DEVELOPMENT OF REMOTE REAL TIME TEMPERATURE MONITORING SYSTEM BY USING WIRELESS SENSOR NETWORK

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BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **DEVELOPMENT OF REMOTE REAL TIME TEMPERATURE MONITORING SYSTEM BY USING**

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DEVELOPMENT OF REMOTE REAL TIME TEMPERATURE MONITORING SYSTEM BY USING WIRELESS SENSOR NETWORK

NOR SUAIDA BINTI ABD WAHAB

**A Thesis Submitted in Fulfillment for the
Requirement Award of the degree of
Bachelor of Electrical Engineering (Electronics)**

**Faculty of Electrical and Electronics Engineering
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DEDICATION

Specially dedicated to
My beloved parents,

ABD WAHAB BIN MOHD NOR
FATIMAH BINTI SAID

siblings, siblings' in-laws, lecturer, nephews
and all of my special and best friends.

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Not to forget my lovely friends giving me a good cooperation, sharing her ideas and good colleague for making discussions on projects. Besides, they helping me went through difficult time. The experience and knowledge I learn from them will help me facing the future challenge.

Suaida Wahab

ABSTRACT

Monitoring system has employed in various applications, including temperature, pressure, flow rate, capacity, acceleration, and so on. This monitoring is commonly use in all area of the world n traditional method of farming, human labors were required to visit the greenhouse at specific time and need to check the temperature level manually. This conventional method is considered time consuming and needs a lot of work and effort. Therefore this research focuses on developing a system that can remotely monitor and predict changes of temperature level in agricultural greenhouse. The objective of the research is to develop the remote real time temperature monitoring system by using Zigbee network. The proposed system has measurement which capable of detecting the level of temperature. This system also has a mechanism to alert farmers regarding the temperature changes in the greenhouse so that early precaution steps can be taken. In this research, several tests had been conducted in order to prove the viability of the system. Test results indicated that the reliability of the system in propagating information directly to the farmers could be gained excellently in various conditions.

ABSTRAK

Sistem pemantauan bekerja dalam pelbagai aplikasi, termasuk suhu, tekanan, kadar aliran, kapasiti, pecutan, dan sebagainya. Pemantauan ini biasanya digunakan di semua kawasan dunia ini dalam kaedah tradisional perladangan dimana tenaga kerja manusia yang diperlukan untuk melawat rumah hijau pada masa tertentu dan diperlukan untuk memeriksa tahap suhu secara manual. Ini kaedah konvensional dianggap memakan masa dan memerlukan banyak kerja dan usaha. Oleh itu, kajian ini memberi tumpuan kepada pembangunan sistem yang jauh dimana boleh memantau dan meramal perubahan tahap suhu dalam rumah hijau pertanian. Objektif kajian untuk membangunkan sistem pemantauan suhu masa dengan menggunakan rangkaian ZigBee. Sistem yang dicadangkan mempunyai ukuran yang mampu mengesan tahap suhu. Sistem ini juga mempunyai mekanisme untuk memberi amaran kepada petani mengenai perubahan suhu dalam rumah kaca supaya langkah-langkah berjaga-jaga awal dapat diambil. Dalam kajian ini, beberapa ujian telah dijalankan untuk membuktikan daya maju system ini. Keputusan ujian menunjukan bahawa sistem ini dalam menyebarkan maklumat secara langsung kepada petani adalah berkesan.

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LIST OF ABBREVIATIONS

GUI	Graphical User Interface
PC	Personal Computer
V	Volt
DC	Direct Current
MHz	Mega Hertz
EIA	Electronics Industries Association
ADC	Analog to Digital Converter
USB	Universal Serial Bus
cc	Clock Cycle
°C	Degree Celsius
GND	Ground
Vcc	5V DC
LED	Light Emitting Diode
GSM	Global System for Mobile communication

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

Long time ago, traditional monitoring system mostly introduced wired connections mode, and very relevant alarm needs wiring. This kind of design needs a large amount of investment and complex of work .It can never meet the practical requirements of intelligent agricultural monitoring system. So distributed intelligent monitoring system will have more market possibility, which is safer, easier to install and lower in cost. In recent years, wireless communication technology has been widely used in the applications of remote data communication. Besides that, the improvement in technology growth larger, advance and more sophisticated.

This project used the application of by Zigbee network using transmitter terminal and receiver terminal to monitor the temperature in the greenhouse. The whole process that was described here is focus only on hardware part. It was known that when the farmer not at the greenhouse, the temperature maybe increase. So, in order to ensure that the temperature in that area do not rise so high that will make farmer feel not comfortable, sensor will detect the temperature. Thus, the system that can fulfill the requirement of this project is the circuit installed in the greenhouse must consist of four main components which is temperature sensor to detect heat, PIC microcontroller that can use to analyze the data and of course Zigbee module which is the function is to transmit the data to the receiver.

1.2 Problem statement

The concern about a lot of customer needs and demand for agricultural product has make farmer was awareness to increase their product by implementing new technology in this industry. The most important thing that may come to farmer's interest is how to control the use of natural environment and natural sources such as soil and water. However, this research focuses more in monitoring levels of temperature in greenhouse.

Previously, human labors were required to visit the green house at the specific time and need to check temperature level manually. This type manual practice is apparently time consuming and needs a lot of works and efforts. The critical plants such as vegetables and flowers need 24 hours attention from human so that the quantities and qualities of the plants can be controlled. With the improvement of management in agriculture techniques and modern telecommunication technology can be implemented.

1.3 Project Objectives

Each project must have the objective to state the purpose of the project or what you are trying to achieve through the investigation. So, for this project, there are two (2) main objectives which are;

i. To develop the remote real time temperature monitoring system by using Zigbee technologies

ii. To construct and develop the model of the circuit design (hardware part)

1.4 Project Scopes

i. To develop a temperature monitoring and alert system using PIC microcontroller that is connected to the Zigbee module.

ii. To write a program that can send signal using assembly language in PIC C Compiler

iii. To combine the system to be one complete system that can be user friendly

1.5 Thesis Outline

Temperature Monitoring System final thesis consist of 5 chapters that explain different part of the project. Each chapter elaborates all part of hardware and software about this chapter. The content also consist of information about the project and the component used as illustrate in literature review

Chapter 1: Introduction of the project. The introduction about this research is the objectives and problems that lead to the implementation of this research are stated. The chapter starts with general information of Zigbee communication and the project background.

Chapter 2: Literature reviews for development this project. Let explains the literature study regarding temperature monitoring system project based on recent journals and papers. The information also comes from few resources in internet that can be trusted. Generally, most of the literature discuss about project module from the basic concept to its application to this project and engineering fields.

Chapter 3: Methodology of this project. It will be more focus methodology of the project. This chapter discusses the full methodology of the overall project. Hardware architecture and software implementation of the project is shown in this chapter. This chapter discusses about the architecture of the project that consists the hardware design and the software implementation

Chapter 4: Result and Analysis. It provides an outline of the results obtained from the transmitter board and receiver board Detail explanation of the result starting from the input until the output will be further discussed in this chapter.

Chapter 5: Conclusion. Conclusion is the last chapter and it contains the brief summary for the whole research from the beginning until it is completed. Conclusion is included as well as some recommendations for future research on temperature monitoring system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Inside this chapter, brief description on each project module that was used in this project will be stated. Besides that, some elaboration on fundamental of data transmission and can be fined in this chapter.

2.2 Remote Monitoring in Agricultural Greenhouse

In this paper, the objective of the research is to develop a remote temperature monitoring system using wireless sensor and Short Message Service (SMS) technology. The proposed system has a measurement which capable of detecting the level of temperature. This system also has a mechanism to alert farmers regarding the temperature changes in the greenhouse so that early precaution steps can be taken. In this research, several tests had been conducted in order to prove the viability of the system. Test results indicated that the reliability of the system in propagating information directly to the farmers could be gained excellently in various conditions. [1]

In this paper, they also made a prediction on the price reduction for remote monitoring sensor products as shown in the graph in Figure 2.1. Based on this work, we may conclude that the price of the products will continue to reduce though it may not follow the same pattern. [1]

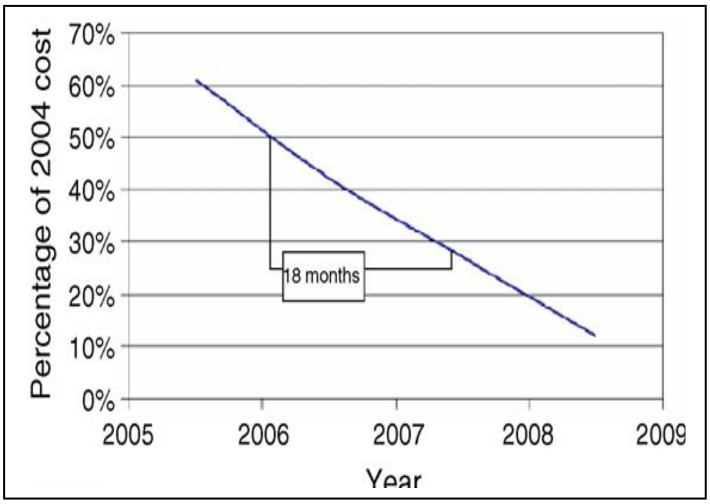

Figure 2.1: Projected price reduction for remote monitoring products

The paper does study on effect of temperature changing in greenhouses. Based on their case study of strawberry farm, MARDI had provided the information which is summarized in the Table 2.1. [1]

Table 2.1: The humidity and temperature affect significantly to the quality of strawberry.

Effect	Example
Developed disease	White rash
Lost of nutritional value	Vitamins
	Minerals
Over-ripen	Texture damage easily
	Rotten quickly
Texture	Toughness
	Firmness / softness
	Juiciness
Appearance	Size
	Color
	Shape / form
Flavor	Sweetness
	Acidity
	Bitterness

2.3 A Zigbee Based Wireless Sensor Network

This project proposed about Blockages in sewers is major causes of both sewer flooding and pollution. Water companies which fail to tackle this problem face hefty fines and high operational costs if they unsuccessful to provide a practical solution to prevent flooding. As a result, the detection of sewer condition is routinely required to inform on the best course of action to eliminate this critical problem. This paper presents a novel low cost wireless sensor technology to detect blockages proactively, and feed these event data back to a central control room. The practical deployment of the proposed WSN in an urban area will be demonstrated. In addition, the challenges of this technology in a field trial and the recorded data in terms of the sensor and communication reliability will be addressed. [2]

2.4 Greenhouse

Article analysis the commercial greenhouse vegetable production is an exacting and costly enterprise. Only expert management can prevent large-scale financial losses. Publications providing general information are available from libraries. Although several companies offer package investment opportunities, supplying equipment, materials and advice, none of these can guarantee success. In greenhouse production there is no substitute for experience. Temperature requirements for major greenhouse vegetables differ between vegetables and stages of growth. For cucumbers, temperatures should be kept between 75 and 77 F during the day and 70 F at night until the first picking. When picking started, we must, reduce temperatures 2 degrees. After picking is started, night temperatures may be reduced 2 degrees per night gradually to 63 F temporarily (for 2-3 days) to stimulate growth. Exceeding maximum temperatures temporarily can be used to cause some flower abortion and maintain the fruit-vine balance. In general, cooler temperatures are used when light intensities are low. [3]

2.5 Greenhouse Activity

The investigate in greenhouse is done with found the article that related in greenhouse activity. The objective if this article is to maintain the temperature inside the structure during cold or hot season and produce any selected crops. The structure also provided by heat control equipment to ensure the suitable temperature for the crops. The tropical greenhouse mainly built for protection of crops inside the structure from heavy rain and direct sunlight effect. The heavy rain especially monsoon season able to damage leafy vegetables and certain food crops. The structure mostly covered with 32 meshes netting to inhibit any pests to enter inside structure. The trend of greenhouse technology is more accepted my many farmers in Malaysia. [4]

Second article said that the vegetable crops research program covers a wide range of commodities which include chilli, tomato, long bean, cucumber, okra, brinjal, French bean, kalian, and a number of temperate vegetable types such as cabbage, cauliflower, broccoli, chinese cabbage, lettuce and bell pepper. The present hectarage of vegetables in Malaysia is around 44,000 hectares and it is mostly under small holdings. Research & Development (R&D) is vital to sustain these crops and to develop efficient and cost-effective large scale production systems. R&D activities are focused on the following thrust areas. The thrust areas is Technologies developed will be disseminated to the local industry through advisory services, consultancy, exhibitions, seminars, training & extension services, contract research, networking and collaboration with agricultural agencies, which are expected to support the needs and accelerate the growth of the vegetable industry.[5]

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology consists of overall of systems, hardware development and software development. The overall of the systems divides into three important parts that gives function to the board.

,

3.2 Overall System

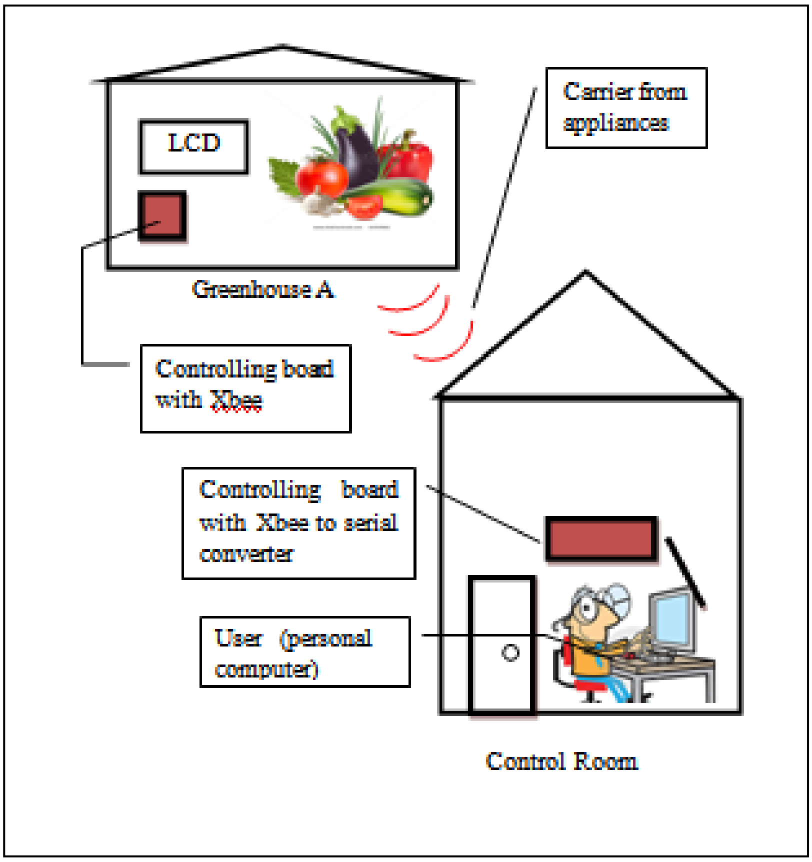

Figure 3.1: Methodology of overall system (block diagram)

After create a proper GUI by using Labview in personal computer (PC), the user now is able to identify the status of greenhouse. Firstly, the sensor was detected the temperature in the greenhouse. Then, the controlling board will send the value to control room in binary value by using Zigbee module also knows as transmitter. Secondly, Zigbee module will detect the value that function as receiver. The coding in microcontroller was develop to receive data and sent it to the PC through the serial converter. The methodology of overall system was shown in Figure 3.1.

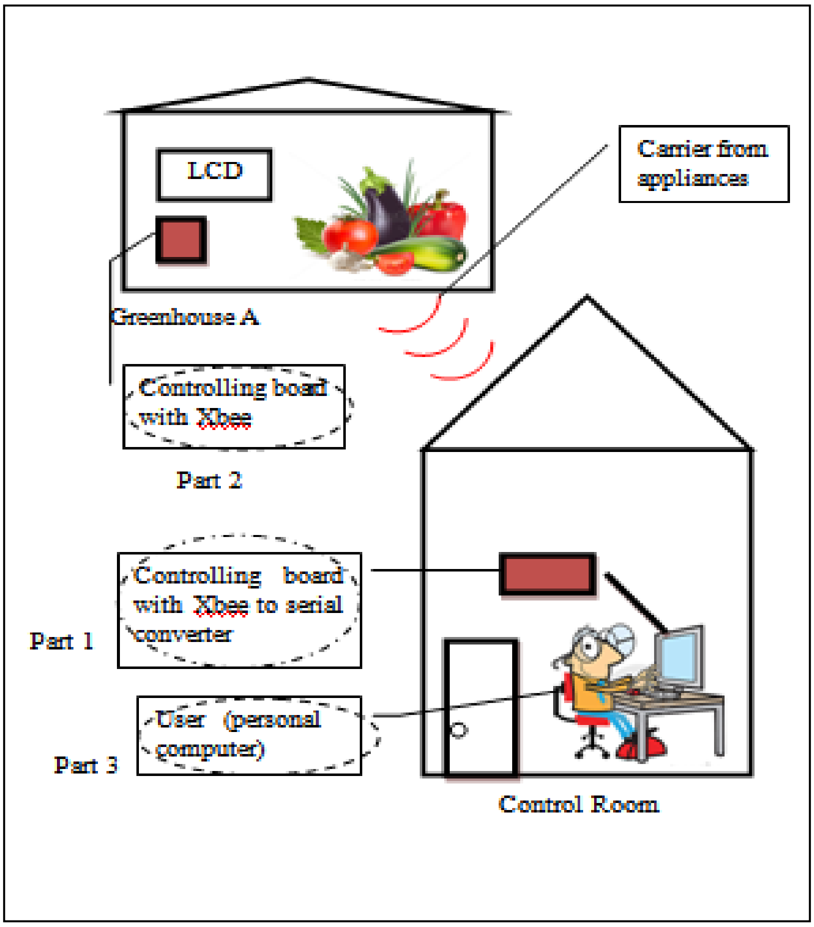

Figure 3.2: Three main part of project

Based on figure 3.2, there are three important parts in order to fulfill the objective of this project and complete the overall systems. There is Controlling board with Xbee to serial converter, controlling board with Xbee, and GUI (Graphical User Interface) in personal computer

3.2.1 Controlling board with Xbee to serial converter (Part 1)

Xbee USB to serial converter that functions to receive the data from controlling board for checking status proposes. XBee is designed for 3.3V system. So I developed the power circuit that gives the 3.3V. But to complete the configuration of UART, I used SKXBee that ready for embedded wireless development. Transmitting and receiving data require software or firmware development on particular microcontroller. Before develop software programming, we should know how to setting XBee Module Source address and Destination address, it is very important for us to transfer data by transparently from one XBee module (Source) to another XBee module (Destination).Two ways to setting ID address which is using X-CTU software or using programming code to send specified command for XBee ID address setting. After configuration, I had to connected XB_RX pin to PIC Transmitter pin TxD (PIC16F877A) and XB_TX pin to PIC Receiver pin RxD (PIC16F877A). The role of controlling board to serial converter is described by a simple block diagram as in Figure 3.10.

3.2.2 Controlling board with Xbee (Part 2)

The main electronic device in controlling board are PIC 16F877A, temperature sensor and LCD. The application board plays the role to reads the current status of the greenhouse. The current status was detecting the temperature by sensor and display on LCD. By referring the objectives of the project, this system is should be design to reading status of greenhouse. The both systems are clearly shown by a flow chart method.

3.2.3 Graphical User Interface (Part 3)

A graphical user interface (GUI) is one of the ways to interface between computer and human who can be manipulated by a mouse or a keyboard. The graphical- oriented is developed by using Labview. The powerful of Labview is makes the system friendly with user. The user can monitor the temperature of greenhouse on PC, if Universal Serial Bus (USB) port was connected with PC.

3.3 Hardware Development

The hardware design consists of microcontroller board module, zigbee module, sensor module, and serial communication. Microcontroller board had power circuit, clock circuit, reset circuit and PIC16F877A. For Zigbee module, it had power circuit 3.3V and Xbee.

3.3.1 Power Circuit

A regulator is needed to provide a constant and stable 5V DC. Electronic devices are sensitive to the supply voltage especially microcontroller. Any unstable voltage supply can easily cause damage the electronics component. In this project, voltage regulator LM7805 is used to regulate 5V DC voltage. Figure 3.3 shows the schematic diagram for power circuit

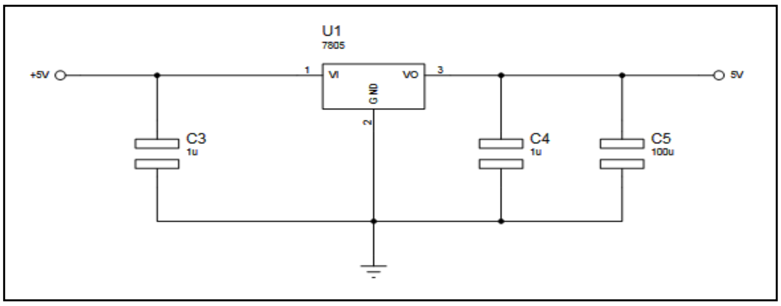

Figure 3.3: Power Circuit

3.3.2 Clock Circuit

Crystal oscillator provide stable and constant clock signal at high frequency. In this project, a 20 MHz crystal is used to produce 5 MHz output clock cycle. The clock circuit is connected to the pin XTAL and EXTAL at the microcontroller. Figure 3.4 shows the schematic diagram of clock circuit.

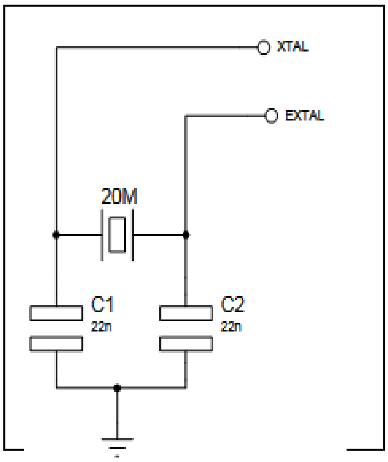

Figure 3.4: Clock Circuit

3.3.3 Reset Circuit

Reset circuit is used to reset the microcontroller process. The reset process occur by simply pressing the push button and this will causes the signal to be pulled low, thus forcing a reset on microcontroller. For microcontroller PIC 16F877A, the reset operation must be longer than 6 clock cycle (cc) so that the system can distinguish from internal reset. Hence, the value of resistor and capacitor must be chosen properly so that the reset circuit can produce output greater than 6cc. The reset circuit is shown in Figure 3.5.

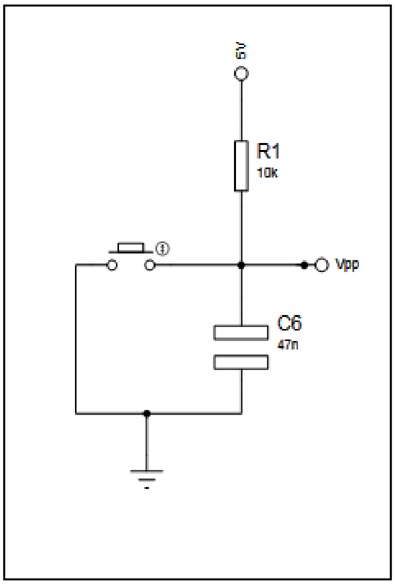

Figure 3.5: Reset Circuit

3.3.4 PIC 16F877A

Figure 3.6: PIC 16F877A (40 pin)

PIC6F877A have the same function but they had different because of amount of pin. They have extra advancement amongst microcontrollers. This device was build with special features such as 100,000 erase/write cycles enhanced flash program memory typical, self-reprogrammable under software control, In-Circuit Serial Programming via two pins, programmable code protection and power saving sleep model PIC16F87XA devices have a Watchdog Timer which can be shut- off only through configuration bits

Table 3.1: PIC16F87XA Device Features

Key Features	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	8K	8K
Data Memory (bytes)	368	368
EEPROM Data Memory (bytes)	256	256
Interrupts	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3
Capture/Compare/PWM modules	2	2
Serial Communications	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels
Analog Comparators	2	2
Instruction Set	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

3.3.5 Xbee Module

Figure 3.7: Xbee S1 transceiver

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other. The important features of Xbee are as in show below: [6]

a) 3.3V @ 215mA
b) 250kbps Max data rate
c) 60mW output (+18dBm)
d) 1 mile (1500m) range
e) Built-in antenna
f) Fully FCC certified
g) 6 10-bit ADC input pins
h) 8 digital IO pins
i) 128-bit encryption
j) Local or over-air configuration
k) AT or API command set

The XBee/XBee-PRO OEM RF Modules interface to a host device through a logic-level asynchro-nous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART or through a level translator to any serial device. Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure next page. The connection Vcc and ground connected. Bear in mind, Vcc is 3.3V for zigbee module. DI is also TX that connected with RF of the microcontroller. While, DO is also RX that connected with the microcontroller.

3.3.6 Power Circuit of 3.3V

This circuit was developing to give the power to Zigbee Module. The circuit was shown in Figure 3.8.

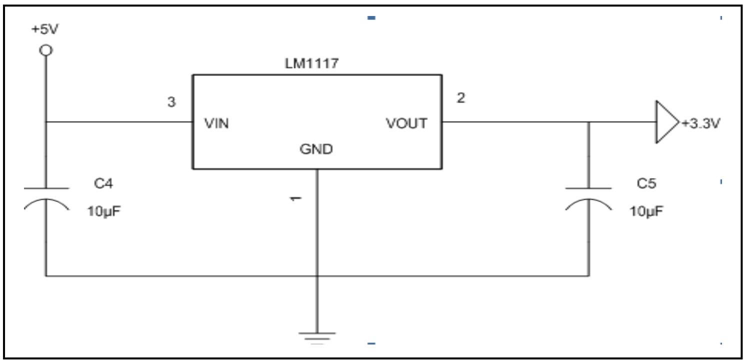

Figure 3.8: Power module of 3.3V DC

3.3.7 Sensor Circuit

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin. The LM35 does not require any external calibration or trimming to provide typical.

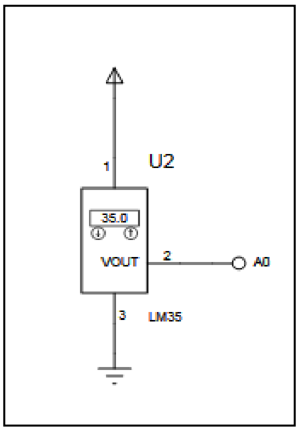

Figure 3.9: LM 35 Circuit

3.3.8 Serial Communication Module

In this project, microcontroller has to send data to computer and display the data on GUI. Since serial communication is selected to communicate with computer, EIA232 module is required. EIA232 module is a standard protocol for data transferring via serial communication. MAX 233 is used to achieve the standard of EIA232. A basic circuit of MAX 233 is shown in Figure 3.5. MAX 233 is connected to pin TxD and RxD of microcontroller to enable data to be transmitted serially for a longer distance.

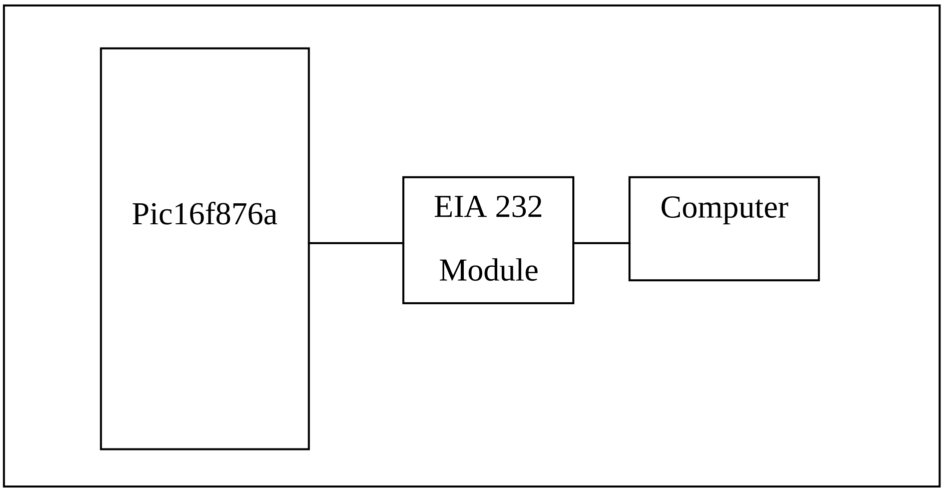

Figure 3.10: Block Diagram of Serial Communication Module

3.4 Software Development

There are several software were used to complete this project, such as Proteuse 7 professional PCB design, Eltima, Labview, PIC C compiler and PIC kit 2 v2.50.

3.4.1 Proteuse ISIS 7 professional

PROTEUS allows me to run interactive simulations of real designs, and to reap the rewards of this approach to circuit simulation. And then, a range of simulator models for popular micro-controllers and a set of animated models for related peripheral devices such as LED and LCD displays, keypads, an RS232 terminal and more. It is possible to simulate complete micro-controller systems and thus to develop the software for them without access to a physical prototype.

In a world where time to market is becoming more and more important this is a real advantage. The figure 3.16 in below is shows a simple designing page layout of Proteuse 7 professional PCB design.

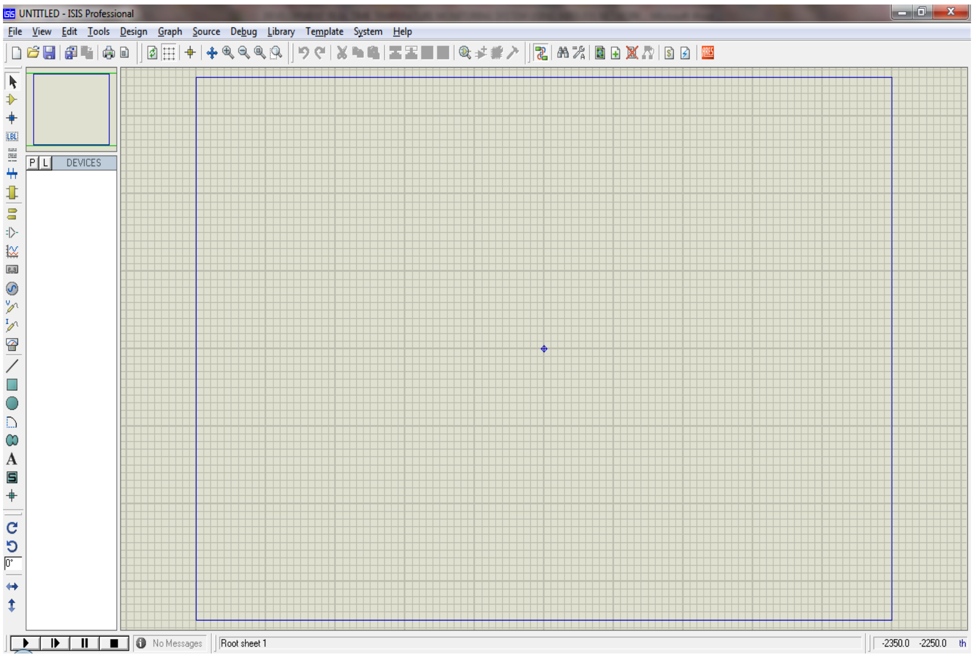

Figure 3.11: Designing page of Proteuse 7 professional

3.4.2 PIC C compiler

These compilers are specifically designed to meet the unique needs of the PIC® microcontroller. This allows developers to quickly design applications software in a more readable, high-level language. A program is made up of the following four elements in a file. There are Comment, Pre-Processor DirectiveData Definition and Function Definition. Save time and reduce risk also the advantages using this compiler. . The figure 3.16 in below is CCS of PIC C compiler

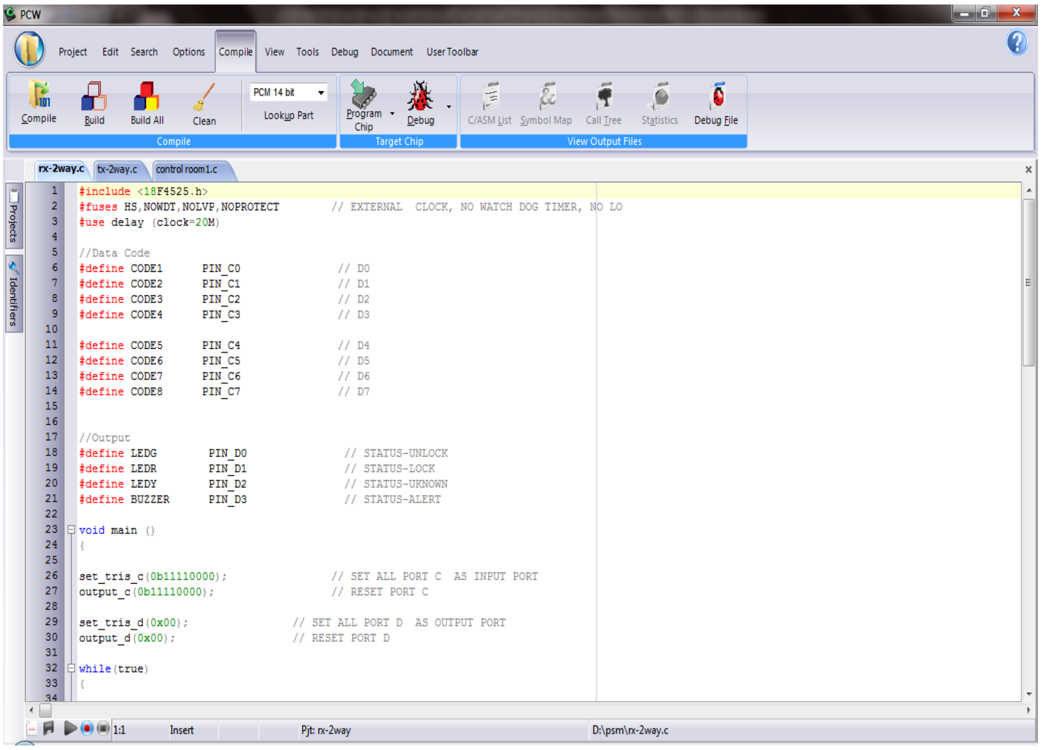

Figure 3.12: CCS of PIC C compiler

3.4.3 PIC kit 2 v2.50.

The PICkit 2 Development Programmer/Debugger is a low-cost development programmer. This software useful when write the program into PIC microcontroller. After the code developed and compiled, we had launched the program software and wrote them. The figure 3.18 in below is shows a simple layout of PIC kit 2 v2.50.

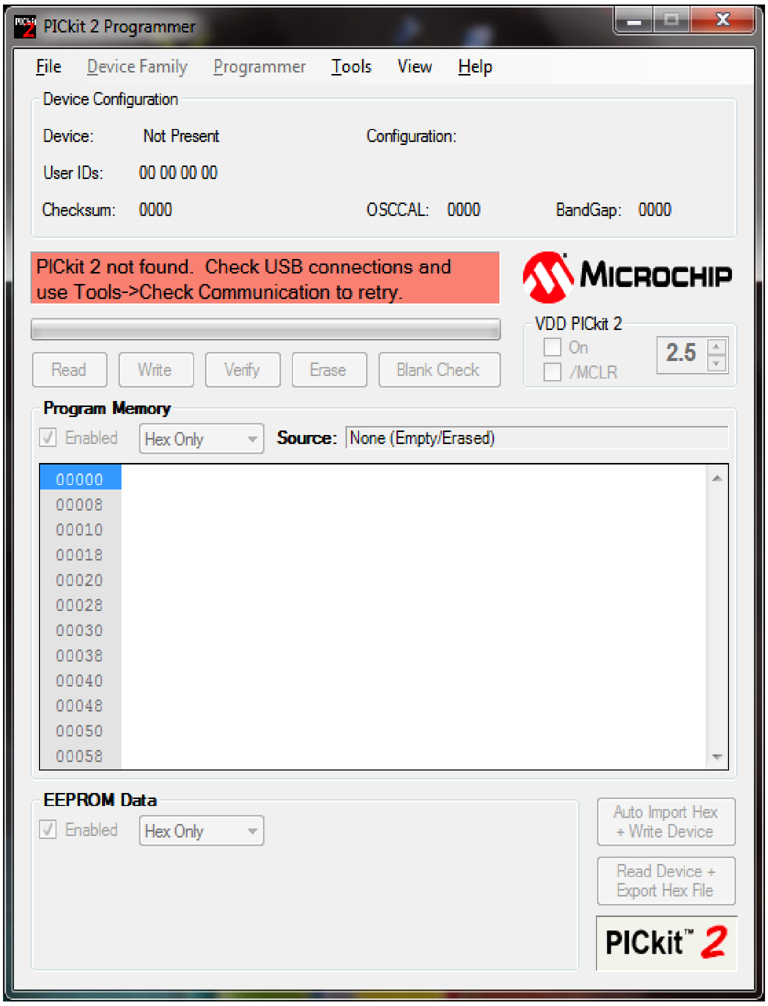

Figure 3.13: layout of PIC kit 2 v2.50.

3.4.4 X-CTU Configuration

The zigbee had configuration using X-CTU software. The function is reading or setting zigbee parameters. After configuration, the zigbee can send and receive data. For this project I had used SKXBee board to configure the parameters. The figure 3.18 in below is shows a simple layout of X-ctu software.

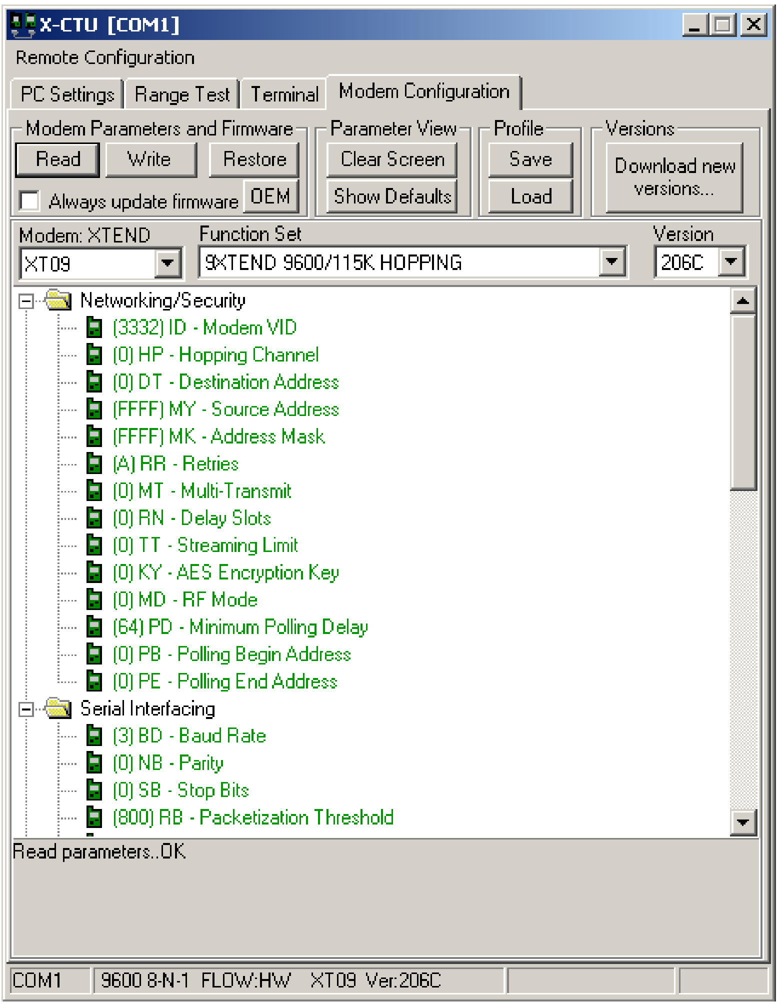

Figure 3.14: Layout X-CTU software

3.4.5 Labview

The LabVIEW was function as GUI in this project. There many choice other this software such as MATLAB, Microsoft Visual Basic and Microsoft Visual Studio. The LabVIEW is the best software which is easy to develop and very easy to understand.

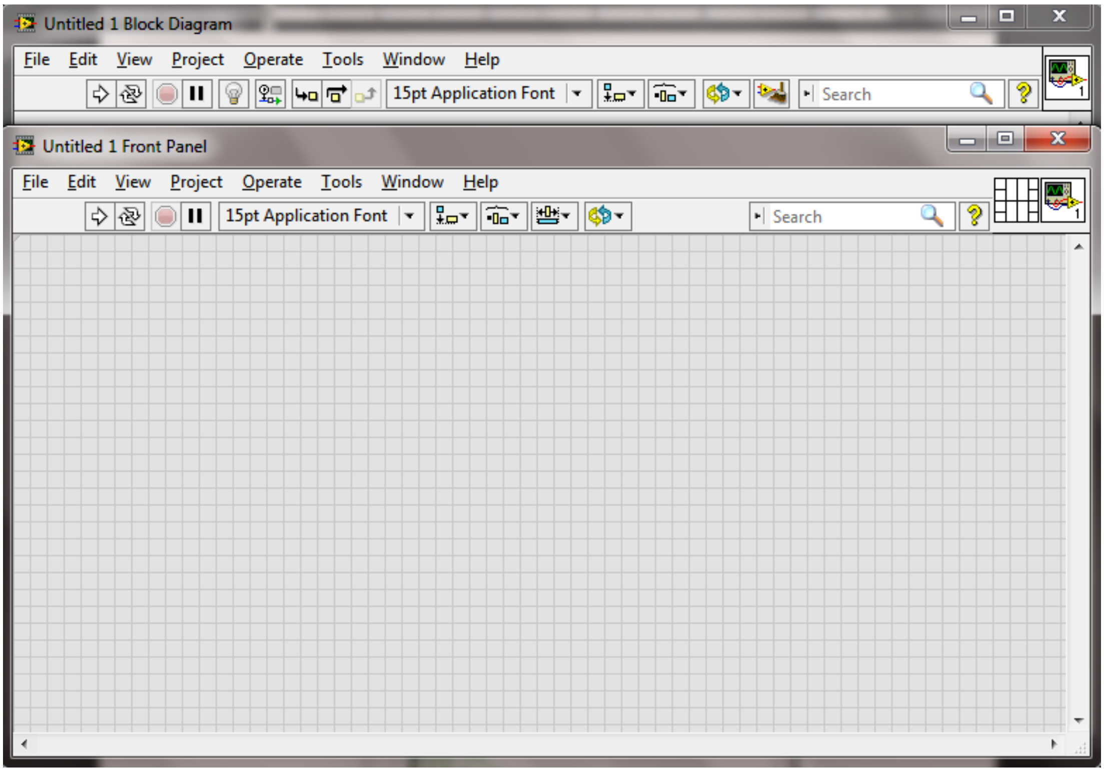

Figure 3.15: Layout LabVIEW software

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

Several testing have been performed during the development of this system. The approach taken in executing the various tests is discussed in this chapter. In developing Temperature Monitoring System, various tests are conducted. The tests are microcontroller board testing, sensor module testing, wireless communication testing and serial communication testing. Finally, each module is integrated into a single system to produce a fully functioning Temperature Monitoring System

.

4.2 Discussion

4.2.1 Microcontroller System Board Testing

Microcontroller PIC16F877A system board is shown in Figure 4.1. A simple program as shown in Figure 4.2 is executed by microcontroller. As the result, a simple alternate light glowing is produced. This verifies that microcontroller system is functioning successfully.

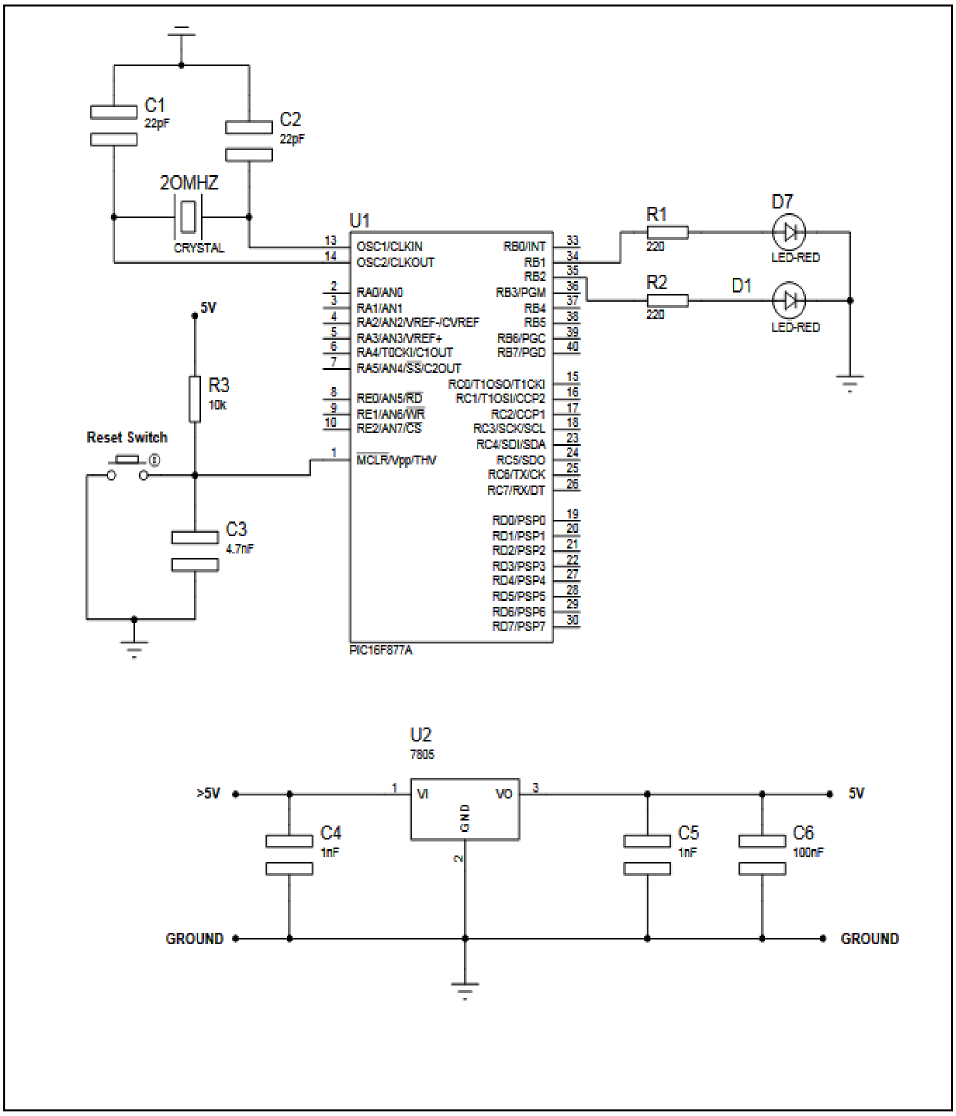

Figure 4.1: Layout microcontroller PIC16F876A system board

```
#INCLUDE <16F877A.h>
#FUSES HS,NOWDT,NOLVP,NOPROTECT
#USE DELAY(CLOCK=20M)
void main()
{
set_tris_b(0x00);    //set port b as output
output_b(0x00);      //reset port b
while (true)
{
output_b(0x0E); // on red LED
delay_ms(1000);
output_b(0x00);   //on red LED
}
}
```

Figure 4.2: Microcontroller System Board Testing Program

4.2.2 Sensor Module Testing Circuit

A simple program was developed to testing the temperature sensor. LCD was used to display the current temperature in greenhouse. The output of LM35 is analog voltage. Hence, the voltage must be converted to digital form in order to manipulate by microcontroller. One of the features of PIC16f877a is internal ADC. The internal ADC in microcontroller will convert the analog voltage into 8-bit digital data. Then, 8 bits digital will display on LCD that very familiar to the user.

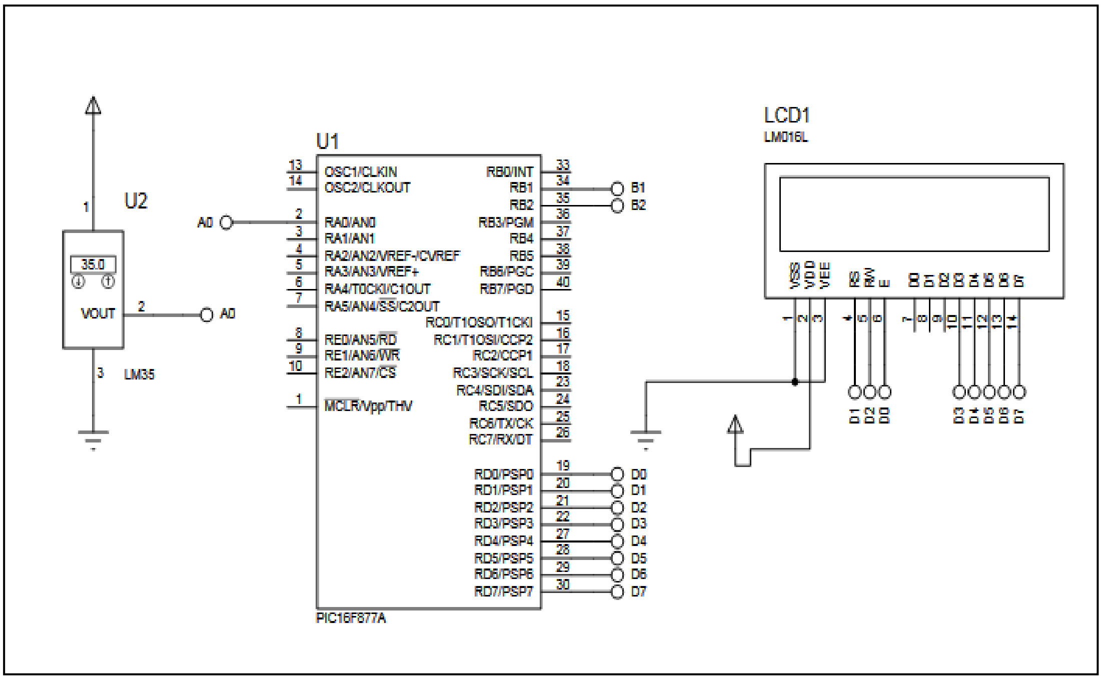

Figure 4.3: Layout Sensor Module Testing Board

```
void main()
{  int32 reading,value;
   lcd_init();
   setup_adc_ports(AN0);                          //SETUP ADC PORT
   setup_adc(ADC_CLOCK_INTERNAL);
   while (true)                                  // MAIN PROGRAM
  {  set_adc_channel(0);
  delay_ms(100);
  reading=read_adc();
  value = reading *500/1023;
  lcd_gotoxy (1,2);
  printf(lcd_putc, "Value = %u C", (int)value);
```

Figure 4.4: Sensor Module Testing Program

4.2.3 Controlling board Xbee transceiver testing

Since the controlling board consists of extensive devices, each of them must be tested individually to ensure its functionality. The result of the testing reveal that controlling board is ready for interface purpose and Xbee transceiver is function properly based fixed protocol. The figure 4.5 below showed the layout transmitter board and flow chart of guideline of transmitter board shown in chapter 4.6. For the received, layout of received board show in figure 4.7 and flow chart of guideline of received board in figure 4.8.

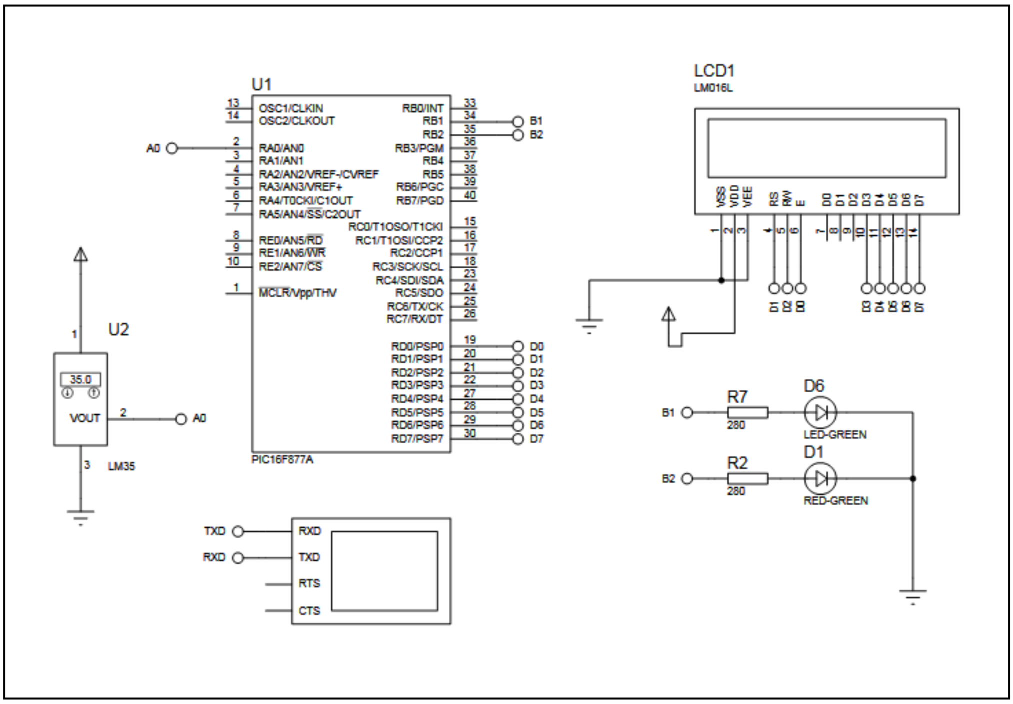

Figure 4.5: Layout of transmitter board

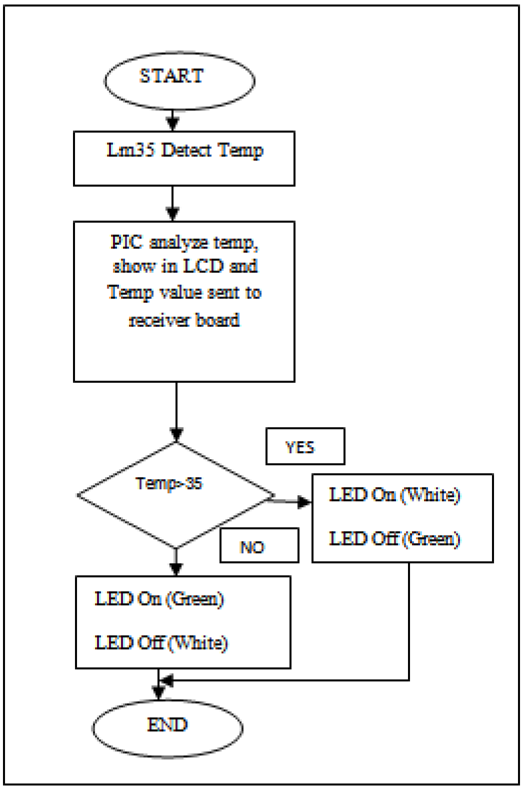

Figure 4.6: Flow chart of guideline of transmitter board

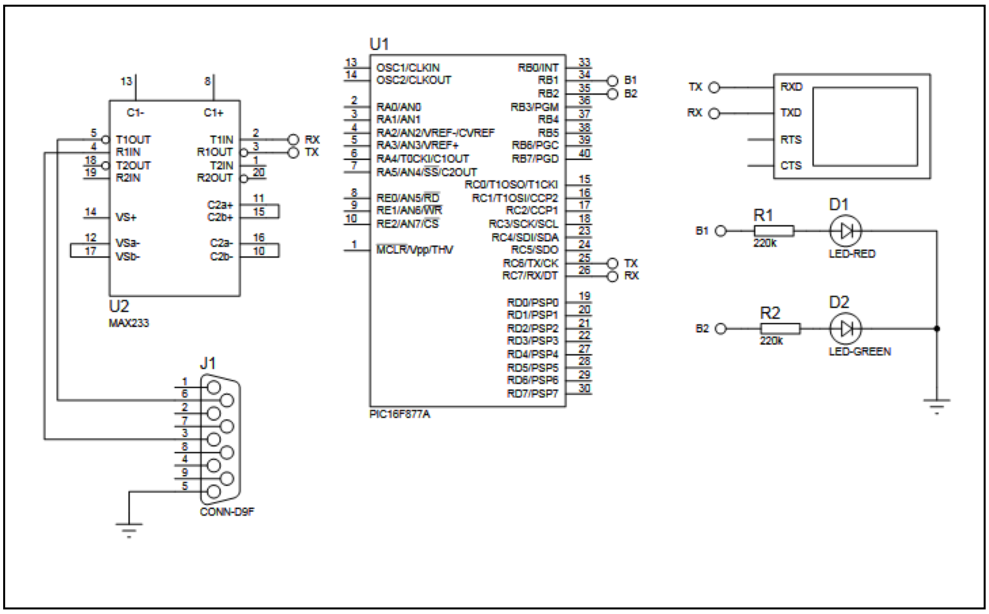

Figure 4.7: Layout of received board

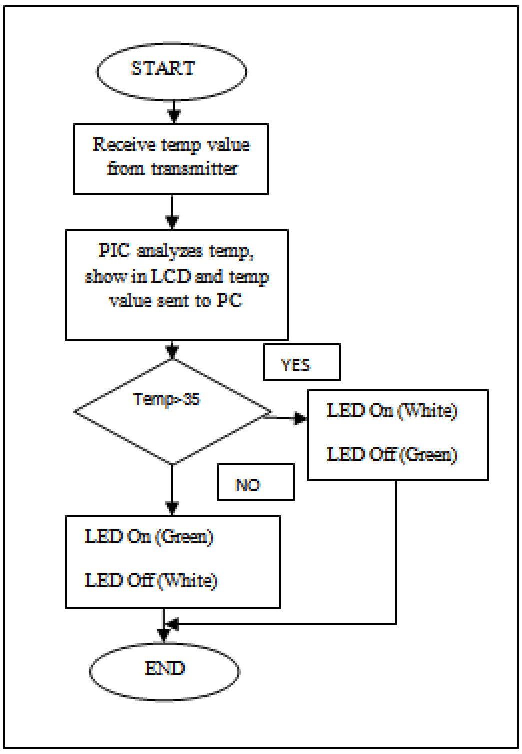

Figure 4.8: Flow chart of guideline of received board

4.2.4 Serial Communication Testing

The hardware was developing as shown in Figure 4.7. After that, the coding was developed that sends the value to the PC. To test the serial communication, I was using the Hyper Terminal. The value of temperature was shown in the Figure 4.8. The situation occurs after connected USB and launched Hyper Terminal software.

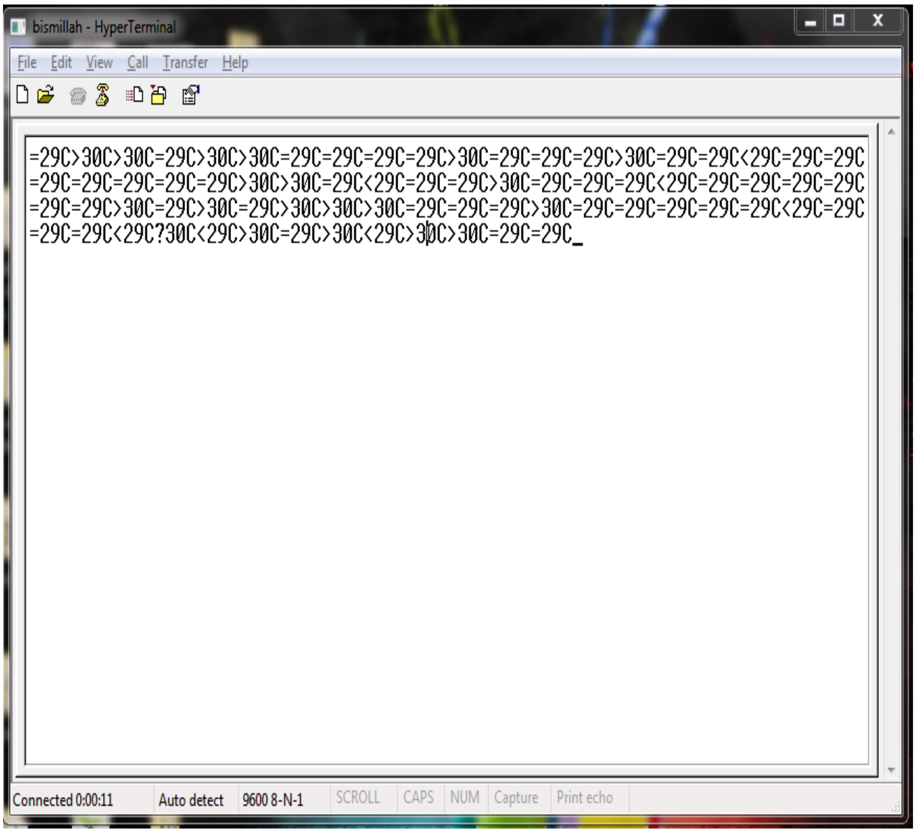

Figure 4.9: Serial Communication Testing

4.3 Result

The system now is able to monitor all current temperature in the greenhouse by a Personal computer and the system is 100 percentages based on Zigbee wireless technology and PIC 16f877a is rolled as the brain of the system. The result of my project is shown by some figures as below:

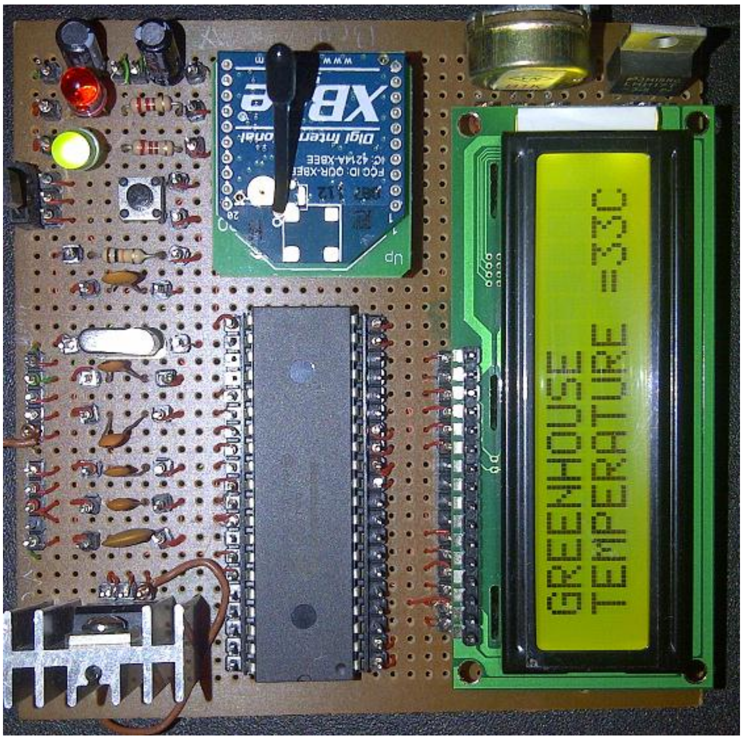

Figure 4.10: Transmitter Board

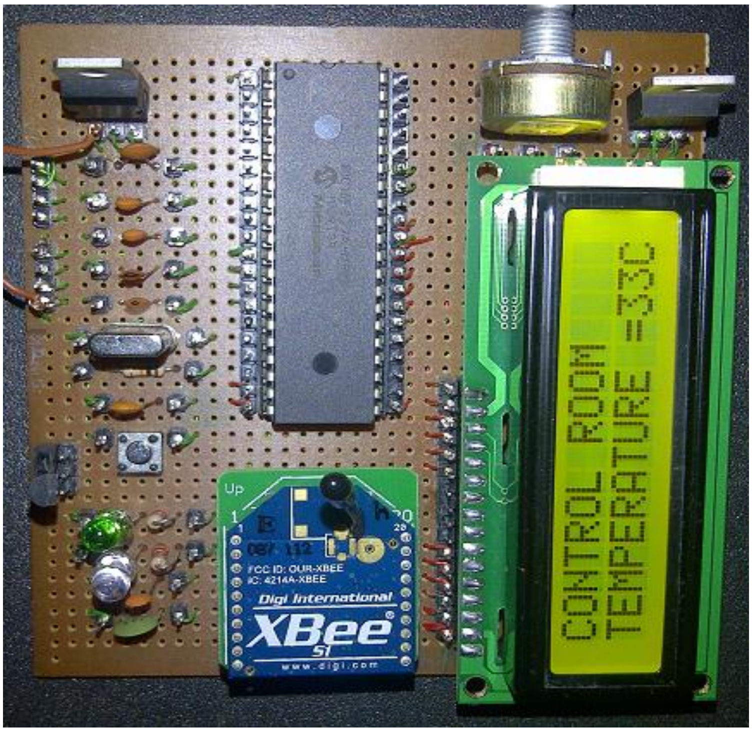

Figure 4.11: Receiver Board

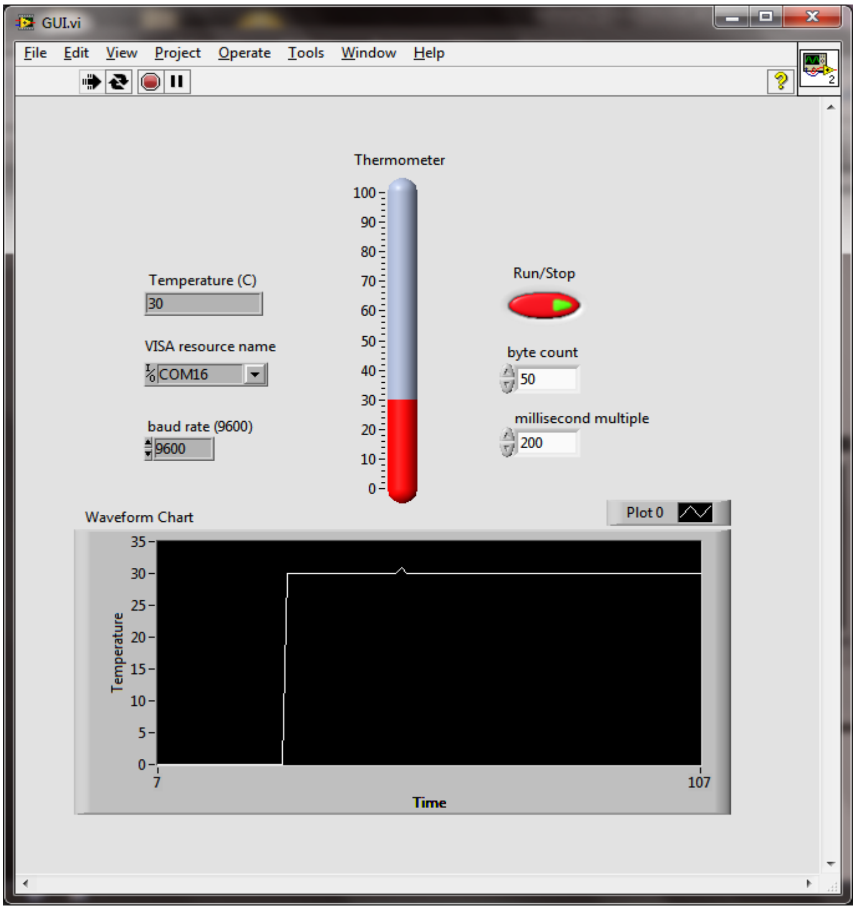

Figure 4.12: GUI

The analysis was done by measuring the level of temperature at the specific time that shown in figure 4.1. The value of voltage had increase linear with the temperature. That means 1mV equal 1Celcius. The vegetables were infected if the temperature increases such as the vegetable lost he vitamin and not produce the good quality and quantity of vegetable. Critical time was 11am until 12am which is not suitable for temperature. So, that is the reason why the alert system is very important to farmer take the action or can add other system to excuse increase temperature. In the table also was shown the average the temperature at that time.

Table 4.1: The analysis of temperature monitoring

Voltage(mV)	Celsius	Time
24	24	7am-8am
23	23	
24	24	
23	23	
31	33	11am-12am
33	33	
34	34	
32	32	
25	25	11pm-12pm
27	25	
28	25	
26	26	

Average

The table 4.2 show the analysis distance between transmitter and receiver. From that analysis, the disturbance also effected the signal generate by transmitter. The datasheet said the range for Xbee S1 is 0m until 30m. So, it was proven by this analysis. For the out range, the data was transmitter but had some error.

Table 4.2: The range of distance between transmitter and receiver.

Range of distance (m)	Temperature(C)	
	Transmitter	Receiver
0-5	25	25
5-10	26	26
10-15	26	26
15-30	27	27
30-35	27	25
300-350 with disturbance	27	0

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this last chapter, will be include with the conclusions through all the projects overall as well as recommendations in order to upgrade the system and to overcome all the problems arise during the project completion.

5.2 Conclusion

The project has accomplished the main objective where the Temperature Monitoring System is successfully developed. The project consists of three parts which are controlling board with Xbee to serial converter, controlling board with Xbee, and GUI. The controlling board with Xbee is capable to measure temperature and transfer this data wirelessly to control centre module. This data is then displayed at computer. We had added alarm system to alert the farmer with increase temperature in greenhouse.

5.3 Recommendations

Although temperature systems are commercially available today, there is a need to further research to address the challenges of real world scenarios. Here are some recommendations for future development:

i. More application module can be added such as water level measurement that is very important for greenhouse system

ii Improve the transmission quality by introduce the ZigBee technology. It is better use Zigbee PRO for long distance.

iii. Program of the system should be improved to provide more friendly system such as add more alert application to the system by using GSM technologies.

5.4 Costing and Commercialization

The overall cost of the whole project is based on the hardware development. As discussed in previous chapter, the hardware development consists of one main board. Therefore the whole project coat is depends on the cost of electronic devices. The total cost for the development system is RM 350.00. This cost is far cheaper to the development board exist in the market. Furthermore, the system can be redesigned to suit and meet the requirement of the user. Needless to say, the product has highly potential to be commercialized

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APPENDIX A

Data sheets

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input
  DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^{2}C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

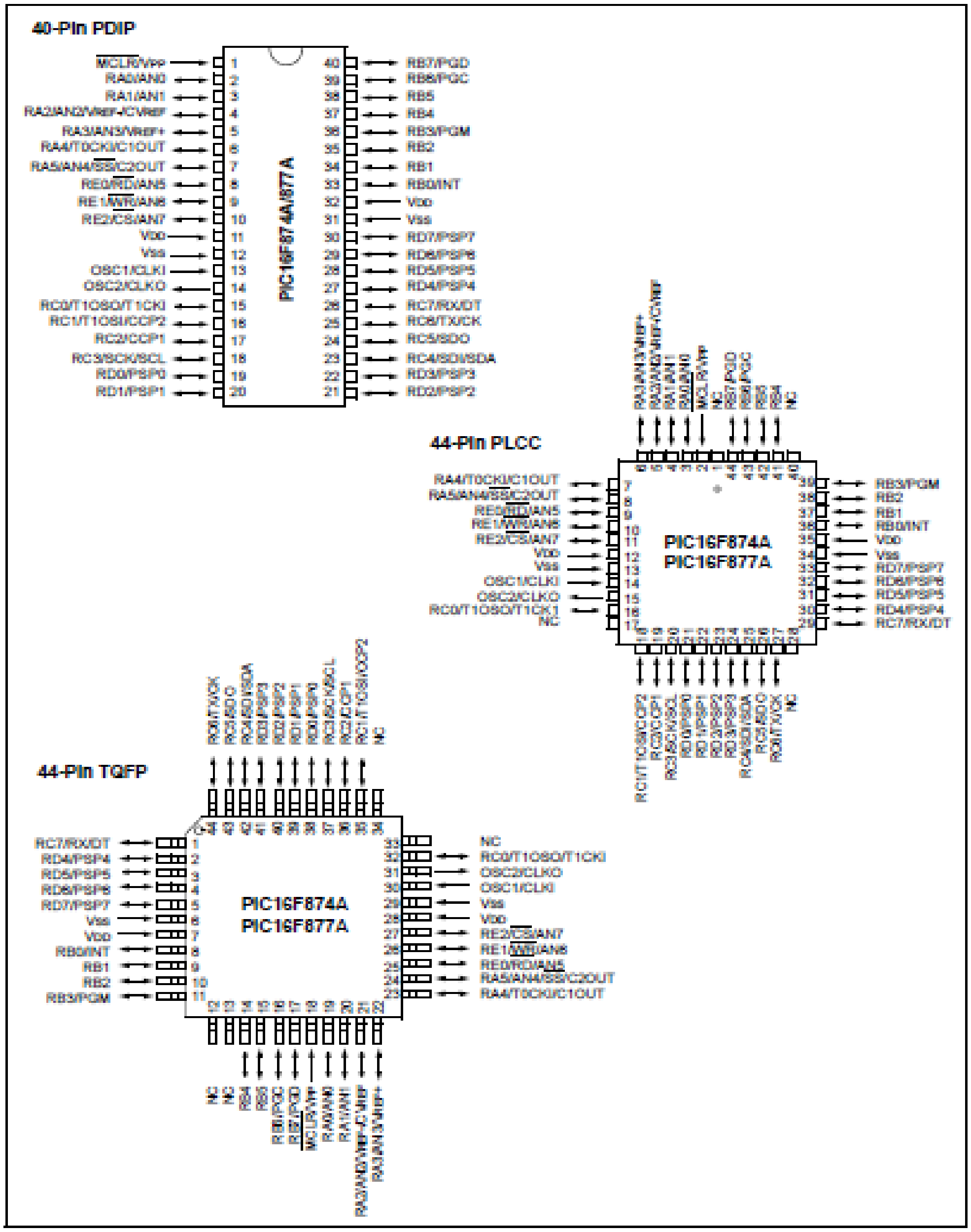
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^{2}C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

Pin Diagrams (Continued)



PIC16F87XA

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	38		ST/TTL(3)	
RD0					I/O		Digital I/O.
PSP0					I/O		Parallel Slave Port data.
RD1/PSP1	20	22	39	39		ST/TTL(3)	
RD1					I/O		Digital I/O.
PSP1					I/O		Parallel Slave Port data.
RD2/PSP2	21	23	40	40		ST/TTL(3)	
RD2					I/O		Digital I/O.
PSP2					I/O		Parallel Slave Port data.
RD3/PSP3	22	24	41	41		ST/TTL(3)	
RD3					I/O		Digital I/O.
PSP3					I/O		Parallel Slave Port data.
RD4/PSP4	27	30	2	2		ST/TTL(3)	
RD4					I/O		Digital I/O.
PSP4					I/O		Parallel Slave Port data.
RD5/PSP5	28	31	3	3		ST/TTL(3)	
RD5					I/O		Digital I/O.
PSP5					I/O		Parallel Slave Port data.
RD6/PSP6	29	32	4	4		ST/TTL(3)	
RD6					I/O		Digital I/O.
PSP6					I/O		Parallel Slave Port data.
RD7/PSP7	30	33	5	5		ST/TTL(3)	
RD7					I/O		Digital I/O.
PSP7					I/O		Parallel Slave Port data.
							PORTE is a bidirectional I/O port.
RE0/$\overline{\text{RD}}$/AN5	8	9	25	25		ST/TTL(3)	
RE0					I/O		Digital I/O.
$\overline{\text{RD}}$					I		Read control for Parallel Slave Port.
AN5					I		Analog input 5.
RE1/$\overline{\text{WR}}$/AN6	9	10	26	26		ST/TTL(3)	
RE1					I/O		Digital I/O.
$\overline{\text{WR}}$					I		Write control for Parallel Slave Port.
AN6					I		Analog input 6.
RE2/$\overline{\text{CS}}$/AN7	10	11	27	27		ST/TTL(3)	
RE2					I/O		Digital I/O.
$\overline{\text{CS}}$					I		Chip select control for Parallel Slave Port.
AN7					I		Analog input 7.
VSS	12, 31	13, 34	6, 29	6, 30, 31	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	12, 35	7, 28	7, 8, 28, 29	P	—	Positive supply for logic and I/O pins.
NC	—	1, 17, 28, 40	12,13, 33, 34	13	—	—	These pins are not internally connected. These pins should be left unconnected.

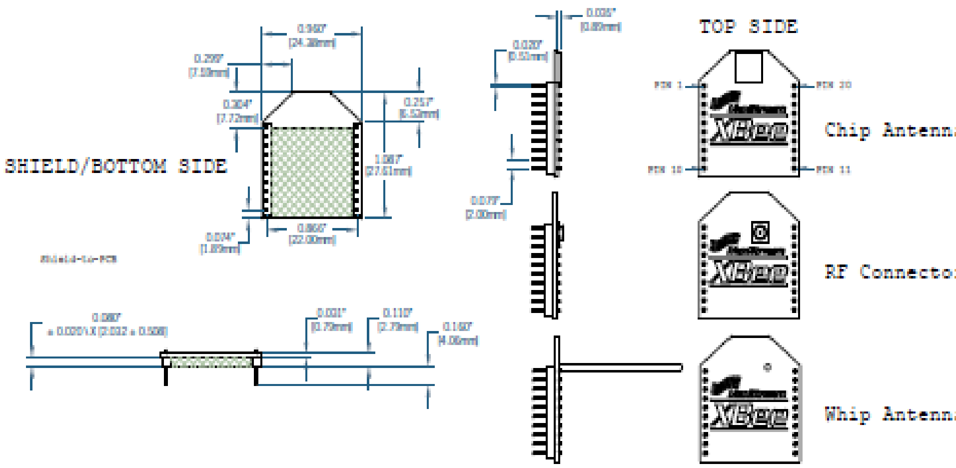
Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

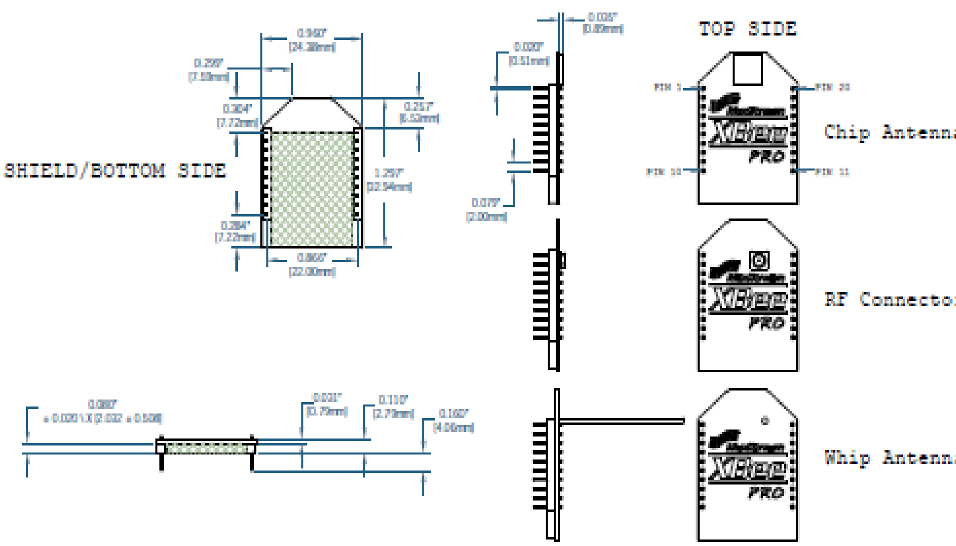
XBee Mechanical Drawings

XBee and XBee-PRO OEM RF Modules are pin-for-pin compatible with each other.

XBee OEM RF Module



XBee-PRO OEM RF Module



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1. XBee/XBee-PRO OEM RF Modules

The XBee and XBee-PRO OEM RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between devices.

The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

1.1. Key Features

Long Range Data Integrity

XBee

- Indoor/Urban: up to 100' (30 m)
- Outdoor line-of-sight: up to 300' (100 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm

XBee-PRO

- Indoor/Urban: up to 300' (100 m)
- Outdoor line-of-sight: up to 1 mile (1500 m)
- Transmit Power: 100 mW (20 dBm) EIRP
- Receiver Sensitivity: -100 dBm

RF Data Rate: 250,000 bps

Advanced Networking & Security

Retries and Acknowledgements

DSSS (Direct Sequence Spread Spectrum)

Each direct sequence channels has over 65,000 unique network addresses available

Source/Destination Addressing

Unicast & Broadcast Communications

Point-to-point, point-to-multipoint and peer-to-peer topologies supported

Coordinator/End Device operations

Low Power

XBee

- TX Current: 45 mA (@3.3 V)
- RX Current: 50 mA (@3.3 V)
- Power-down Current: < 10 µA

XBee-PRO

- TX Current: 215 mA (@3.3 V)
- RX Current: 55 mA (@3.3 V)
- Power-down Current: < 10 µA

ADC and I/O line support

Analog-to-digital conversion, Digital I/O

I/O Line Passing

Easy-to-Use

No configuration necessary for out-of box RF communications

Free X-CTU Software (Testing and configuration software)

AT and API Command Modes for configuring module parameters

Extensive command set

Small form factor

Free & Unlimited RF-XPert Support

1.1.1. Worldwide Acceptance

FCC Approval (USA) Refer to Appendix A [p57] for FCC Requirements. Systems that contain XBee/XBee-PRO RF Modules inherit MaxStream Certifications.

ISM (Industrial, Scientific & Medical) **2.4 GHz frequency band**

Manufactured under **ISO 9001:2000** registered standards

XBee/XBee-PRO RF Modules are optimized for use in the **United States, Canada, Australia, Israel and Europe.** Contact MaxStream for complete list of government agency approvals.

1.5. Pin Signals

Figure 1-03. XBee/XBee-PRO RF Module Pin Numbers
(top sides shown - shields on bottom)

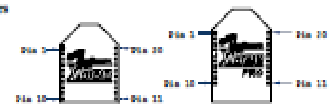


Table 1-02. Pin Assignments for the XBee and XBee-PRO Modules
(Low-asserted signals are distinguished with a horizontal line above signal name.)

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

* Function is not supported at the time of this release

Design Notes:

- Minimum connections: VCC, GND, DOUT & DIN
- Minimum connections for updating firmware: VCC, GND, DIN, DOUT, RTS & DTR
- Signal Direction is specified with respect to the module
- Module includes a 50k Ω pull-up resistor attached to RESET
- Several of the input pull-ups can be configured using the PR command
- Unused pins should be left disconnected

2. RF Module Operation

2.1. Serial Communications

The XBee/XBee-PRO OEM RF Modules interface to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device (For example: Through a MaxStream proprietary RS-232 or USB interface board).

2.1.1. UART Data Flow

Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure below.

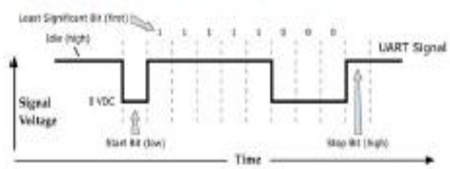
Figure 2-01. System Data Flow Diagram in a UART-interfaced environment
(Low-asserted signals distinguished with horizontal line over signal name.)

Serial Data

Data enters the module UART through the DI pin (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted.

Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

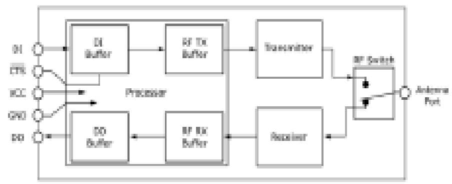
Figure 2-02. UART data packet 0x1F (decimal number "31") as transmitted through the RF module
Example Data Format is 8-N-1 (bits - parity - # of stop bits)



The module UART performs tasks, such as timing and parity checking, that are needed for data communications. Serial communications depend on the two UARTs to be configured with compatible settings (baud rate, parity, start bits, stop bits, data bits).

2.1.4. Flow Control

Figure 2-03. Internal Data Flow Diagram



DI (Data In) Buffer

When serial data enters the RF module through the DI pin (pin 3), the data is stored in the DI Buffer until it can be processed.

Hardware Flow Control ($\overline{CTS}$). When the DI buffer is 17 bytes away from being full; by default, the module de-asserts $\overline{CTS}$ (high) to signal to the host device to stop sending data [refer to D7 (DIO7 Configuration) parameter]. $\overline{CTS}$ is re-asserted after the DI Buffer has 34 bytes of memory available.

How to eliminate the need for flow control:

1. Send messages that are smaller than the DI buffer size.
2. Interface at a lower baud rate [BD (Interface Data Rate) parameter] than the throughput data rate.

Case in which the DI Buffer may become full and possibly overflow:

If the module is receiving a continuous stream of RF data, any serial data that arrives on the DI pin is placed in the DI Buffer. The data in the DI buffer will be transmitted over-the-air when the module is no longer receiving RF data in the network.

Refer to the RO (Packetization Timeout), BD (Interface Data Rate) and D7 (DIO7 Configuration) command descriptions for more information.

DO (Data Out) Buffer

When RF data is received, the data enters the DO buffer and is sent out the serial port to a host device. Once the DO Buffer reaches capacity, any additional incoming RF data is lost.

Hardware Flow Control ($\overline{RTS}$). If $\overline{RTS}$ is enabled for flow control (D6 (DIO6 Configuration) Parameter = 1), data will not be sent out the DO Buffer as long as $\overline{RTS}$ (pin 16) is de-asserted.

Two cases in which the DO Buffer may become full and possibly overflow:

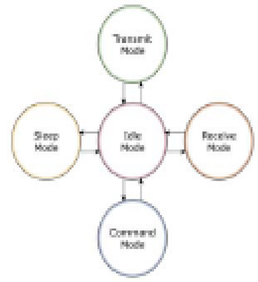
1. If the RF data rate is set higher than the interface data rate of the module, the module will receive data from the transmitting module faster than it can send the data to the host.
2. If the host does not allow the module to transmit data out from the DO buffer because of being held off by hardware or software flow control.

Refer to the D6 (DIO6 Configuration) command description for more information.

2.5. Modes of Operation

XBee/XBee-PRO RF Modules operate in five modes.

Figure 2-07. Modes of Operation



2.5.1. Idle Mode

When not receiving or transmitting data, the RF module is in Idle Mode. The module shifts into the other modes of operation under the following conditions:

- Transmit Mode (Serial data is received in the DI Buffer)
- Receive Mode (Valid RF data is received through the antenna)
- Sleep Mode (Sleep Mode condition is met)
- Command Mode (Command Mode Sequence is issued)

2.5.2. Transmit/Receive Modes

RF Data Packets

Each transmitted data packet contains a Source Address and Destination Address field. The Source Address matches the address of the transmitting module as specified by the MY (Source Address) parameter (if MY >= 0xFFFE), the SH (Serial Number High) parameter or the SL (Serial Number Low) parameter. The <Destination Address> field is created from the DH (Destination Address High) and DL (Destination Address Low) parameter values. The Source Address and/or Destination Address fields will either contain a 16-bit short or long 64-bit long address.

The RF data packet structure follows the 802.15.4 specification.

[Refer to the XBee/XBee-PRO Addressing section for more information]

Direct and Indirect Transmission

There are two methods to transmit data:

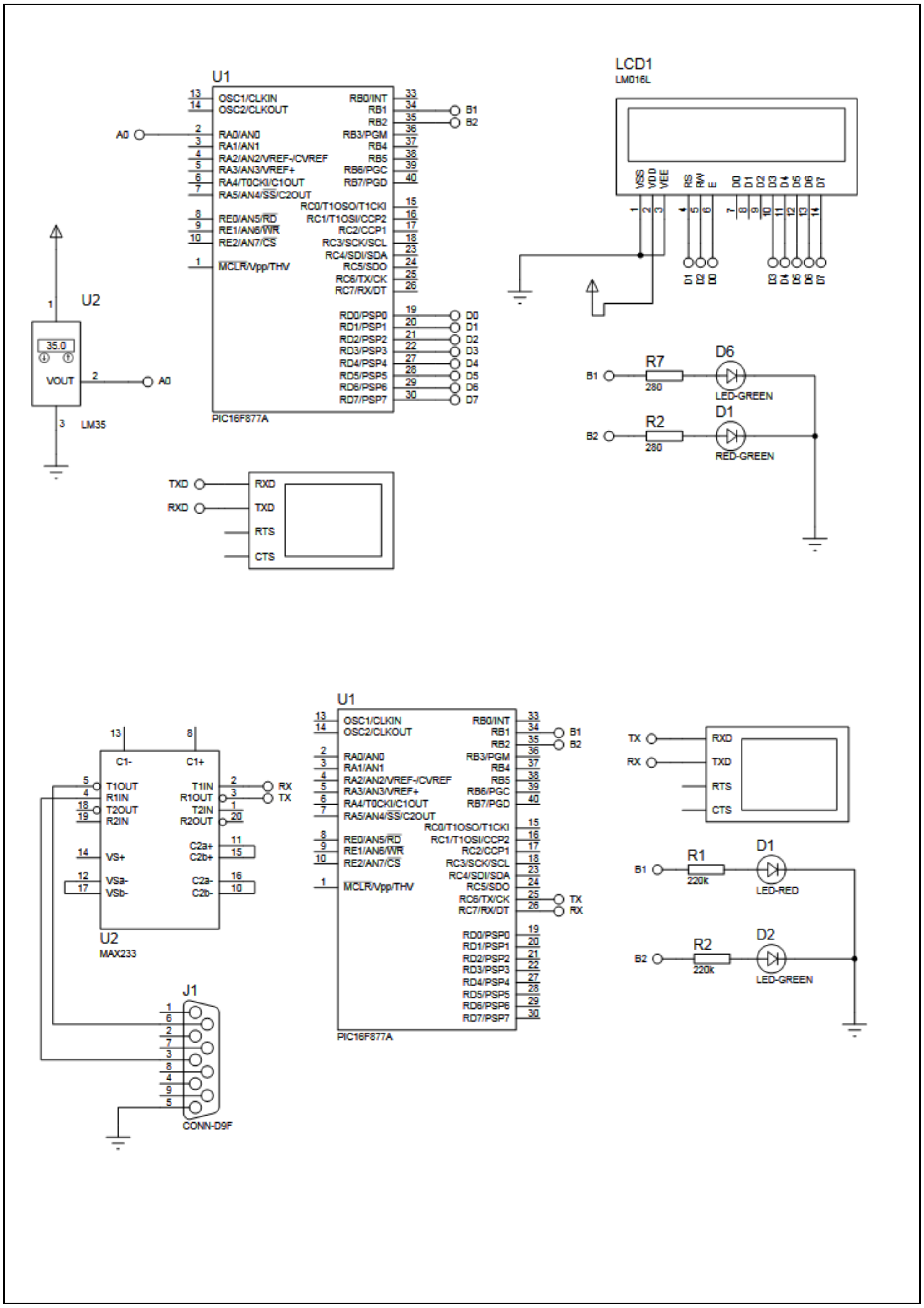
- Direct Transmission - data is transmitted immediately to the Destination Address
- Indirect Transmission - A packet is retained for a period of time and is only transmitted after the destination module (Source Address = Destination Address) requests the data.

Indirect Transmissions can only occur on a Coordinator. Thus, if all nodes in a network are End Devices, only Direct Transmissions will occur. Indirect Transmissions are useful to ensure packet delivery to a sleeping node. The Coordinator currently is able to retain up to 2 indirect messages.

APPENDIX B

Schematic Circuit Diagram

i) Schematic Circuit Diagram for transmitter and receiver



APPENDIX C

Program

i) Program for Transmitter

```
#include <16f877a.h>

#fuses HS, NOWDT, NOLVP, NOPROTECT

#device adc=10

#use delay(CLOCK=20M)

#include <lcd.c>

/#define LCD_ENABLE_PIN  PIN_D0

#define LCD_RS_PIN      PIN_D1

#define LCD_RW_PIN      PIN_D2

#define LCD_DATA4       PIN_D4

#define LCD_DATA5       PIN_D5

#define LCD_DATA6       PIN_D6

#define LCD_DATA7       PIN_D7

#define     ledA

#define     ledB

void main()

{

int32 reading,value;

lcd_init();

  //SETUP ADC PORT

  setup_adc_ports(AN0);

  setup_adc(**************);
```

```
//initialize port
   set_tris_a(0b00000001);
   set_tris_b(0b00000000);
   set_tris_c(0b10000000);
   set_tris_d(0b00000000);
   set_tris_e(0b00000000);
   delay_ms(1);
   lcd_putc(****************");
   while (true)
  {
  set_adc_channel(0);
  delay_ms(100);
  putc(**********);
  delay_ms(50);
  value = reading *500/1023;
  lcd_gotoxy (1,2);
  printf(lcd_putc, *****************************);
 delay_ms(50);
}
```

ii) Program for Receiver

```
#include <16f877a.h>                                              //use pic16f877a
#fuses HS, NOWDT, NOLVP, NOPROTECT                                //fuse setting
#device adc=10                                                    //use 10bit adc
#use delay(CLOCK=20M
#include <lcd.c


#define LCD_ENABLE_PIN  PIN_D0
#define LCD_RS_PIN      PIN_D1
#define LCD_RW_PIN      PIN_D2
#define LCD_DATA4       PIN_D4
#define LCD_DATA5       PIN_D5
#define LCD_DATA6       PIN_D6
#define LCD_DATA7       PIN_D7
#define     ledA
#define     ledB
//system variables
char myget,value;
void main()
{
lcd_init();
//setup io for each pic pin
```

```
//setup io for each pic pin
 set_tris_a(0b00000000);
 set_tris_b(0b00000000);
 set_tris_c(0b10000000);
 set_tris_d(0b00000000);
 set_tris_e(0b00000000);
 setup_port_a(NO_ANALOGS);


 delay_ms(1);
 lcd_gotoxy (1,1);
 lcd_putc("CONTROL ROOM");


   while (true)
  {
  value = myget *500/1023;
  lcd_gotoxy (1,2);
  printf(*****************);
  printf("*****************);
}
}
```