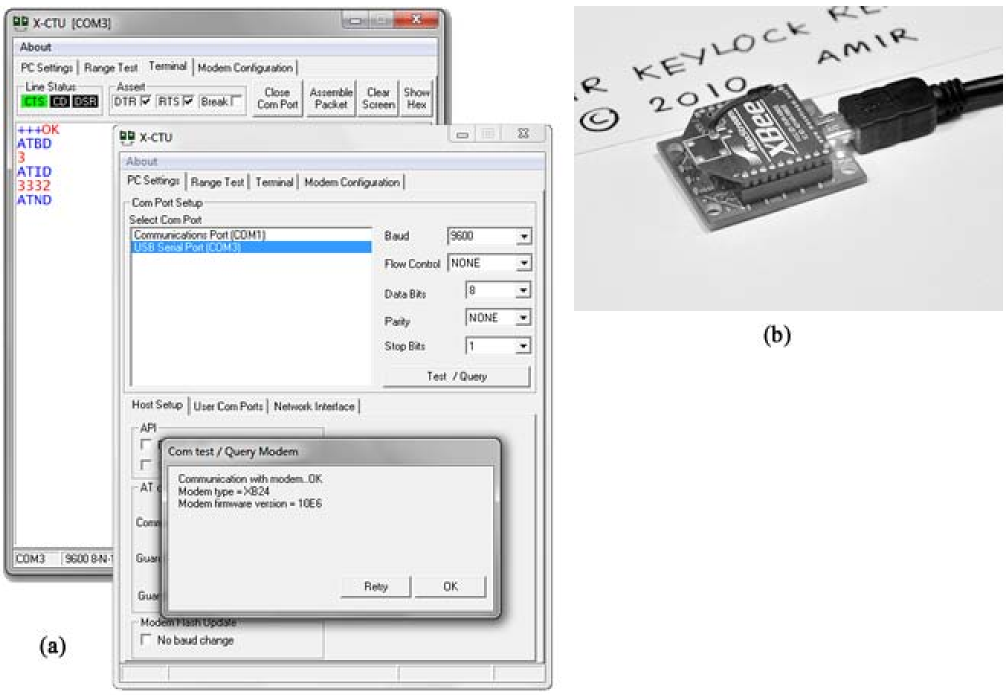


Figure 12: (a) X-CTU software provided by Digi, manufacturer of XBee device. (b) XBee connected to computer by using XBee USB Explorer

There are several interfaces to directly control the XBee operation such as HyperTerminal and X-CTU software. Since XBee comes with X-CTU software support from its distributor, the X-CTU interface is better compared to other command windows

3.9 Modem Configuration

In computer, Modem Configuration needs to be set with modem parameters and firmware. Serial Communication setting option in computer Device Manager must be changed and the baud rate should be set as same as the changes written to XBee in order to make connection between computer and XBee Wireless Modules. Since the XBee SUB Explorer is connected via USB, USB Serial Port needs to be configured.

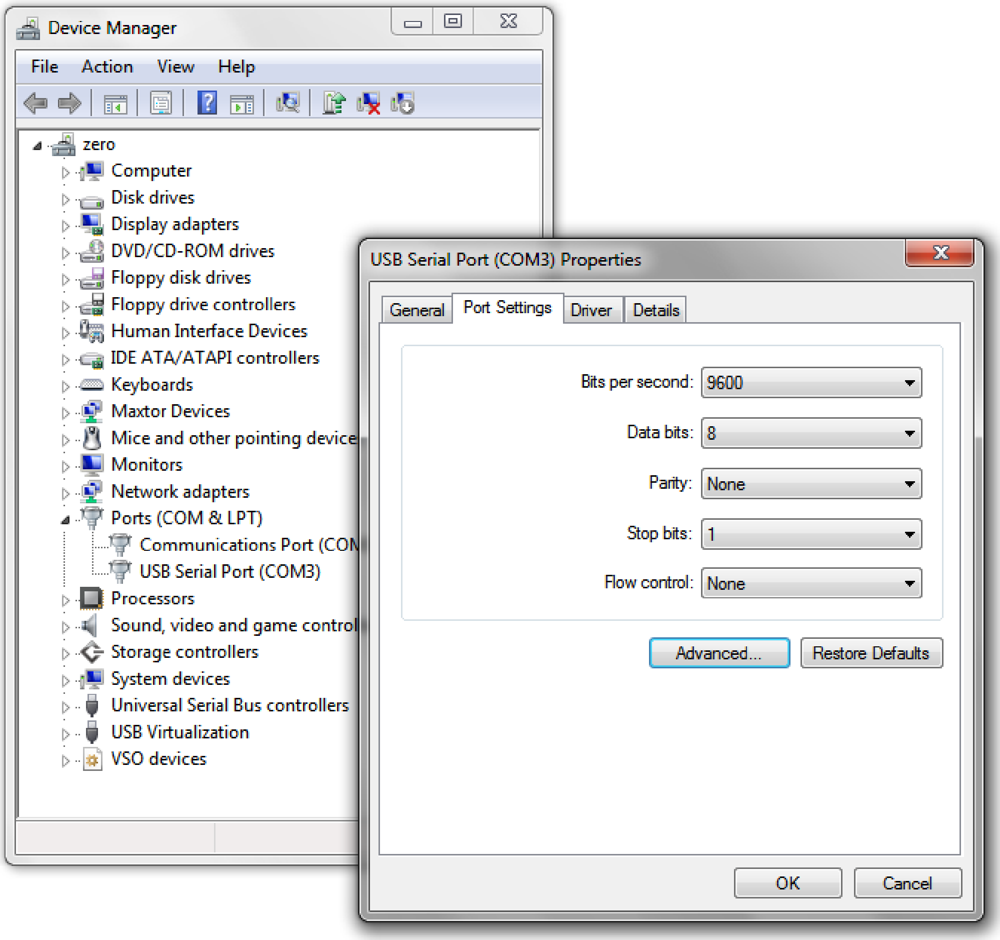


Figure 13: The setting in USB Serial Port (COM3) is set as in XBee modules

3.10 Testing

In Test section, both circuit boards, development circuit board and final circuit board must be tested with in-circuit functionality (ICT) test and software run test to make sure there is no complication rising from hardware.

In-circuit functionality test is a test carried out on full-scale, which each pins and wires are tested with adjacent pins. All points with possibility to short circuit are tested. After rectifying short circuit points on the circuit, it could be concluded that the system is not affected by short circuit and hardware design.

Software run test is a test carried out to run a sample program to check the software programming is compatible with the circuit. In the test, Microcontroller is programmed with instructions in CCS C compiler to communicate between microcontrollers via XBee Wireless Modules. When the test is successfully completed, it could be concluded that the system is ready for the real application. The following is the block diagram for software run test at both side of microcontroller

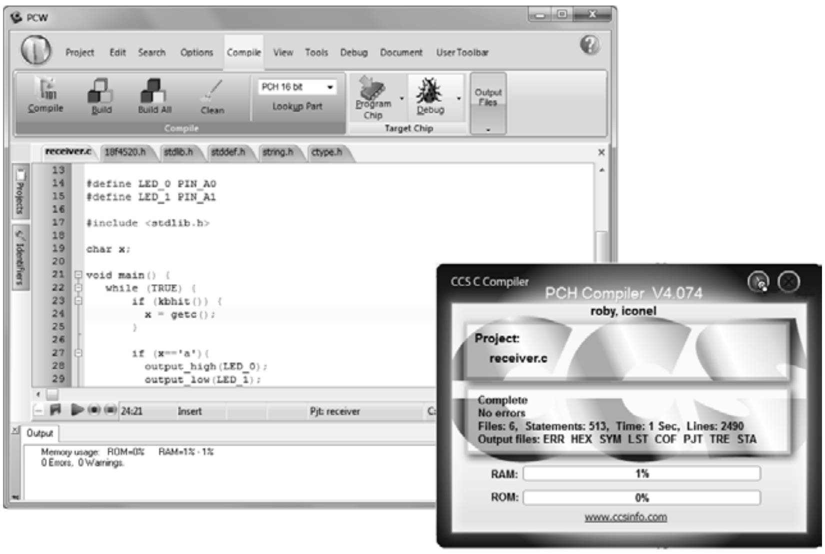


Figure 14: CCS C Compiler

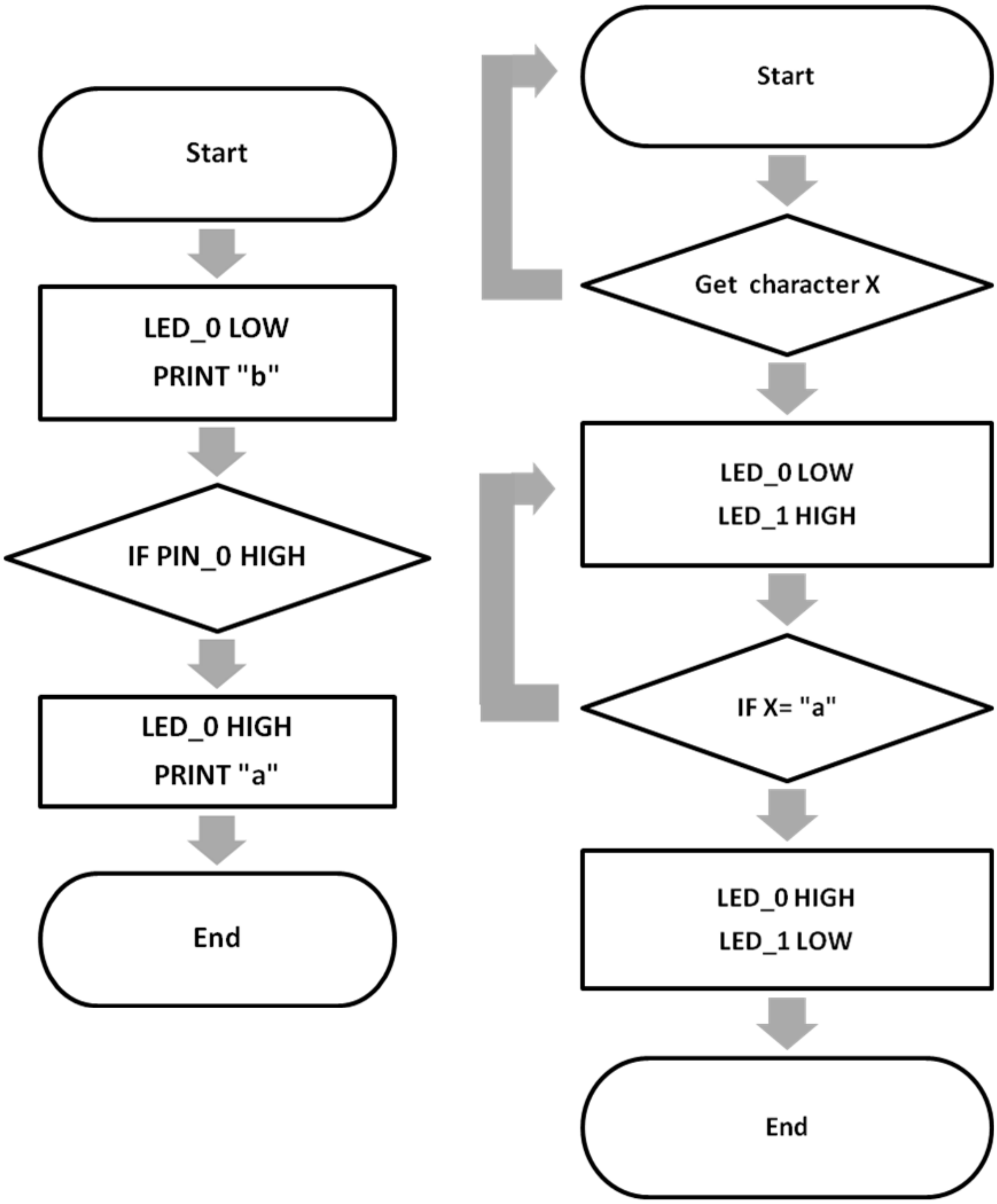


Figure 15: Test program block diagram of transmitter and receiver

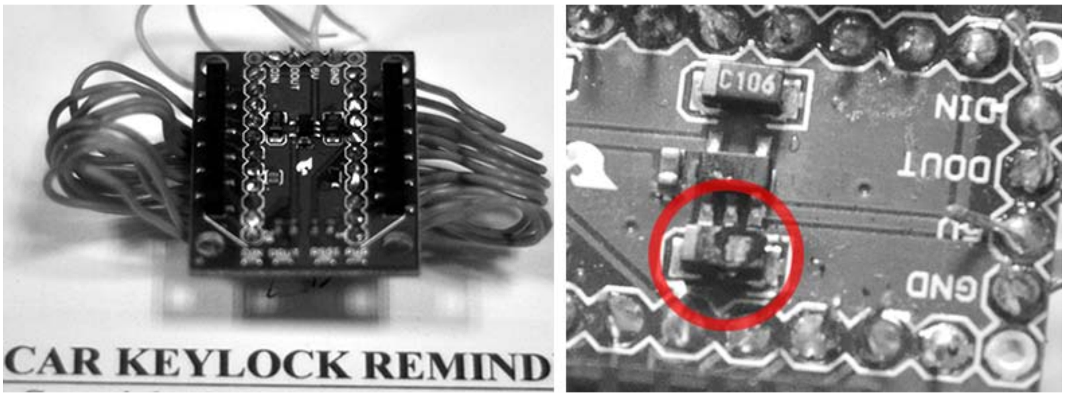
CHAPTER 4

RESULT AND DISCUSSION

4.1 In-circuit and Software Run Test

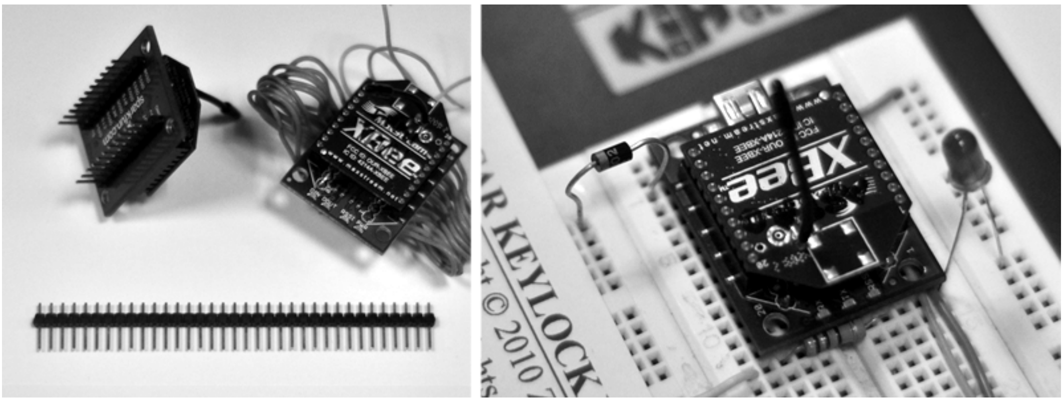
In these tests, the initial design is tested and expected to deliver the outcome specified in the methodology.

During the construction of the circuit, one of the XBee Regulators Board was burned due to incorrect assignment of terminal polarity. The problem is caused by the unpleasing arrangement of wires around the XBee Regulator Board, eventually it creates confusion between positive and negative terminal. However, the problem is solved by using XBee Explorer as the alternative regulator board. In order to prevent the same problem occurs, the confusing wires are eliminated by soldering 2x10 header pins directly under the board and by using diode as protection to ensure only one direction at positive/negative terminal.



(a) (b)

Figure 16: (a) The burned XBee Regulator Board with unpleasing wires around it and (b) the affected SMT components 3.3V regulator and capacitor C106.



(a) (b)

Figure 17: XBee Explorer is soldered to 2x10 header pins; diode is placed as protection from incorrect polarity.

In the in-circuit test, the circuits are examined and from the test showed that there are a few short circuit points detected and imperfect PCB design. Solutions for these issues are to remove the short circuited points and make jumper wire to the circuit. The circuit is being improved neatly after each functionality test to ensure there are no loose and confusing wires afterward. Currently the final circuit board is fully completed and modified accordingly.

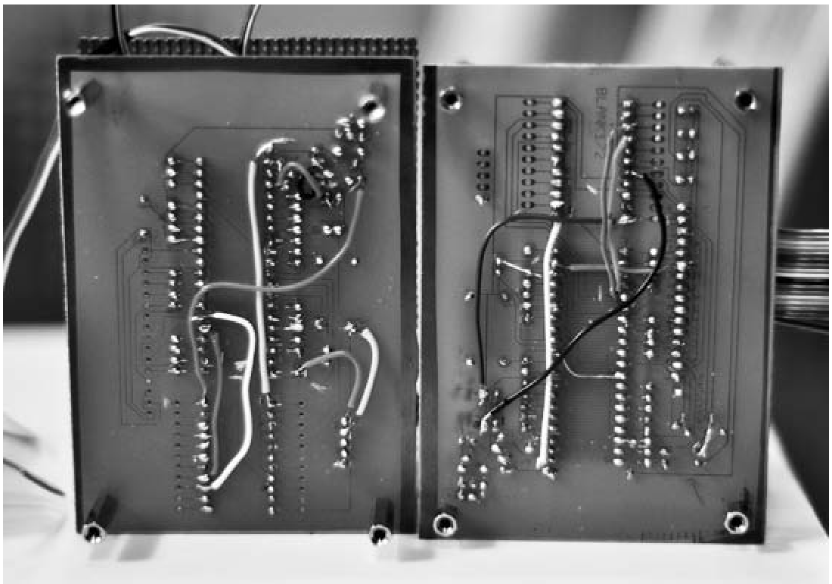


Figure 18: Removing short circuit points and implementation of jumper wire to modify the circuit.

In the software run test, upon the completion of the circuit, a lot of experiments have been conducted. One major change that has been implemented is the use of CCS compiler instead of MPLAB IDE with Hi-Tech Compiler. The reason behind the change is due to the slight different of C language of Hi-Tech C compiler compare to the exact C programming, that might be time consuming process to troubleshoot afterward. After consideration and discussion, CCS compiler seems to be one of the reliable compilers that use the exact C programming.

The change from MPLAB IDE to CCS is quite challenging for configuring the LCD. Many source examples have been referred because the LCD driver (configuration) is differ from one LCD module than another and there are different kind of approaches to get the LCD display working. The author collected one 16x1 LCD display from EE store and acquired a brand new LCD display 16x2 from Cytron. Due to the problem, the author has referred to reference CCS textbook and several students. Finally after going through the code for 2 weeks the LCD is now working perfectly.

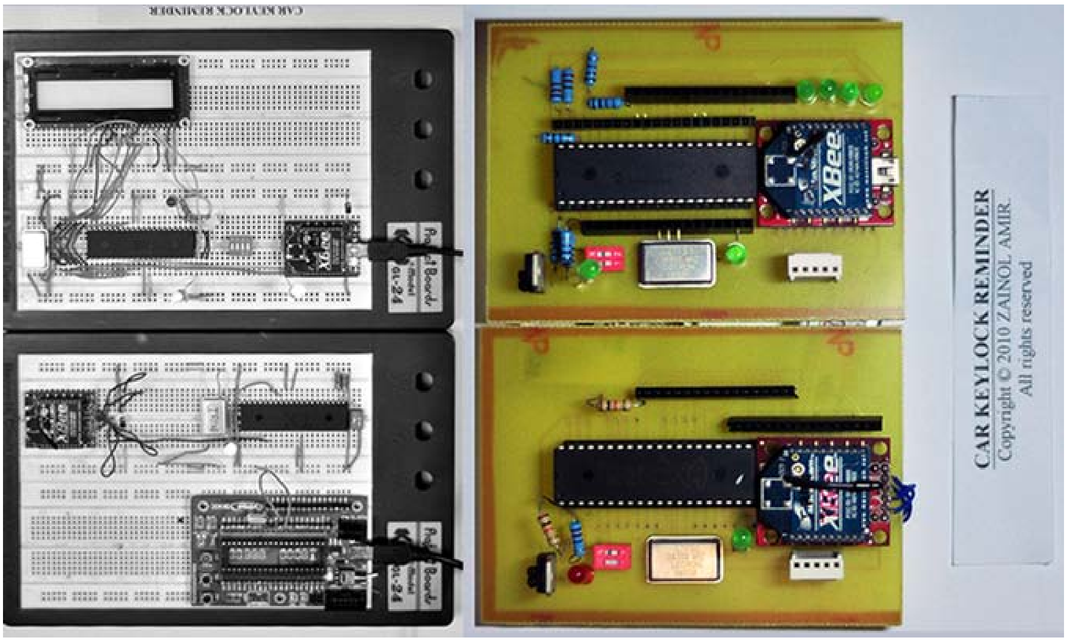


Figure 19 : Left the development circuit board and right the final circuit board

One of the problem occurred during testing of the code is the occurrence of *Dotting Effect* in the X-CTU terminal line (refer to figure 20 below) during the data transmission. The expected result in the terminal should be either printed character "a" or "b" since the output has been specified in the code. However, dotting character was printed instead of the specified outputs.

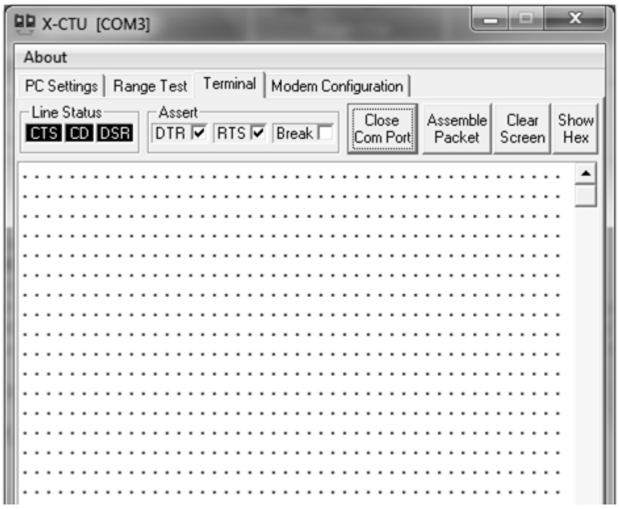


Figure 20: The *Dotting Effect* appears in terminal of X-CTU is usually caused by wrong clock assignment and poor XBee wiring.

Another problem is to configure the XBee module as Transceiver. As we know Transceiver works as Transmitter and Receiver at the same time. The author has to configure a way to use Tx and Rx pins at the same time. Currently, the Tx and Rx only can be used in one way communication and after the reset the other way communication can be established.

By the completion time, programming of communication between transmitter and receiver is completed and resulting successful testing with the coding by following the previous programming block diagram. The programming has successfully control the LEDs at the Receiver by switching ON the switch at the Transmitter. . The system managed to transmit emulated condition of the car from transmitter to receiver and send alert via blinking red LED to receiver. The final test showed that the circuit is working accordingly to the program

4.2 RSSI Input Display Test

As additional features, the project integrated LCD display with microcontroller as part of the transmitter, which the device will display the current relative RSSI measurement over 255 threshold level to determine whether the car is near or far, in graphical format. The program code of LCD display is successfully combined with the basic communication between transmitter and receiver and excellently working. A range test is also conducted to show the decrement of relative RSSI in a function of distance as explained in the literature review. The result is recorded in the table below.

Table 7: Average RSSI range test result

Distance	**10 ft**	**20 ft**	**30 ft**	**40 ft**	**50 ft**	**54 ft**
Signal Loss	No	No	No	No	No	Yes

Figure 21 :LCD display 16x2 JHD1602A

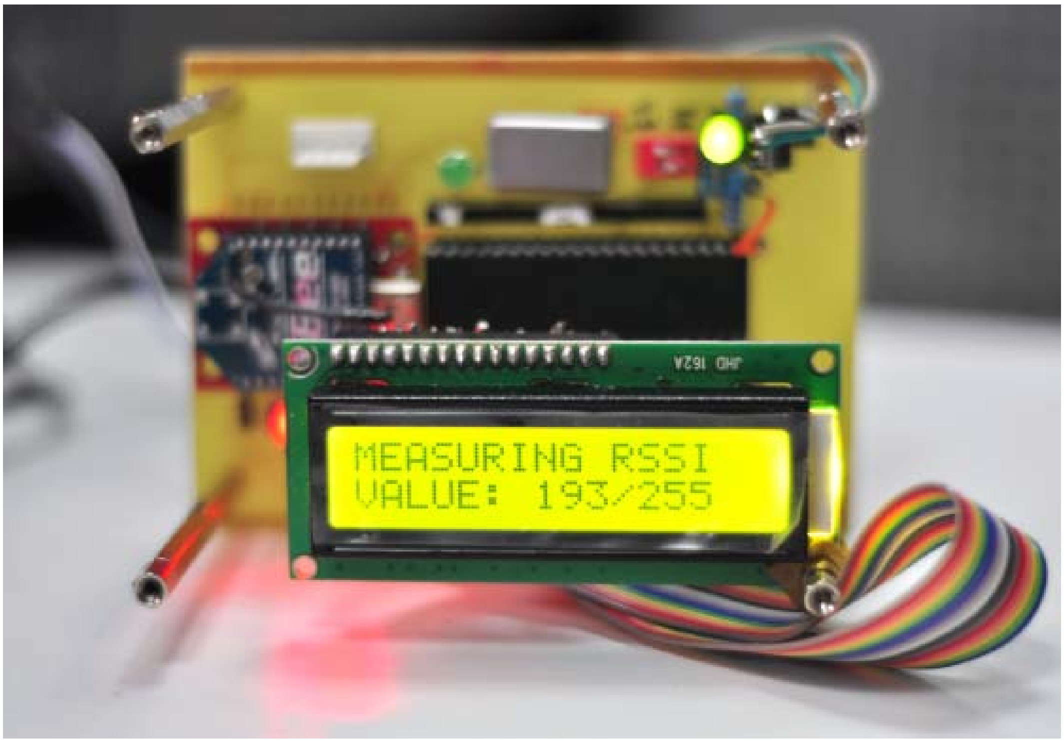


Figure 22: Real time measuring RSSI value is displayed on LCD

4.3 Simulation of the Printed Circuit Board

Process of printed circuit board design simulation is different from circuit schematic design. Since the first schematic is designed in ExpressPCB software, the design has to be redesigned in Eagle software because the file generated in Eagle is required for the etching process of Printed Circuit Board (PCB). The process of generating the PCB file requires careful position of components and pins on the board to make sure successful routing of wires. In addition to that, more features is added to the design for additional purposes such as the integration of direct cable to LCD display and additional female pins to the unused microcontroller pins for troubleshooting purpose and further expansion.

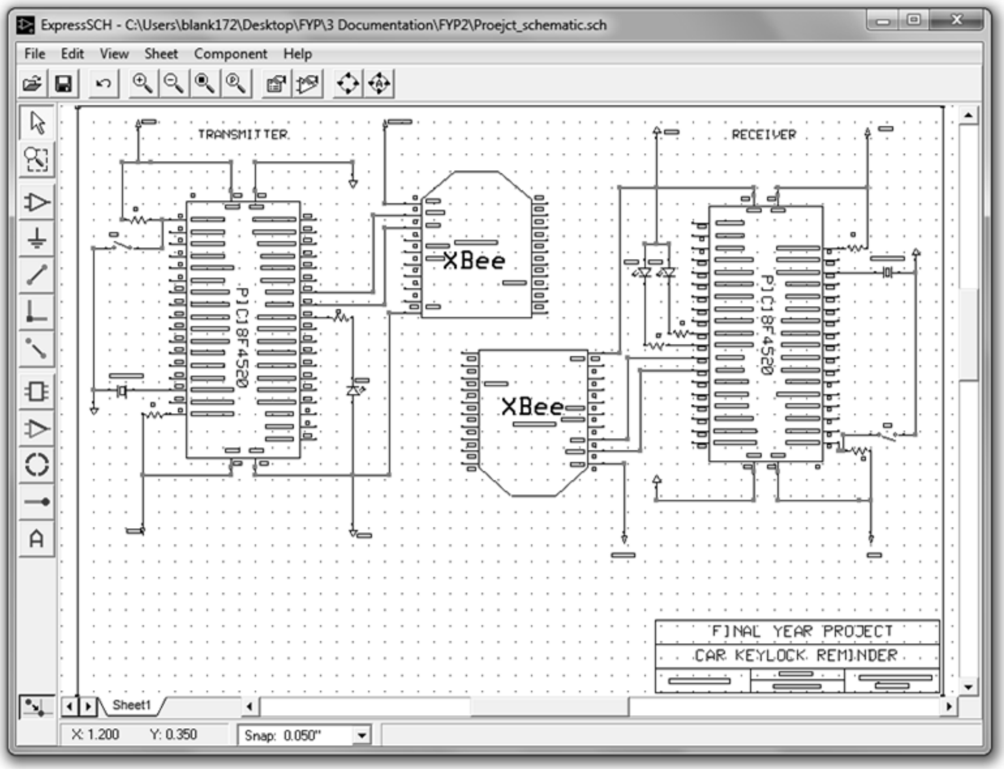


Figure 23: Schematic diagram created in ExpressPCB

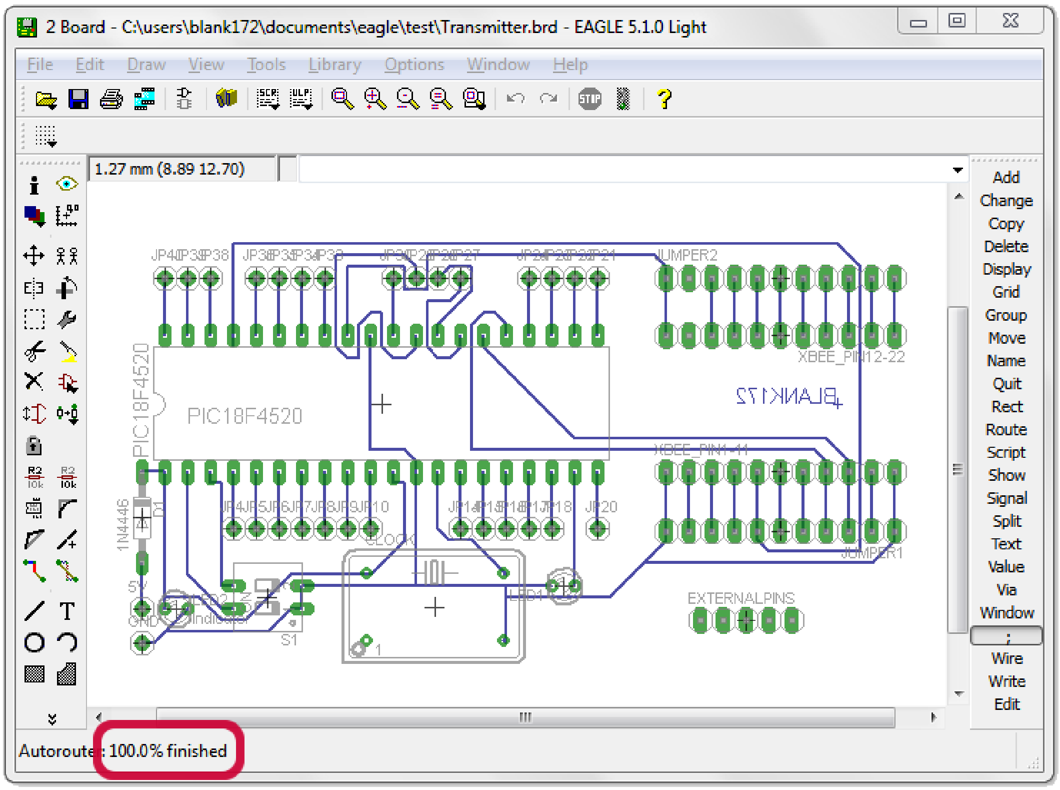


Figure 24: 100% result of PCB Auto route in Eagle for the PCB board.

4.4 Etching of the Printed Circuit Board

Several meeting are conducted with PCB technician in EE building to get more information regarding PCB etching process, resulting the completion of PCB board in two weeks. However, there are some short circuit points found on the board that need to be modified.

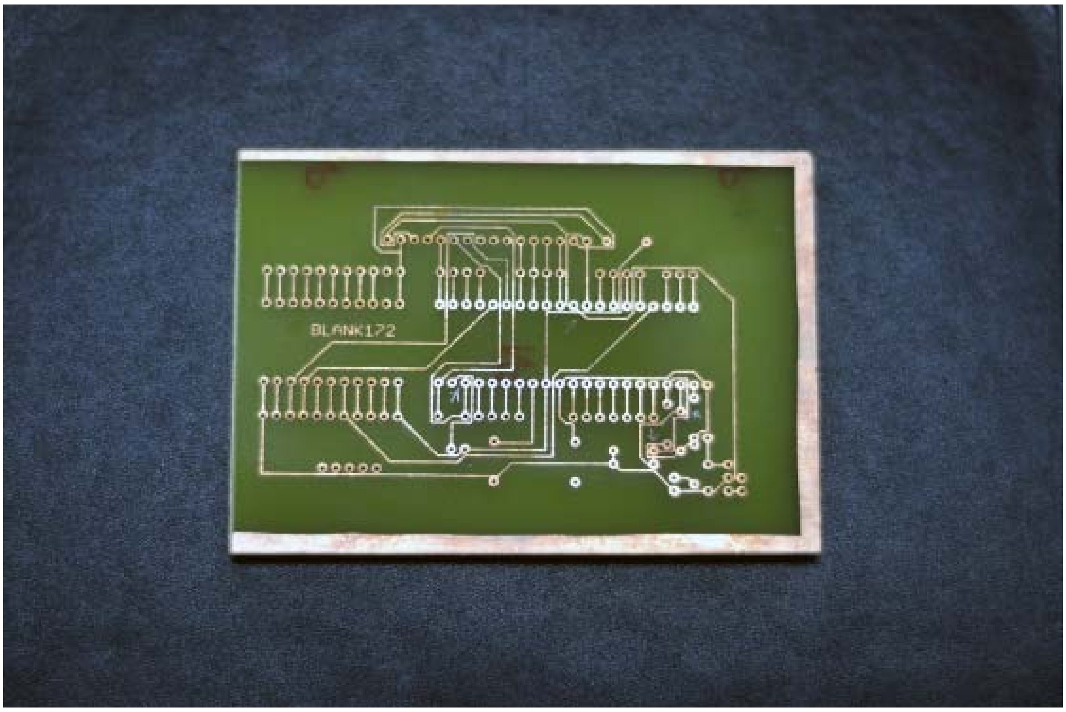


Figure 25: A completed etched printed circuit board from the project

4.5 Design of the Prototype

After the completion of development circuit board, the final circuit board is constructed and together with the prototype design. The features that have been explained in the methodology, circuit design, are been incorporated into the prototype. The two buttons at the handheld device (Refer to figure below) are to simulate the common key fob's function to open and close.

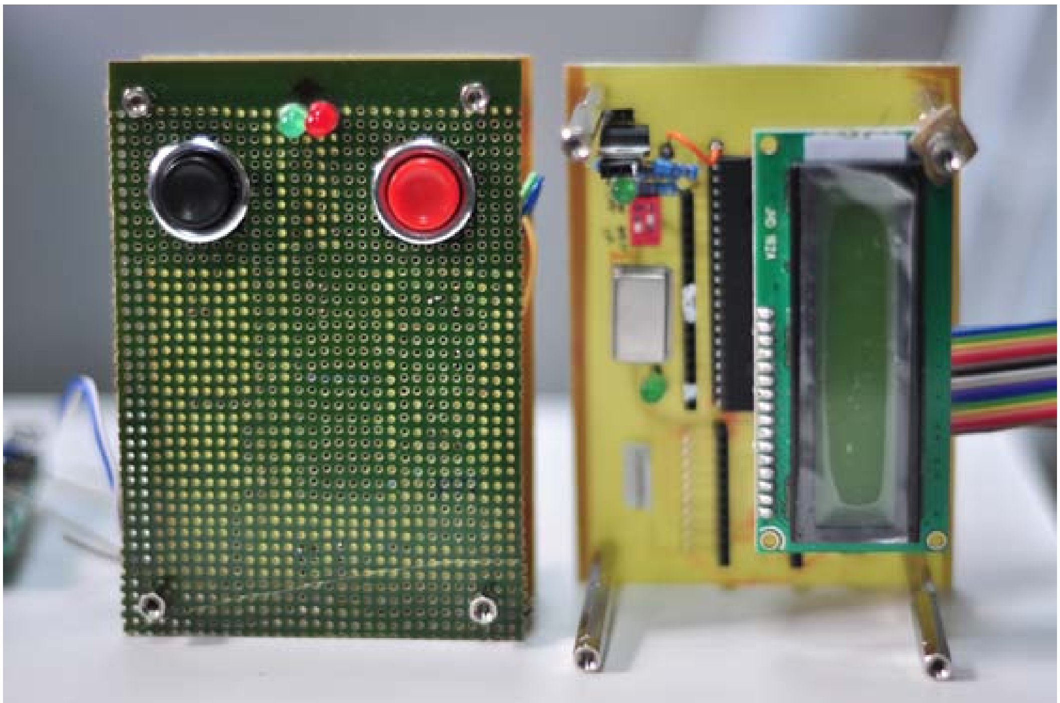


Figure 26: Car Key Lock Reminder prototype. Left is the handheld device prototype and on the right the static node in the vehicle

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Car Key Lock Reminder integrates human interaction in making decision, by not granting full privilege of decision making to the technology or machine. The system assists vehicle user to lock their vehicle and protect them from any vulnerability chances caused by forgotten to lock the vehicle. This project is completed within the allocated time. The project main objective is to produce a physical prototype of conceptual system for Car Key Lock Reminder. The prototype built can demonstrate two main system criteria as the following:

- A static node which will be placed in the vehicle
- A handheld node will be able to alert user if user exceed a predefined distance while the car is still unlocked.

5.2 Recommendation

In this project, there are some portion of Car key Lock Reminder that could not be implemented such as minimal power consumption, apart from the fact that the wireless module used has the lowest power consumption among all other wireless modules. The next steps that should be put into account is the ability of the whole circuit to turn into low power consumption mode, or often called SLEEP mode, and the ability of circuit in determining the approximate distance between nodes. Since the circuit will be fully rely on battery in the real implementation, the ability of putting the circuit into SLEEP mode will ensure the limited power supply from battery will not be drained out. Thus, more effort should be allocated to study the power utilization.

REFERENCES

[1] Intel Press Release, “Intel-Newsweek Report: Economic Growth will be Fueled by Technology Innovation”, Novermber 2009, [Online]. Available: http://www.intel.com/pressroom/archive/releases/2009/20091116corp_a.htm [Accessed: 28 October 2010]

[2] Limor Fried, “Social Defense Mechanisms: Tools for Reclaiming Our Personal Space”, 2005

[3] K. Benkic, M. Malajner, P. Planinsic, Z. Cucej, ”Using RSSI value for distance estimation in Wireless sensor networks based in ZigBee”, 2000

[4] T. Waraksa, K. Fraley, R. Kiefer, D. Douglas, and L. Gilbert, “ Passive keyless entry system” , 1990

[5] Paolo Santi, “Topology Control in Wireless Ad Hoc and Sensor Networks”, September 2005

[6] Brian Clark, “Sociable Pint”, August 2008, [Online], Available: http://sociablepint.net/2008/08/18/xbee-modules-as-proximity-sensors/ [Accessed: 1 September 2010]

[7] Tom Igoe, “Making Things Talk”, [Online], Available: http://bit.ly/9yqkSd [Accessed 22 April 2010]

[8] William Stalling, “Data and Computer Communications 8th Edition”, Pearson Education, 2007

[9] Drew Gilason, “Zigbee Wireless Networking”, Newness, 2008

[10] John Iovine, “PIC Microcontroller Project Book”, McGraw Hill, 2000

[11] Fred Eady, “Hands-On Zigbee: Implementing 802.15.4 with Microcontrollers” Newness, 2007

[12] Maxstream, “XBeeTM/XBee-PROTM OEM RF Modules Manual”, 2006

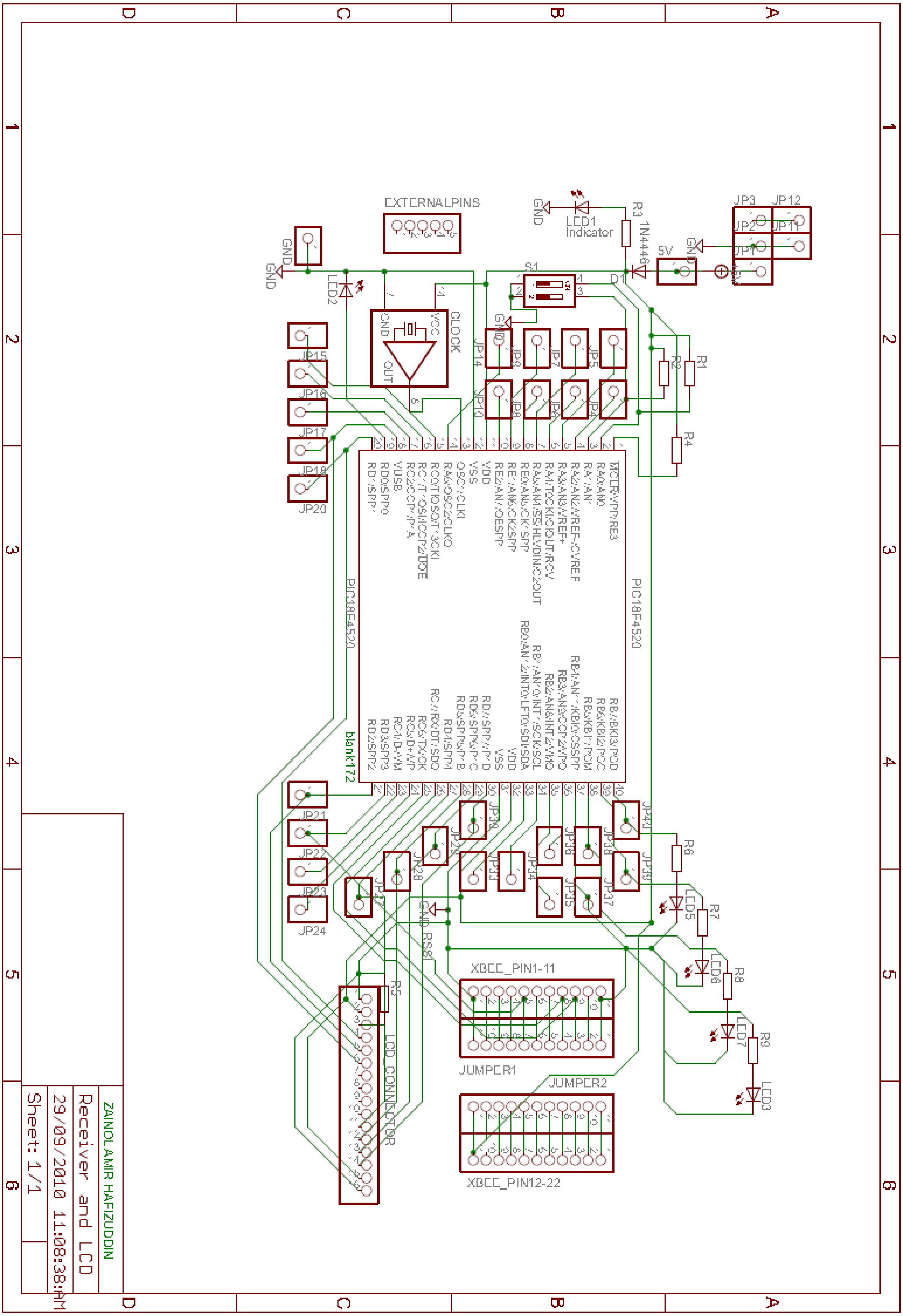
[13] Michael Ferguson, “XBEE Basics *How to do it yourself*”, [online]. Available: http://forums.trossenrobotics.com/tutorials/how-to-diy-128/XBee-basics-3259/ [Accessed: 22 April 2010].

[14] Limor Fried, “Wireless Arduino programming/serial link”, [online]. http://www.ladyada.net/make/xbee/index.html [Accessed: 23 April 2010]

APPENDICES

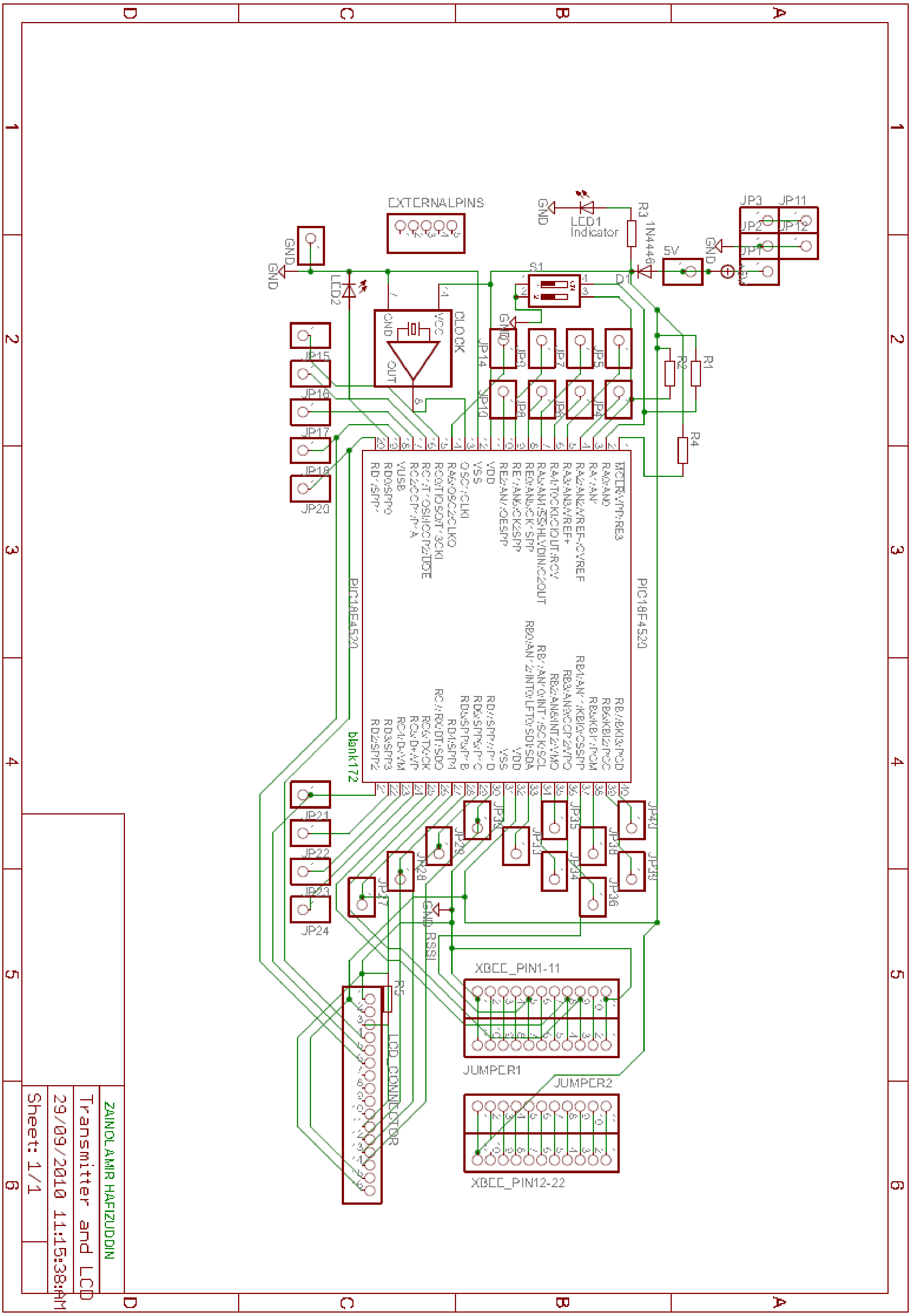
APPENDIX A

Circuit Diagram for receiver



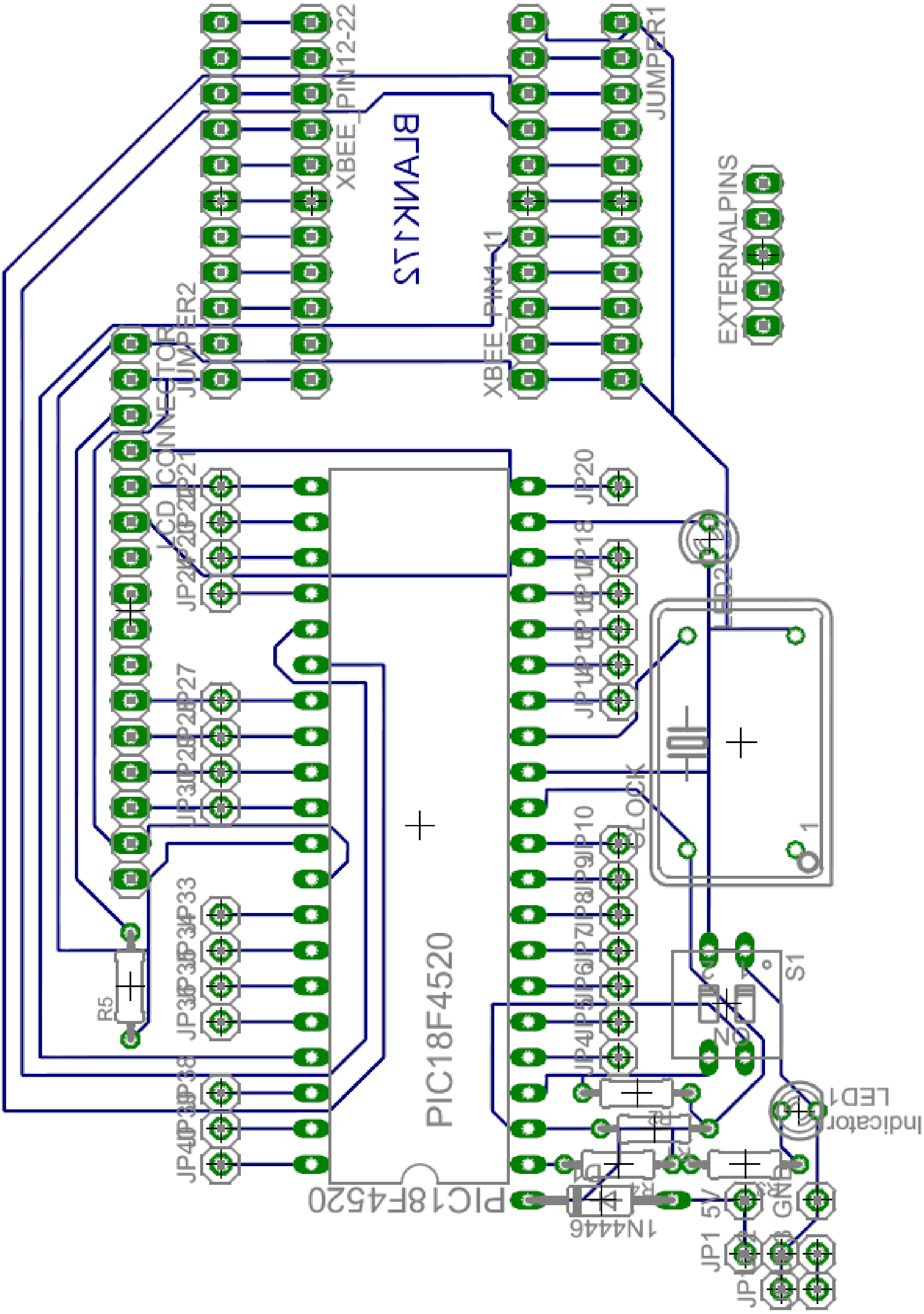
APPENDIX B

Circuit Diagram for transmitter



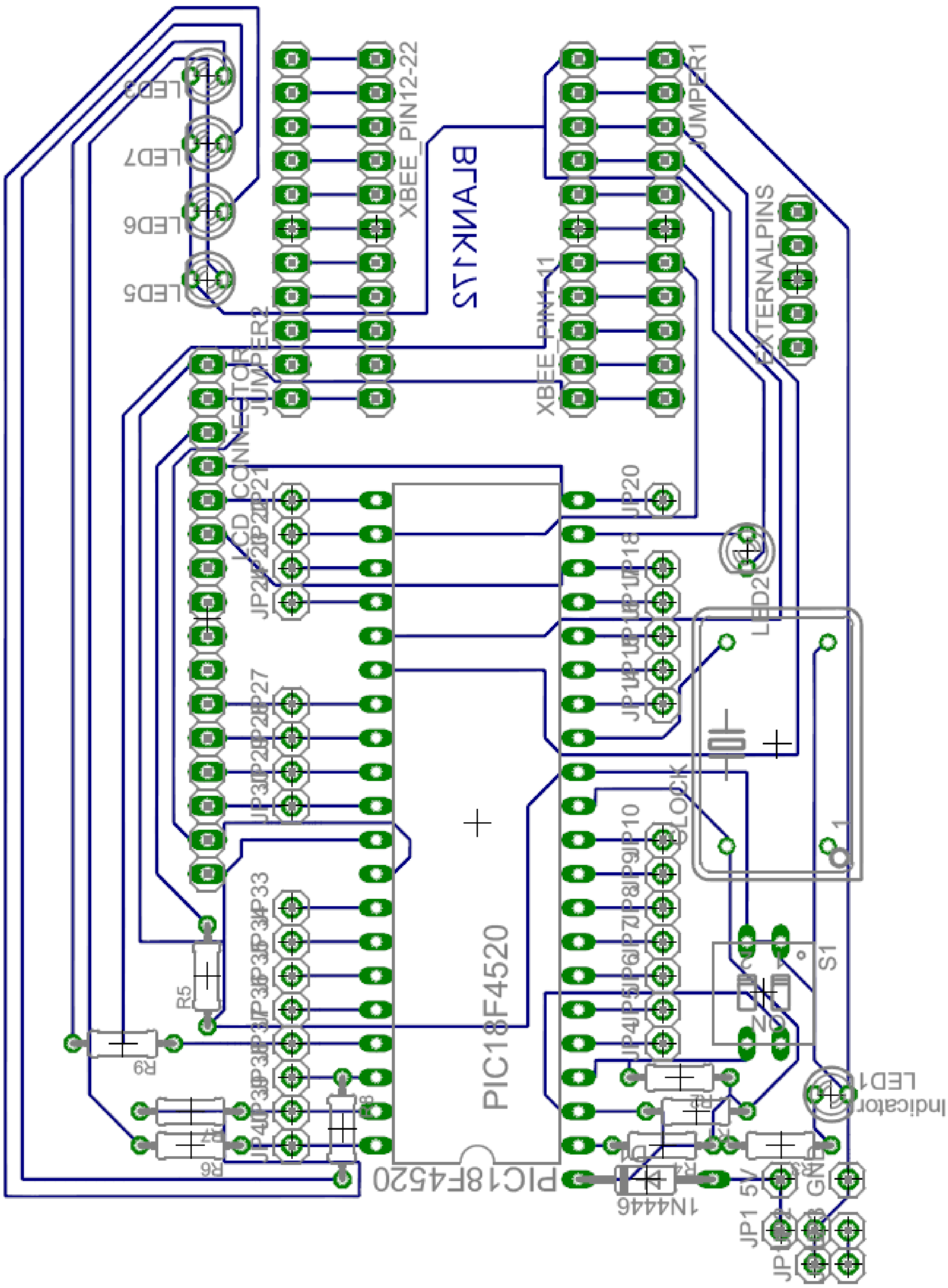
APPENDIX C

Circuit Diagram for receiver



APPENDIX D

Circuit Diagram for transmitter



APPENDIX E

Sample code for Static Node (Transmitter)

```
/*
Title: Transmitter program
Name: Zainol Amir Hafizuddin Bin Zainol Abidin
Student ID: 9535
Final Year Project Car Keylock Reminder
Supervisor: Dr. Fawnizu Azmadi Hussin
*/


#include <18f4520.h>
#device ADC=10
#fuses HS,NOLVP,NOWDT,NOPROTECT
#use delay(clock=24000000)


//#use rs232(baud=19200, xmit=PIN_A0, rcv=PIN_A1)    // you can use
any pins for software uart...
//#use rs232(baud=9600, UART1)       // hardware uart much better;
uses  RC6/TX and RC7/RX
#use rs232(baud=9600, parity=N, xmit=PIN_C6,
rcv=PIN_C7,stream=,bits=8)
// characters tranmitted faster than the pic eats them will cause UART
to hang.


#include <LCD.c>
#include <string.h>
#include <stdlib.h>
#define LED_0  PIN_B7
#define LED_1  PIN_B6
#define SW_0   PIN_A0 //RSSI
#define SW_1   PIN_A1
```

```
int RSSIValue;

float RSSI;

void main(){

      lcd_init();

      setup_adc_ports(AN0_ANALOG); //Set Pin A0 as analog input

      setup_adc(ADC_CLOCK_INTERNAL);

      set_adc_channel(0); //RSSI Pin A0


      set_tris_a(0x03);

      set_tris_b(0x00);


      while(TRUE){

      RSSIValue = read_adc(); //get adc reading

      delay_ms(50);

      RSSI = RSSIValue/255*100; //max threshhold = 100 percent

      delay_ms(50);

      lcd_gotoxy(1,1);

      lcd_putc("\fMEASURING RSSI");

      lcd_gotoxy(1,2);

      printf(lcd_putc, "VALUE: %d dBm", RSSIValue);

      delay_ms(1000);


      if (RSSIValue >= 190){

         if (input(SW_1)==1){

         output_high(LED_1);

         output_high(LED_0);

         printf("a"); //sends signal a // for condition LOCKED

        }
```

```
        else {
        output_high(LED_1);
        output_high(LED_0);
        delay_ms(1000);
        output_low(LED_1);
        output_low(LED_0);
        printf("b"); //sends signal b // for condition UNLOCKED
        }
      }
      else{
      printf("c"); //send signal c for ERROR condition
      output_high (LED_0);
      output_low(LED_1);
      delay_ms(1000);
      output_low(LED_0);
      output_high(LED_1);
      }
      }
  }
```

APPENDIX F

Sample code for Moving Node (Receiver)

```
/*

File: Receiver

Author: Zainol Amir Hafizuddin B Zainol Abidin

Description: The program receives signal via XBee and resend new
instruction to

transmitter

*/



#include <18f4520.h>

#fuses HS,NOLVP,NOWDT,NOPROTECT

#use delay(clock=24000000)       // 24 MHz crystal on PCB

//#use rs232(baud=19200, xmit=PIN_A0, rcv=PIN_A1)    // you can use any
pins for software uart...

//#use rs232(baud=9600, UART1)       // hardware uart much better; uses
RC6/TX and RC7/RX

//#use rs232(baud=9600, parity=N, xmit=PIN_C6, rcv=PIN_C7, stream=GSM,
bits=8, ERRORS)

#use rs232(baud=9600, parity=N, xmit=PIN_C6, rcv=PIN_C7,stream=,bits=8)

// characters tranmitted faster than the pic eats them will cause UART
to hang.

//#include <lcd.c>



#define LED_0  PIN_B7 //RED

#define LED_1  PIN_B6 //GREEN

#define SW_1   PIN_A0 //MOCK x characters

#define SW_2   PIN_A1

#include <stdlib.h>

char x,temp;
```

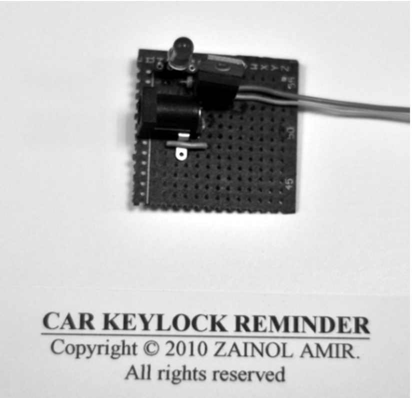
```
void main() {
   delay_ms(10);
   //lcd_init();
   set_tris_a(0xFF);
   set_tris_b(0x00); //set
   output_low(LED_1); // GREEN LED
   output_low(LED_0);

   while (TRUE) {
         if (kbhit()){
         x = getc();
         }
         else{
         x ='d';
         }

         if (x=='a'){      // The car is locked!
            temp=x;
            output_high(LED_1); // GREEN LED
            output_low(LED_0);
         }
          else if(x=='b') { // UNLOCKED OR LOST SIGNAL.
            temp=x;         // Show last car condition
            output_low(LED_1);// RED LED!!
            output_low(LED_0);
            delay_ms(1000);
            output_low(LED_1);
            output_high(LED_0);
            delay_ms(1000);
            }
```

```
        else if(x=='c'){
            temp=x;
            output_high(LED_1); // RED & GREEN LED
            output_high(LED_0);}
         else if(x=='d'){
            output_low(LED_1);// RED LED!!
            output_low(LED_0);
            delay_ms(1000);
            output_high(LED_1);
            output_high(LED_0);
            delay_ms(1000);
            if(temp=='a'){
            output_high(LED_1); // GREEN LED
            output_low(LED_0);
            }
            else if(temp=='b'){
            output_low(LED_1);// RED LED!!
            output_low(LED_0);
            delay_ms(1000);
            output_low(LED_1);
            output_high(LED_0);
            delay_ms(1000);
            }
            else if(x=='c'){
            output_high(LED_1); // RED & GREEN LED
            output_high(LED_0);
            }
         }
   }
}
```

Appendix G



9V to 5V regulator board to regulate car battery power supply.