UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **EMBEDDED SENSOR NETWORKS FOR WEATHER MONITORING IN UMP PEKAN**

SESI PENGAJIAN: **2011/2012**

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EMBEDDED SENSOR NETWORKS FOR WEATHER MONITORING IN UMP PEKAN

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This thesis is submitted as partial fulfillment of the requirements for the award of the

Bachelor Degree of Electrical Engineering (Electronics)

Faculty of Electrical & Electronics Engineering

University Malaysia Pahang

JUNE, 2012

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Date : 21 JUNE 2012

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

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Date : 21 JUNE 2012

To my beloved mother and father,

Norzalina Bt Nasron and Noor Azam B. Muhammad

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In the name of Allah S.W.T, the Most Gracious, The Ever Merciful. Praise to Allah, Lord of the Universe and Peace and Prayers be upon His final Prophet Muhammad s.a.w.

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ABSTRACT

This paper presents the implementation of the event-driven Embedded Sensor Network for weather monitoring which is used for environmental monitoring using temperature and humidity sensors.The current situation in Pekan town, especially in UMP Pekan Campus is that the weather is unpredictable and can be very unstable, due to its location. UMP Pekan sits near to the river mouth of Sungai Kuala Pahang and just a few meters away from the South China Sea.Sea wind brings along hot air from the ocean to the land during the day, and brings back cold air from the land to the sea during the night. These phenomenon, together with the huge variance in the humidity parameter, would definitely affect the livelihood of people living in UMP campus. Therefore, this work would like to propose a monitoring mechanism that takes reading samples at constant rates throughout its operation.The aim is to design a system that evaluates samples only when it is triggered by an outside event, which in this rain, hot air,wind, and cold air .The objective of this paper is to develop an embedded sensor network by modifying the programs that run the sensor networks. The embedded sensor network system that will be mechanism developed has variable sampling rates with interfaces to temperature sensors and humidity sensor. The developed system would provide an applicable device that can be used in Universiti Malaysia Pahang as an

organised weather and environmental forecasting system.

ABSTRAK

Projek ini membentangkan pelaksanaan rangkaian pengesan terbenam yang didorong oleh peristiwa untuk pemantauan cuaca yang digunakan untuk pemantauan alam sekitar menggunakan situasi semasa pengesan.Suhu dan kelembapan di Bandar Pekan, terutamanya di Kampus UMP Pekan adalah tidak menentu dan boleh menjadi sangat tidak stabil, kerana kedudukannya. UMP Pekan terletak berhampiran muara sungai Kuala Pahang dan hanya beberapa meter dari angin bayu laut.Laut China Selatan membawa bersama udara panas dari lautan ke darat pada siang hari, dan membawa kembali udara sejuk dari darat itu kepada laut pada waktu malam. Fenomena ini, bersama-sama dengan perubahan besar dalam parameter kelembapan, pasti akan memberi kesan kepada kehidupan orang-orang yang tinggal di kampus UMP. Oleh itu, projek ini ingin mencadangkan satu mekanisme pemantauan yang mengambil masa membaca sampel pada kadar malar seluruh matlamat operasi.Tujuannya adalah untuk merekabentuk satu sistem yang menilai sampel yang hanya apabila ia dicetuskan oleh peristiwa yang di luar, seperti hujan , udara panas, udara angin, dan kelembapan. objektif projek ini adalah untuk membangunkan satu rangkaian pengesan tertanam dengan mengubah suai program yang menjalankan rangkaian sensor. Rangkaian pengesan tertanam ini adalah sistem yang mempunyai kadar pensampelan boleh ubah dengan menggunakan pengesan suhu dan pengesan kelembapan. Sistem yang

dibangunkan akan memberi manfaat yang boleh digunakan di Universiti Malaysia Pahang sebagai sistem ramalan cuaca yang teratur dan sistematik.

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INTRODUCTION

1.0 Background Of Project

This paper presents the implementation of the event-driven Embedded Sensor Network for weather monitoring which is used for environmental monitoring using temperature and humidity sensors.The current situation in Pekan town, especially in UMP Pekan Campus is that the weather is unpredictable and can be very unstable, due to its location.

UMP Pekan sits near to the river mouth of Sungai Kuala Pahang and just a few meters away from the South China Sea.Sea wind brings along hot air from the ocean to the land during the day, and brings back cold air from the land to the sea during the night. These phenomenon, together with the huge variance in the humidity parameter, would definitely affect the livelihood of people living in UMP campus.

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The objective of this paper is to develop an embedded sensor network by modifying the programs that run the sensor networks. The embedded sensor network system that will be mechanism developed has variable sampling rates with interfaces to temperature sensors and humidity sensor. The developed system would provide an applicable that can be used in University Malaysia Pahang as an organised weather and environmental forecasting system.

1.1 **Problem Statement**

The current situation in Pekan town, especially in UMP Pekan Campus is that the weather is unpredictable and can be very unstable, due to its location. UMP Pekan sits near to the river mouth of Sungai Kuala Pahang and just a few meters away from the South China Sea. Sea wind brings along hot air from the ocean to the land during the day, and brings back cold air from the land to the sea during the night.

These phenomenon, together with the huge variance in the humidity parameter, would definitely affect the livelihood of people living in UMP campus. Therefore, this work would like to propose a monitoring mechanism that takes reading samples at constant rates throughout its operation.

1.1.1 **Research Objective**

i. Develop An Embedded Sensor Network By Modifying The Programs That Run The Sensor Networks.

1.1.2 Scope Of Project

i. Determine the area covered by the network
ii. Determine the number of sensor nodes needed to be placed in the network.
iii. Identify the type of sensor used.

1.2 Overview of this Project

This part of introduction provides the work frame of the project. This project consists of five chapters including the introduction.

Chapter 2 holds discussion about the literature review or the past research of this project.

Chapter 3 involves the methodology of the project. The sensor chosen is then applying to embedded sensor network.

Chapter 4 is about the result and discussion about the projects. The result obtain of the display is then discuss on that chapter.

Chapter 5 is about future work and recommendations on how far this project can go further.

1.3 **Summary of chapter.**

In this modern world, most of the systems in the world especially in our country, Malaysia have been developed by experts in their own specific areas for the better quality of life for everyone in this planet. Due to this factor, we can now predict and forecast the weather anywhere on the earth. So with the development of this technology such as the embedded sensor network for weather forecasting will ensure the quality of life will be fine. To achieve this objective, we come out with an idea to build and develop a prediction system that can guarantee a better weather forecasting approach.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, it will aims to review the critical points of current knowledge and or methodological approaches that this project want to develop. This Literature reviews are secondary sources, and as such, do not report any new or original experimental work.

2.1 Embedded Sensor Network ([1] ,[2], [3])

An embedded sensor network is a network of embedded computers placed in the physical world that interacts with the environment. These embedded computers, or sensor nodes, are often physically small, relatively inexpensive computers, each with some set of sensors or actuators. These sensor nodes are deployed in situ, physically placed in the environment near the objects they are sensing. Sensor nodes are networked, allowing them to communicate and cooperate with each other to monitor the environment and (possibly) effect changes to it.

Current sensor networks are usually stationary, although sensors may be attached to moving objects or may even be capable of independent movement. These characteristics: being embedded, being capable of sensing, actuation, and the ability to communicate, define the field of sensor networking and differentiate it from remote sensing, mobile computing with laptop computers, and traditional centralized sensing systems. Although research in sensor networks dates back to the 1990s or earlier, the field exploded around the year 2000 with the availability of relatively inexpensive (sub-$1000) nodes, sensors, and radios. As of 2004, sensor networking is a very active research area with well-established hardware platforms, a growing body of software, and increasing commercial interest. Sensor networks are seeing broader research and commercial deployments in military, scientific, and commercial applications including monitoring of biological habitats, agriculture, and industrial processes.

Sensor networks present challenges in three key areas. First, energy consumption is a common problem in sensor network design. Sensors are often battery operated and placed in remote locations, so any activity drains the sensor battery, and bringing the node closer to death.3 Second, how sensors sense and interact with the physical world is of great interest. Sensor networks focus on collaborative signal processing algorithms to exploit multiple, physically separate views on the environment. Finally, with tens, hundreds, or even thousands of sensor nodes, the network and applications as a whole must be self-configuring.

2.2 Wireless Sensor Network ([4],[5],[6],[7],[8],[9])

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.[4][5]

The WSN is built of nodes from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting.[6][7]

A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes"(demo video) of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.[8][9]

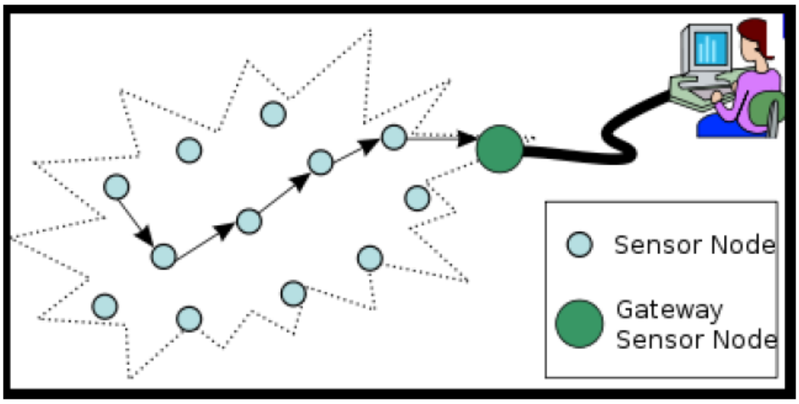

Figure 2.1 :Typical multi-hop wireless sensor network architecture

2.3 Environmental Monitoring [23]

Environmental Monitoring is a typical application for Wireless Sensor Network. The potential benefits of monitoring the environments for example the office environment are to increase the comfort of office workers, employers adhering to health and safety regulations and thus increase the performance, efficiency and productivity of staff [23].

2.3.1 Relative Humidity and Its Effects to Environment

Temperature and humidity can have a significant impact on how alert or tired somebody might feel. This, in turn, can have a dramatic effect on the performance of workers. In hot environments, it is not uncommon for staff to become irritable and less efficient. Humidity can be measured in several ways, but Relative Humidity is the most common. In order to understand relative humidity, it is helpful to first understand absolute humidity. Absolute Humidity is the mass of water vapour divided by the mass of dry air in a volume of air at a given temperature. The hotter the air is, the more water it can contain. Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity which depends on the current air temperature. A reading of 100 percent relative humidity means that the air is totally saturated with water vapour and cannot hold any more, creating the possibility of rain. This doesn't mean that the relative humidity must be 100 percent in order for it to rain. It must be 100 percent where the clouds are forming, but the relative humidity near the ground could be much less.

High Humidity Levels increase our susceptibility to high temperature levels as evaporation of body sweat is impeded. Low Humidity Levels has a debilitating effect on our ability to breathe and swallow without discomfort as our mouths and noses can become dry due to the increased level of evaporation in the surrounding environment. Humans are very sensitive to humidity, as the skin relies on the air to get rid of moisture. The process of sweating is your body's attempt to keep cool and maintain its current temperature. If the air is at 100-percent relative humidity, sweat will not evaporate into the air. As a result, we feel much hotter than the actual temperature when the relative humidity is high. If the relative humidity is low, we can feel much cooler than the actual temperature because our sweat evaporates easily, cooling us off. People tend to feel most comfortable at a relative humidity of about 45 percent. Humidifiers and dehumidifiers help to keep indoor humidity at a comfortable level .[23]

2.3.2 Temperature and Its Effects to Environment [23]

An ergonomics study by the Cornell Institute in the US concluded that there were definitive links between the efficiency/productivity levels of workers and the environmental conditions in offices. Although by no means completely representative of all kinds of environments and all type of industry, the research concluded that higher temperatures (in the region of 24-25ºC) resulted in fewer keyboard errors than occurred at temperatures of around 19ºC. In other words, colder workers could mean more errors and therefore higher costs for the employer. In high temperature level, the employee lethargy and tiredness increased as a result of increased body temperature leading to possible efficiency decreases.Meanwhile, low temperature environment will decreases staff efficiency due to cooler body heat and shivering.[23]

2.4 Application of Wireless sensor Network ([10])

The number of potential application for wireless sensor networks is huge. Actuators may also be included in the sensor network, which makes the number of applications that can be developed much higher. In this section, some example applications are given to provide the reader with the better insight about the potentials of wireless sensor networks.[10]

Military Applications:

Wireless sensor networks can be an integral part of military command, control, communications, computers, intelligence, surveillance, reconnaissance and tracking systems. The rapid deployment, self organization and fault tolerance characteristics of the sensor networks make them a very promising sensing technique for military. Since sensor networks are based on the dense deployment of disposable and low cost sensor nodes, destruction of some nodes by hostile actions does not affect a military operation as mush as the destruction of a traditional sensor. Some of the military applications are monitoring friendly forces, equipment and ammunition, battlefield surveillance, reconnaissance of opposing forces and terrain, targeting, battle damage assessment, and nuclear, biological and chemical attack detection and reconnaissance.[10]

Environmental Application:

Some environmental applications of the sensor networks include tracking the movements of species, i.e., habitat monitoring, monitoring environmental conditions that affect crops and livestock, irrigation, macro instruments for large-scale Earth monitoring and planetary exploration, and chemical/ biological detection.

Commercial Application:

The sensor networks are also applied in many commercial applications. Some of them are building virtual keyboards, managing inventory control, monitoring product quality, constructing smart office spaces and environmental control in office buildings.

2.5 Challenges in WSN([20],[21],[22])

Once WSN is deployed, normally sensor nodes are leave unattended. This leaves the sensor nodes and a dependent power source which will dies out over time. So it is important for sensor nodes to have a very reliable power source to prolong its network lifetime. Imagine if the nodes are place in the enemy line for battlefield surveillance and its power unit can only power up the sensor nodes for a few days, it definitely would be an unreliable system. Energy management has been a major focus on development of WSN for the past few years and alternative energy source has been introduced such as solar panel and piezoelectric transducer to power the sensor nodes . But this alternative energy source works in certain condition only. For example, solar panel needs to have sunlight to convert light to useful energy and piezoelectric need to have vibration. More techniques and protocols involving energy management will be later discussed in the next section.

On certain applications, data collected by sensor nodes are highly sensitive especially in military applications and other government applications. This has brought another issue in WSN which is security. WSN is a special network which has many constraints compared to a standard computer network. Due to these constraints, it is not possible to directly employ the existing security approaches to the area of WSN . The main aspects in security are data confidentiality which to avoid omission of data leaks to neighbouring networks, data authentication for verification of sender and receiver, data integrity to ensure data are not altered during transmission and lastly data freshness is to guarantee data is recent while allowing for delay estimation.

2.6 Universal asynchronous receiver/transmitter (UART) ([4],[5],[6],[7],[13])

A universal asynchronous receiver/transmitter is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with communication standards such as EIA RS-232, RS-422 or RS-485. The universal designation indicates that the data format and transmission speeds are configurable and that the actual electric signalling levels and methods (such as differential signalling etc.) typically are handled by a special driver circuit external to the UART.

A UART is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. A dual UART, or DUART, combines two UARTs into a single chip. Many modern ICs now come with a UART that can also communicate synchronously; these devices are called USARTs (universal synchronous/asynchronous receiver/transmitter).

A UART usually contains the following components:

i. a clock generator, usually a multiple of the bit rate to allow sampling in the middle of a bit period.

ii. input and output shift registers

iii. transmit/receive control

iv. read/write control logic

v. transmit/receive buffers (optional)

vi. parallel data bus buffer (optional)

vii. First-in, first-out (FIFO) buffer memory (optional)

2.7 C language Programming ([14])

C programming language as it applies to embedded microcontroller applications. This programming needed programmer to declaring variables and constant do loops, testing the logic analyser. In c programming there are several types of loops. Next, the important part is software to interface with PIC. Software used is C programming. C compiler is software to write, simulate and burn the program into PIC.

To ensure written programming worked or not, it can combine with software Proteus. From this software, program can be simulating with circuit.[14]

2.8 ZigBee ([15],[16],[17])

Article [15]

Fred Eady is specially described about XBee. In this article, all the information about XBee is stated. The family of XBee, the pin connection, the way XBee can be interface with other product. In this article also explain the suitable microcontroller that can be interface with XBee.[15]

Article [16]

In this article, Fabrice André is specially described about XBee. In this article, it contains the pin description, the software that is used to setup the XBee, the explanation of internal of the XBee, and the comparisons between other wireless devices. In this article, the author explains more information about the software of the XBee. [16]

Article [17]

Fabrice André is specially described about the interfacing of XBee with computer. In this article, it explains more to the hardware of XBee. It explains the limitation of current that can flow in the XBee module. [17]

2.8.1 ZigBee Protocol[24]

ZigBee is a protocol that uses the 802.15.4 standard as a baseline and adds additional routing and networking functionality. The ZigBee protocol was developed by the ZigBee Alliance. The ZigBee Alliance is a group of companies that worked in cooperation to develop a network protocol that can be used in a variety of commercial and industrial low data rate applications. ZigBee is a type of LR-WPAN technology and is built upon the lower layers of the IEEE 802.15.4 LR-WPAN standard. While the 802.15.4 standard defines the lower-level Physical (PHY) and Media Access Control (MAC) layers, the ZigBee standard defines the higher-level Network and Application layers as well as the security services .[24]

2.8.2 Technology Overview

The 802.15.4 is a standard for wireless communication put out by the Institute for Electrical and Electronics Engineers (IEEE). The IEEE is a technical professional association that has put out numerous standards to promote growth and interoperability of existing and emerging technologies. The 802.15.4 standard allows for communication in a point-to-point or a point-to-multipoint configuration. Mesh networking is used in applications where the range between two points may be beyond the range of the two radios located at those points, but intermediate radios are in place that could forward on any messages to and from the desired radios. For example, in the figure below suppose we wanted to transmit data from point A to point B, but the distance was too great between the points. The message could be transmitted through point C and a few other radios to reach the destination.

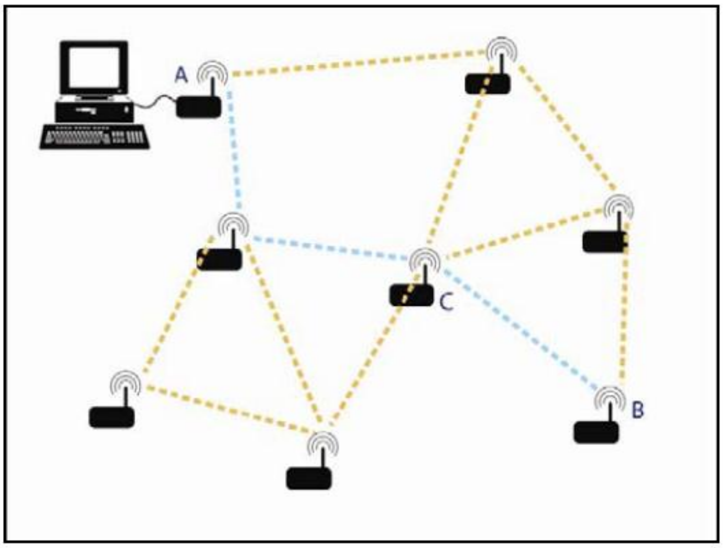

Figure2.2 : Mesh Networking

	ZigBee & 802.15.4	GSM/GPRS CDMA	802.11	Bluetooth
Focus Application	Monitoring and Control	Wide area voice and data	High-speed internet	Device connectivity
Battery Life	Years	1 week	1 week	weeks
Bandwidth	250kbps	up to 128k	11Mbps	720kbps
Typical Range (meters)	100+	Several Km	50-100	10-100
Advantages	Low power, Cost	existing infrastructure	Speed, Ubiquity	Convenience

Figure 2.3 : Comparison between RF protocols

ZigBee was designed for low power applications so it fits well into embedded systems and those markets where reliability and versatility are important but a high bandwidth is not. Figure above offers a comparison of features with several other popular wireless technologies and their different applications. The lower data rate of the ZigBee devices allows for better sensitivity and range, but of course offers fewer throughputs. The primary advantage of ZigBee lies in its ability to offer low power and extended battery life.

2.8.3 IEEE 802.15.4 Standard [25]

ZigBee standard is built on the lower layers defined by the IEEE 802.15.4 standard. From Figure below, the top layer in the system model is where the customer application resides. In terms of general functionality, the Physical Layer provides the basic radio communication capabilities, the MAC Layer provides reliable single-hop transmission, and the Network Layer provides routing and multi-hop transmission for creating more complex topologies. The Application Layer provides device and network management functions as well as message formats.[25]

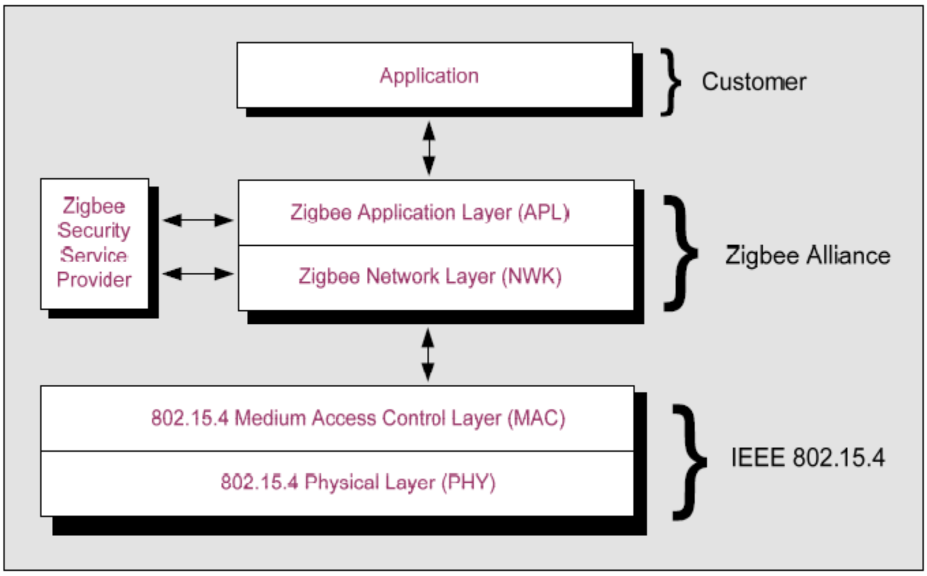

Figure 2.4: The Zigbee Layered model

The 802.15.4 lower layers provide the basic capabilities for LR-WPAN devices such as ZigBee nodes to join a network and send data to a neighboring device, but they do not provide the enhanced functionality for creating more complex multi-hop routed network topologies, nor the device and network management services needed for developing higher-level applications. The role of the ZigBee standard is to define the higher-layer network and application services that build upon the 802.15.4 wireless transmission capabilities to enable the development ofcomplete LR-WPAN systems .

2.8.4 Interface ZigBee [18]

This datasheet is for XBee and XBee Pro. From this datasheet, all the internal connection of XBee is stated. The key feature, specification, RF module operation, ADC and digital I/O line support, network, addressing and mode operation all given in this datasheet.[18]

2.9 PIC16F877A [19]

This reference book is important for students that need a guideline to learn PIC individually. Chapter 1 discusses the history of the PIC 16 and features of other PIC family members such as the PIC 18. It also provides a list of various members of the PIC 16 family. Chapter 2 discusses the internal architecture of the PIC 16 and explains the use of a PIC 16 assembler to create ready-to-run programs. It also explores the stack and the flag register. In chapter 3 the topics of loop, jump, and call instruction are discussed, with many programming example. Chapter 4 is dedicated to the discussion of I/O ports. This allows students who are working on a project to start experimenting with PIC 16 I/O interfacing and start the project as soon as possible. Chapter 5 is dedicated to arithmetic, logic instruction and programs.[19]

2.10 Summary of the chapter

From past research, the projects seemed did not bring much improvement towards the progression of this technology. If the automatic system is controlled by a microcontroller, the system would be able to generate output with good results.

By using PIC 16F877A, we can improve the system to operate with faster speed and greater efficient output. We also would able to achieve more advantages in terms of lower cost, higher productivity, longer lifespan, easy maintenance and easily upgradable to higher version. by implement this project in order to have advance embedded sensor network..

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction of Embedded Sensor Network

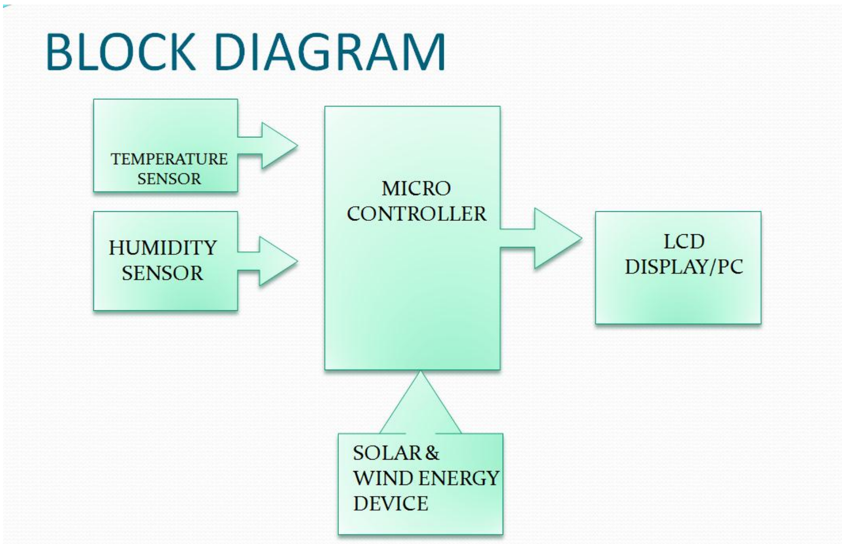

Figure 3.1 :Embedded Sensor Network System

This chapter will explain the research methodology developed for this project.Figure 3.1 shows the block diagram of a wireless sensor network platform. It is divided into two parts which are sensor node and end node. The objective and scope of this project are focused on developing an embedded sensor network by utilizing and modifying available programings that can be used to run the sensor networks.

This project also consist of hardware and software system development and they are designed based on the figure shown above. The hardware system consists of temperature sensors and a humidity sensor withelectronic measurement setup. The programming for the microcontroller unit or Peripheral Interface Controller (PIC) and the display will be implemented in the software part of the system. To develop the sensor node, several type of different components are used such as sensors, PIC and transceivers, while components forthe end node are receivers , PIC and LCD display.

3.1 Project overview

In this project overview, briefly discussions of the overall project design including the workflow of activities, device design and program development will be explained. Initial construction of circuit is done by communicate between two zigbee by using computer. After communicate two zigbee, connect the zigbee with PIC16F877A and communicate to each other again. Test whether the two Zigbees can communicate to each other to make sure the communication between transmitter medium will run successful before other component attach to the system. The software development and board kit includes the programming of the PIC16F877A, which interface to all the hardware part. A set of instruction code is written to indicate the microcontroller performs the function required. In the interfacing stage, hardware and software work together as a complete system as figure 3.1.

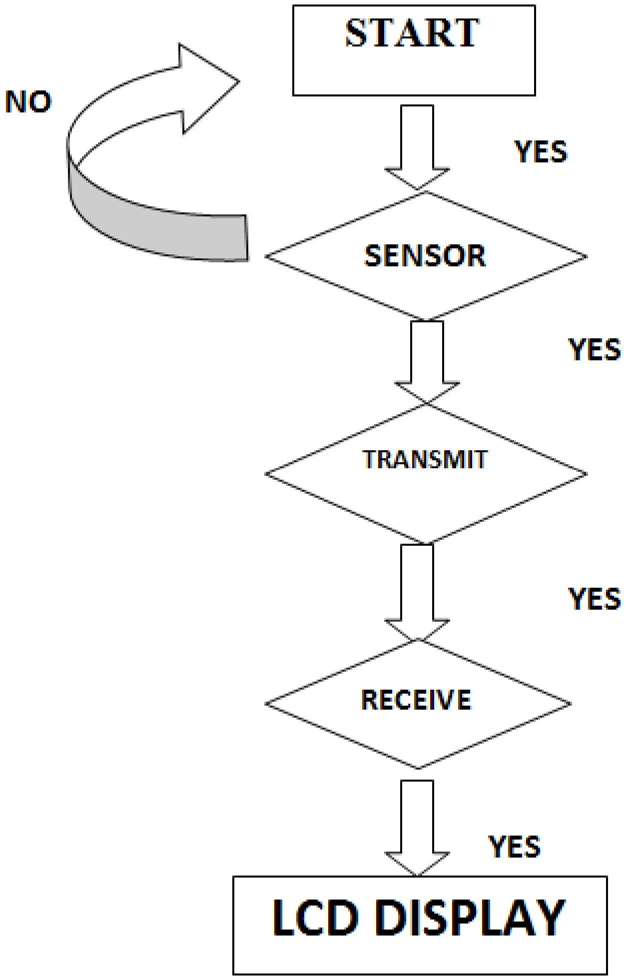

Figure 3.2 is basically shown how the project will goes step by step until collecting the data.

3.1.1 Block Diagram

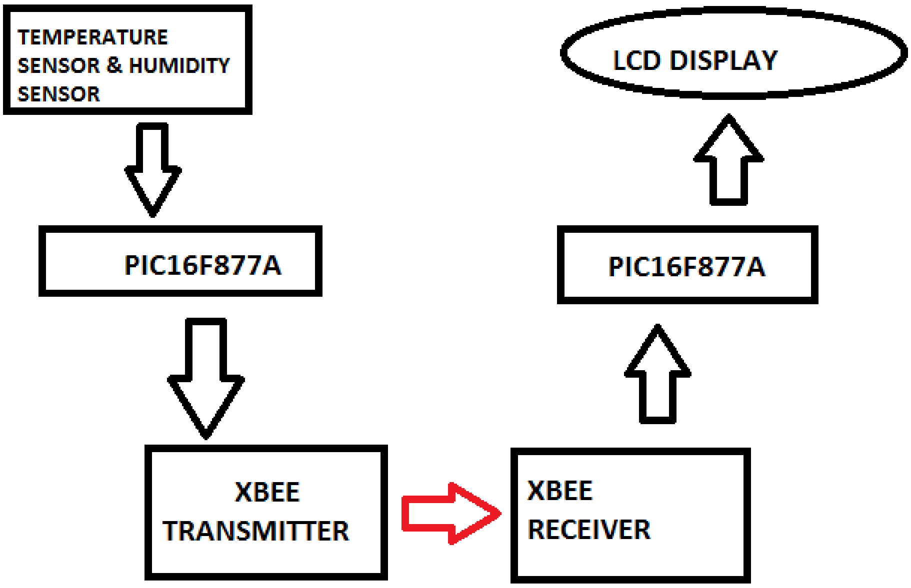

Figure 3.3: Block Diagram

From the block diagram in figure 3.3, the left parts represent the receiver part and the right part represents the receiver part. First of all, sensors which are temperature and pH sensor will be setup in the experimental area. Data from sensors will be collected and sent to the zigbee transmitter which is wireless device that will be used to send the data. To send data, zigbee need to be connected with PIC16F877A which is type of microcontroller on the same board that called transmission board. PIC16F877A has been programmed by using micro c program that can read the data. It also converts to data from analog signal to digital signal zigbee transmitter can read the data in digital form. In this project, PIC16F877A acts as an interface between zigbee circuit and sensor circuit. Then, Zigbee module at transmitter part will pass the data to zigbee module at receiver part and the data will be sent to LCD display.

3.2 Hardware and Development

3.2.1 Microcontroller

The type of microcontroller that the system used is PIC 16F877A. The PIC served as the brain of the system.

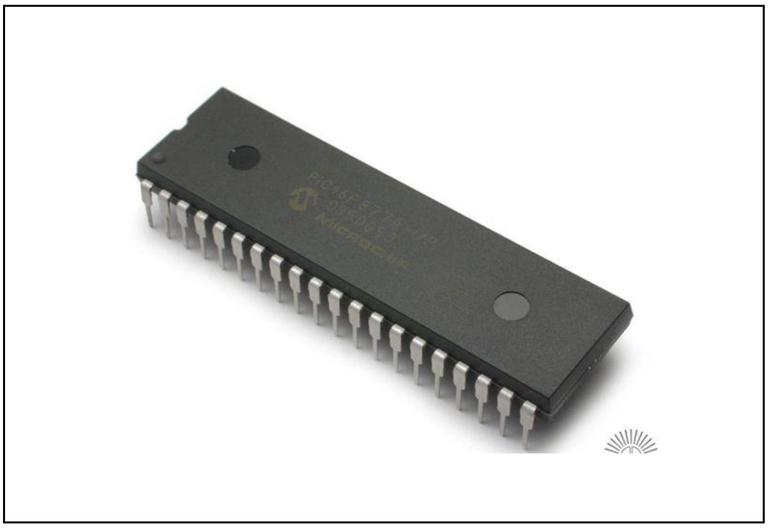

Figure 3.4: PIC 16F877A microcontroller

PIC can read/write program for more than 100,000 times. The PIC can store up to 8Kbytes program. The programming code is downloaded into PIC through a PIC programmer. This program will be used to operate the system. The PIC can operate using 4.5V to 6V DC voltage. In this project the operating is at 5V (by using 7805). It is DIP layout (dual in line package). The digital output of the PIC is 5V (for signal 1) and 0V (for signal 0); these signals will be directly connected to actuators for control purpose. When the PIC pin is set as digital input, it will detect input voltage 5V as signal 1 and 0V as signal 0. Any voltage less than 0V or more than 5V can damage the PIC. Microcontroller has a bidirectional input and output while the PLC is a single direction of input and output. Furthermore, the microcontroller has low powerconsumption, high speed, and low cost. It is also has a small layout, and has analog to digital converter with serial I/O port. Other than that, it also has Ram and ROM, a PWM controller and USB peripherals. For PIC16F877A, it means that this microcontroller is in the PIC family, and is in the 16 series with 14 bit. Other specification are such as it has a maximum frequency of 20MHz a maximum number of pin (40pins) and has 8Kbytes of space for maximum program memory. The overview of this PIC is exibited in Figure 3.5.

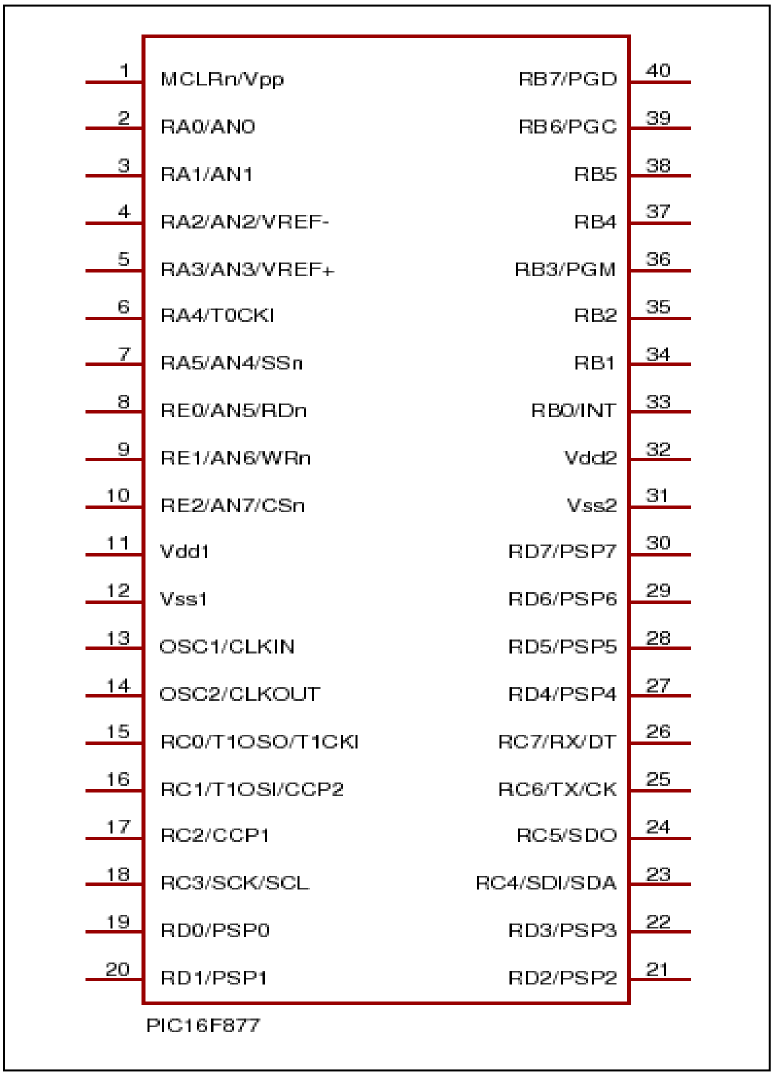

Figure 3.5: Pin Diagram for PIC16F877A

3.2.2 Transceiver

Figure 3.6 Xbee RF module

Xbee RF module is a wireless device that is used for transmitting and receiving data from sensor node to end node. Figure 3.6 presents the Xbee RF module. It has twenty pins. Each pins has its own function which is shown at Table 3.1

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

Table 3.1: Pin Assignments for the Xbee PRO

The XBee RF Modules interface is connected 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.

Devices that have a UART interface can connect directly to the pins of the RF module.

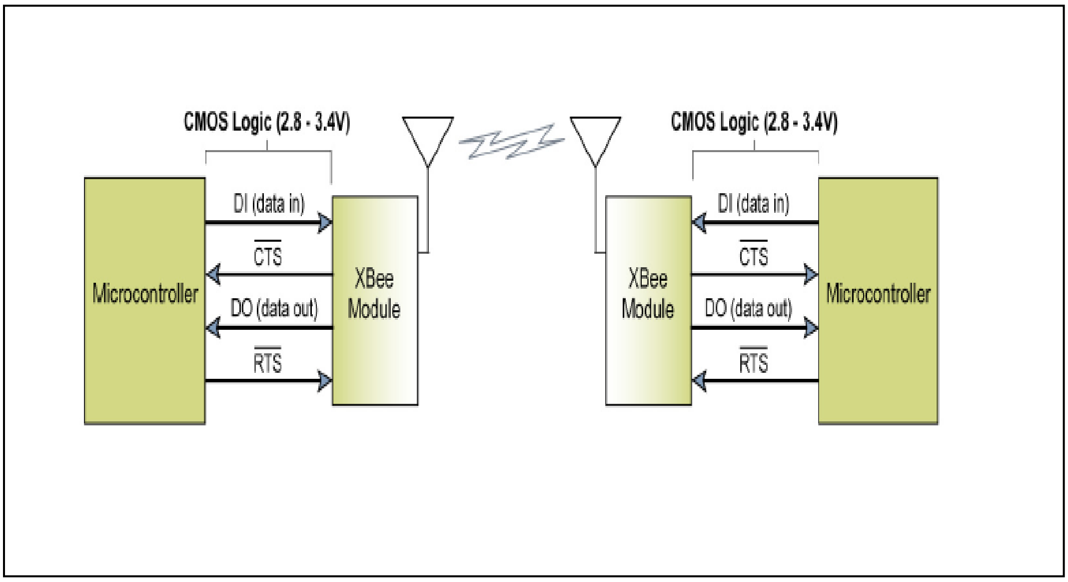

Figure 3.7: System Data Flow Diagram in a UART - interfaced environment

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. From the Figure 3.7, if the module cannot immediately transmit (for instance, if it is already receiving RF data), the serial data is stored in the DI Buffer. The data is pocket-sized and sent at any RO timeout or when 100 bytes (maximum packet size) are received. If the DI buffer becomes full, hardware or software flow control must be implemented in order to prevent overflow (loss of data between the host and module).

Included in a Xbee packet are Xbee header (Figure 3.8), payload and checksum. For the Xbee header, it consists of delimiter, data length, API, frame ID, broadcast and option. Xbee header is appended from the network packet.

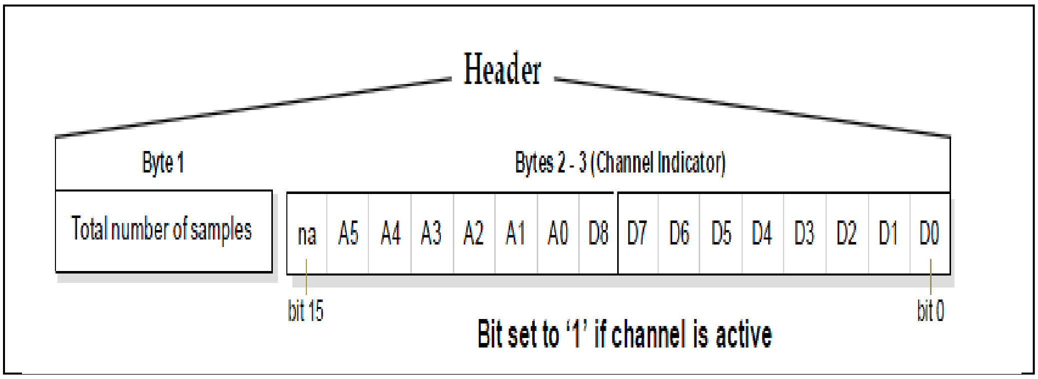

Figure 3.8 :Xbee Header

3.2.3 Temperature Sensor

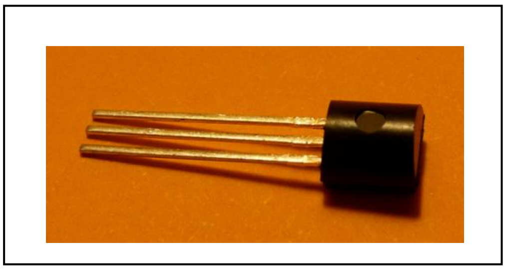

Figure 3.9: LM35 Temperature Sensor

LM35 Temperature Sensor is a sensor that is used in this project. This sensor will produce measurable responses to a change in environment condition, in this case the temperature measurement. The LM35 series are precision integrated-circuit LM35 temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 sensor thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 sensor does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only

60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to +150°C temperature range, while the LM35C sensor is rated for a -40° to +110°C range (-10° with improved accuracy).

3.2.4 Humidity Sensor

Figure 3.10 SN-HMD humidity sensor

The SN-HMD humidity and temperature module from Cytron technology isused as the sensor for WiSNEM. The humidity sensor in SN-HMD is HSM-20G and consist of a special plastic material whose electrical characteristic change according to the amount of water vapor in air. The module of HSM-20G can be use to converted the analog signal to standard voltage output. Figure 3.10 show SN-HMD humidity sensor.

3.2.5 Energy Device For Embedded Sensor Network

9V Battery

9V battery uses a 9 volt alkaline battery to provide power to the sensor node. The battery has both the positive and negative terminals on one end. The negative terminal is fashioned into a snap fitting which mechanically and electrically connects to a mating terminal on the power connector. The power connector has a similar snap fitting on its positive terminal which mates to the battery. This makes battery polarization obvious since mechanical connection is only possible in one configuration. One problem with this style of connection is that it is very easy to connect two batteries together in a short circuit, which quickly discharges batteries, generating heat and possibly a fire. The wiring usually uses black and red wires, red for positive. Battery behaviors as a function of the acoustic transmit and receive power. Long periods of autonomous operations in remote environments will need battery or other renewable energy sources. In order to prolong battery life, all node hardware and software functions are designed to consume minimal power.

Solar Energy

The typical PV stand-alone system consists of a solar array and a battery connection as shown in Figure 2.3. The array powers the load and charges the battery during daytime. The battery powers the load after dark. The inverter converts the DC power of the array and the battery into 60 or 50 Hz power. Inverters are available in a wide range of power ratings with efficiency ranging from 85 to 95 percent. The array was segmented with isolation diodes for improving the reliability. In such designs, if one string of the solar array fails, it does not load or short the remaining strings. Multiple inverters, such as three inverters each with 35 percent rating rather than one with 105 percent rating, are preferred. If one such inverter fails, the remaining two can continue supplying essential loads until the failed one has been repaired or replaced.

Wind Energy

A simple stand-alone wind system using a constant speed generator is shown in Appendix A. It has many features similar to the PV stand-alone system. For a small wind system supplying local loads, a permanent magnet DC generator makes a wind system simple and easier to operate. The induction generator, on the other hand, gives AC power. The generator is self excited by shunt capacitors connected to the output terminals. The frequency is controlled by controlling the turbine speed. The battery is charged by an AC to DC rectifier and discharged through a DC to AC inverter.

3.2.6 Sensor node

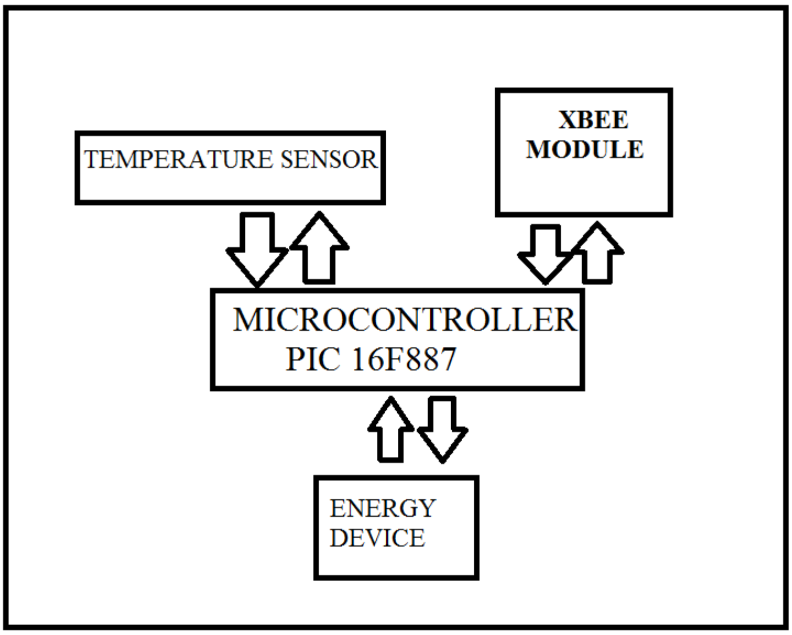

FIGURE 3.11: SENSOR NODE

Figure 3.11 shows the component of the sensor node which consist of a pic microcontroller, an energy device , a sensor, and transceiver.

3.2.7 End node

End node is developed for collecting and receiving data measurements which are the temperature measurements from sensor node. Figure 3.12 shows blockdiagram of the end node, consists of transceiver,PIC microcontroller, energy device and LCD display.

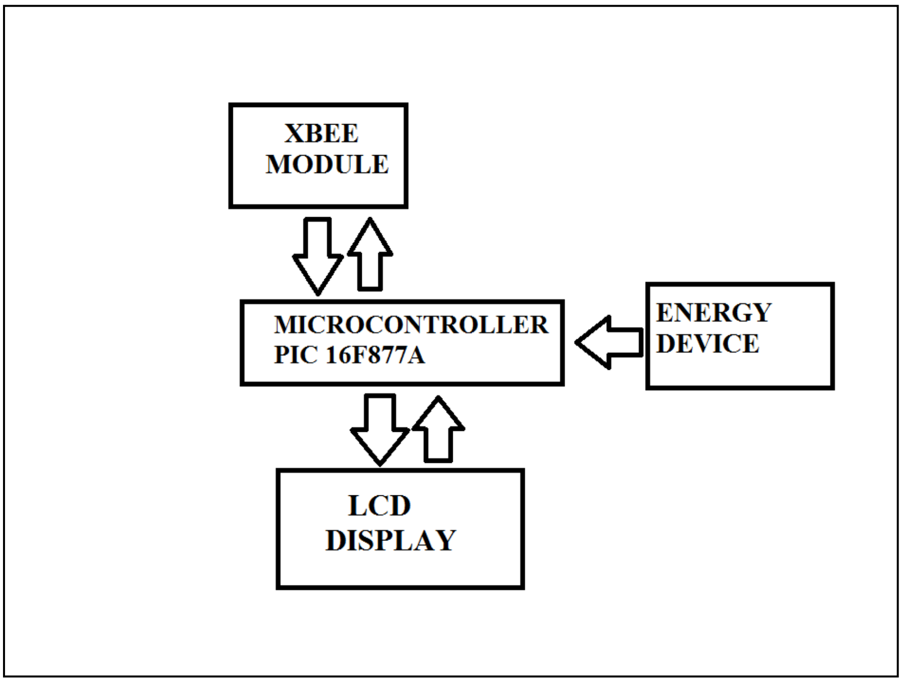

Figure 3.12: Block diagram of end node

3.2.8 LCD

Liquid Crystal Displays or known as LCD, utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current that passes through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light. The most commonly used alphanumeric displays are 1x16 (single line and 16 characters), 2x16 (double line and 16 characters per line) and 4x20 (four lines and twenty characters per line).

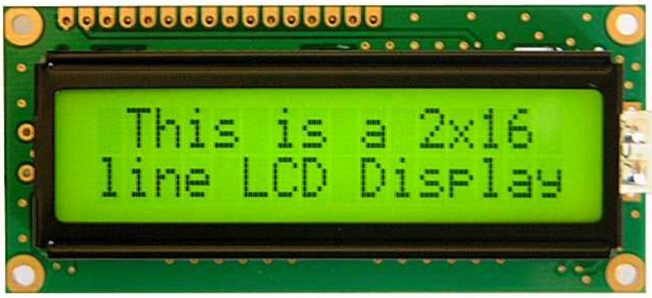

Figure 3.13: LCD Display

The 2x16 character LCD based on the HD44780 controller are a commonly used for display purposes inthe microcontroller project. There is a simple way to include the use of LCD in a project when developing with C18. The pin configuration for the port used for Data, RW, RS and EN pin, interface methods (4bit or 8bit) can be selected. Beside that there are 2 modes that can be selected to drive the LCD.

3.3 Software System

The Software system consist of code programming for the microcontroller to display the data from the sensor network on the LCD display.The result will be displayed in statistical approach (graph and table). Software Design is the important chapter that have significant role on overall system performance. There are three software has been used in the overall project and two main software that really contribute to the system performance are the Proteus 7 Professional and X-CTU software. PICkit 2 Programmer used as the platform to write C programming code, compile it to hex code and finally load it to PIC16F877A microcontroller. Proteus 7 Professional is used to run the software simulation and designing the circuit . Finally, the X-CTU software is used as a tool for Xbee initialization and data reliability checking at the end user PC.

3.3.1 Proteus 7.6

Proteus is a software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. It is developed by Labcenter Electronics. The XGameStation Micro Edition was designed using Labcenter's Proteus schematic entry and PCB layout tools. Proteus was the first product to bridge the gap between schematic and PCB for embedded design, offering system level simulation of microcontroller based designs inside the schematic package itself. Over ten years later, Proteus is still leading the field with more microcontroller variants and peripherals than any competing product, better debugging tools and instruments and a consistent focus on innovation.

Figure 3.14 logo of Proteus

3.3.2 C Compiler

C programming language as it applies to embedded microcontroller applications. This programming needs the programmer to declare\all variables and constanty exercises loopings, in order to test the logic analyzer. . The next important part is the interface between the software andthe PIC.

C compiler is a software that can be used to write, simulate and burn the program into PIC. To ensure the written programming works , it can be combined with the software Proteus and the program codes can be simulated together with the circuit.

3.3.3 PICkit 2 Programmer

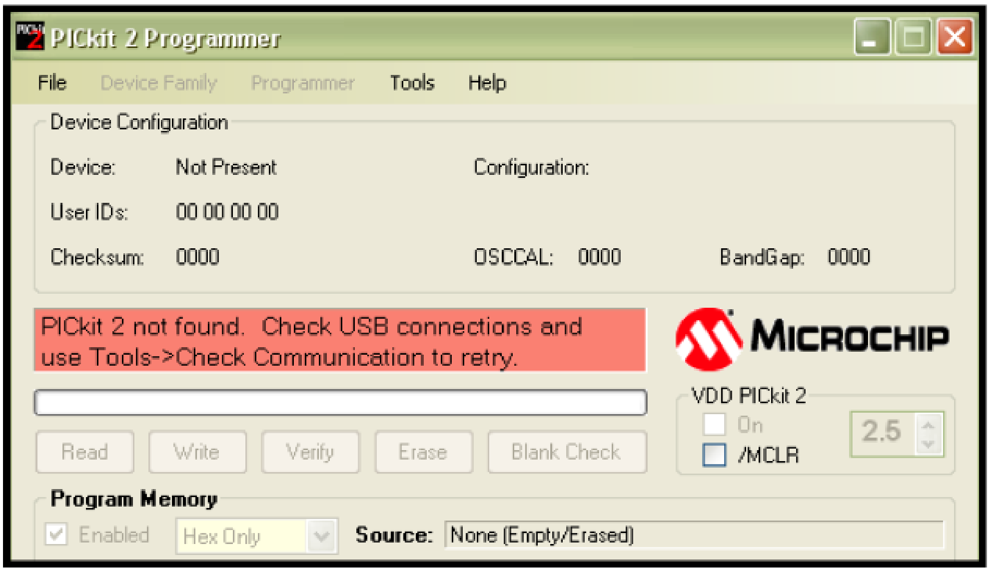

Figure 3.15: PICkit 2 Programmer

The PICkit 2 Development Programmer/Debugger is a low-cost development tool with an easy to use interface for programming and debugging Microchip's Flash families of microcontrollers. The full featured Windows® programming interface supports baseline (PIC10F, PIC12F5xx, PIC16F5xx), midrange (PIC12F6xx, PIC16F), PIC18F, PIC24, dsPIC30, dsPIC33, and PIC32 families of 8-bit, 16-bit, and 32-bit microcontrollers, and many Microchip Serial EEPROM products. With Microchip powerful MPLAB Integrated Development Environment (IDE) the PICkit 2 enables in-circuit debugging on most PIC microcontrollers. In- Circuit-Debugging runs halts and single steps the program while the PIC microcontroller is embedded in the application. When halted at a breakpoint, the file registers can be examined and modified.

3.4 Summary of the chapter

This chapter focuses on the methodology process of the hardware development in order to make the project is a successful. The hardware development focuses more on the circuitry of the transceiver module. While the software development focuses more on writing the programming codes, which then will be uploaded into the PIC microcontroller.

CHAPTER 4

RESULT AND ANALYSIS

4.0 Introduction

In this chapter, final results of the project will be put forward starting off with the block diagram until the end. This chapter will be divided into parts such as testing and system maintenance, Xbee module, interfacing LCD modules with PIC microcontrollers, interfacing sensors with PIC microcontroller and data compilation temperature and humidity. The data received at the end user will be processed and analyzed, and the final result will be displayed in statistical approach (graph and table) on the display panel.

4.1 Testing Xbee module by using SKXBEE board.

4.1.1 Transmitter

PC is use to test the Xbee module communication. The X-CTU software is used to configure the xbee module. When it appear as in Figure 4.1, click on the com port 10 .This first Xbee is function as transmitter .

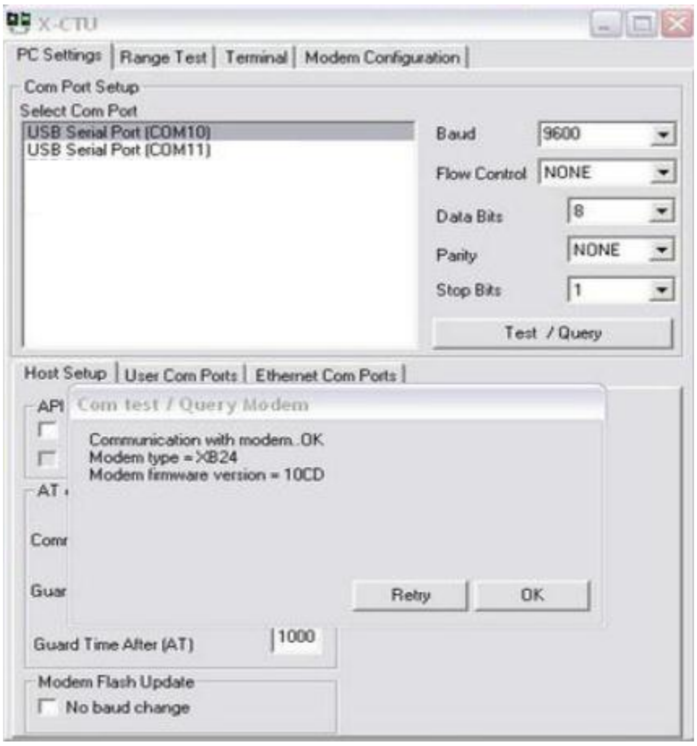

Figure 4.1: Testing zigbee connection using PC

After that, go to modem configuration to check the version and address of the Xbee . Put the value 2222 at destination address low and 1111 at 16-bit source address as shown in figure 4.2.

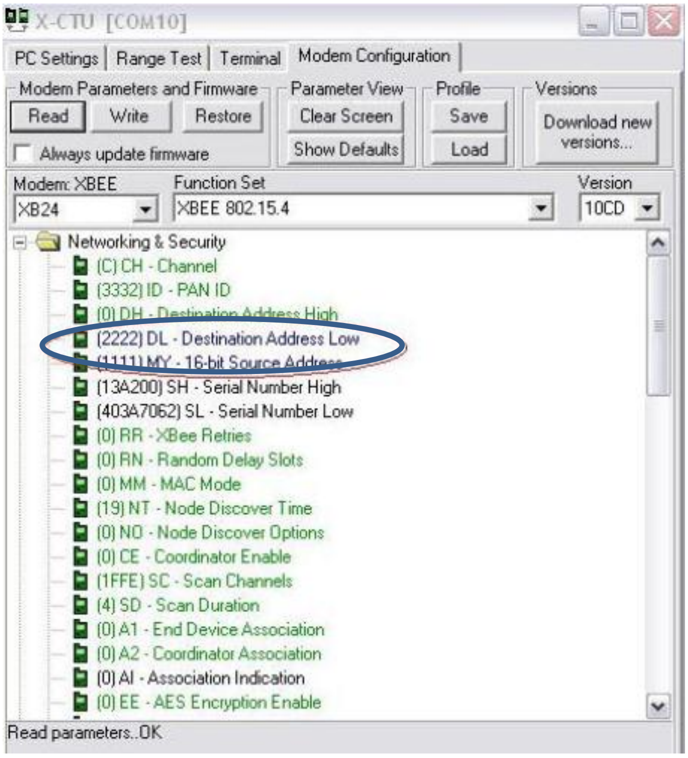

Figure 4.2: X-CTU configuration mode for transmitter

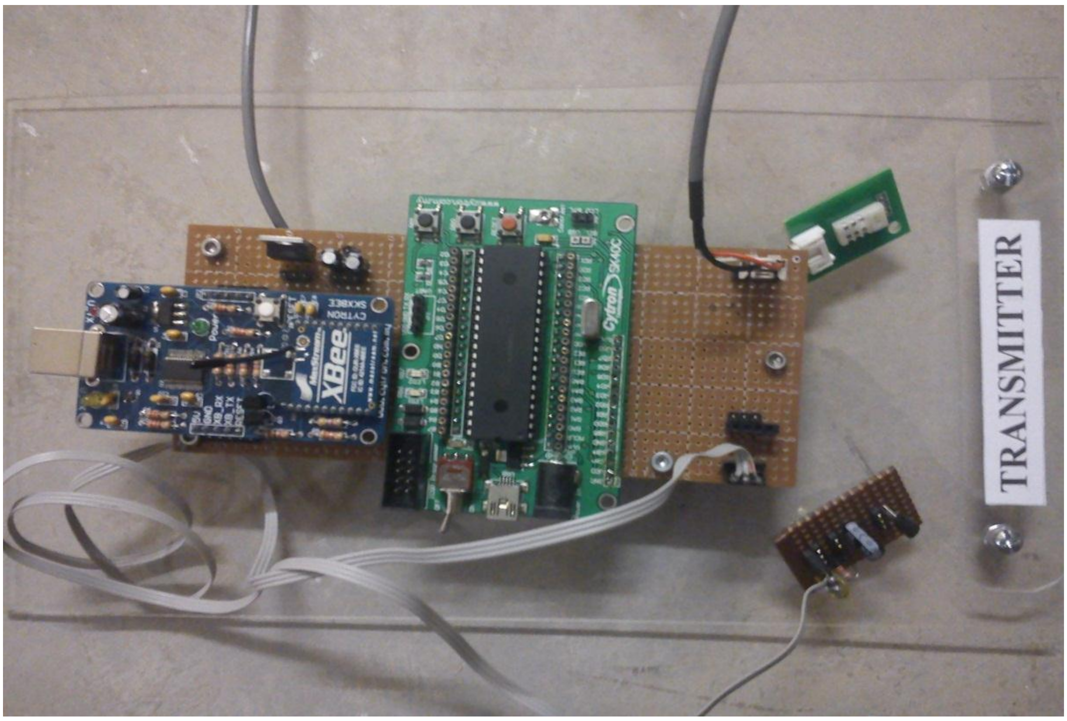

Figure 4.3 : Transmitter Part of The Circuit

4.1.2 Receiver

PC is use to test the Xbee module communication. The X-CTU software is used to configure the xbee module. When it appear as in Figure 4.4, click on the com port 11 .The second Xbee is function as receiver .

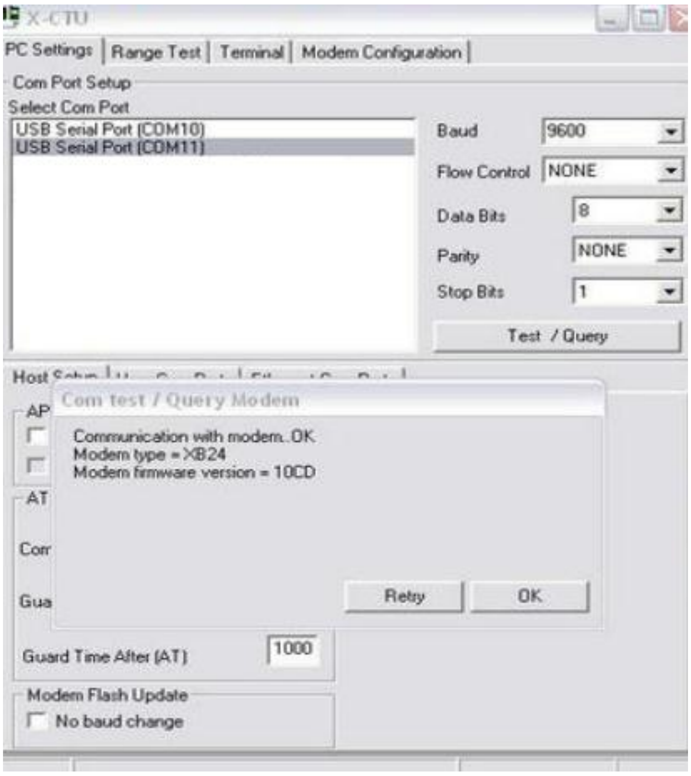

Figure 4.4: Testing zigbee connection using PC

After that, go to modem configuration to check the version and address of the Xbee . Put the value 2222 at 16-bit source address and 1111 at destination address low as shown in figure 4.5.

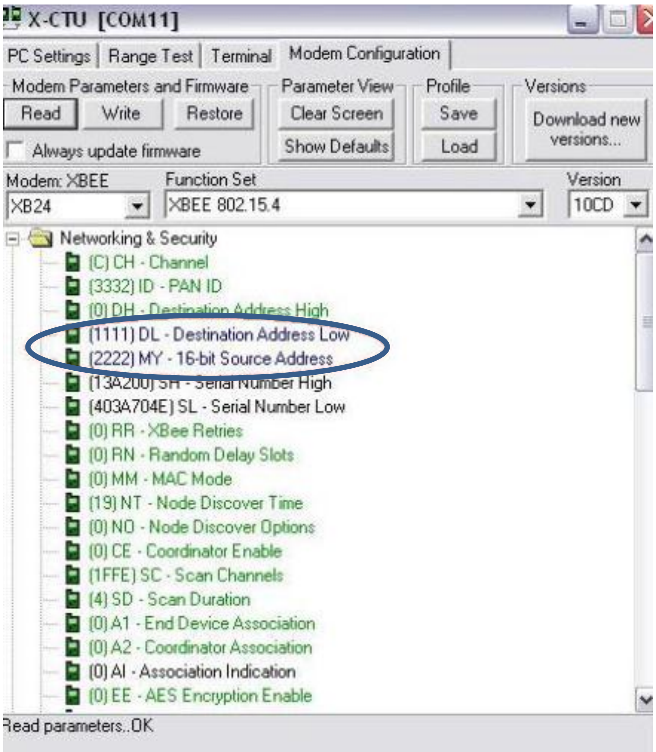

Figure 4.5: X-CTU configuration mode for receiver

After the moderm is connected to each other, try test the terminal bar to see the flow of communication. The blue colour represents the transmitted data while the red colour represents received data.

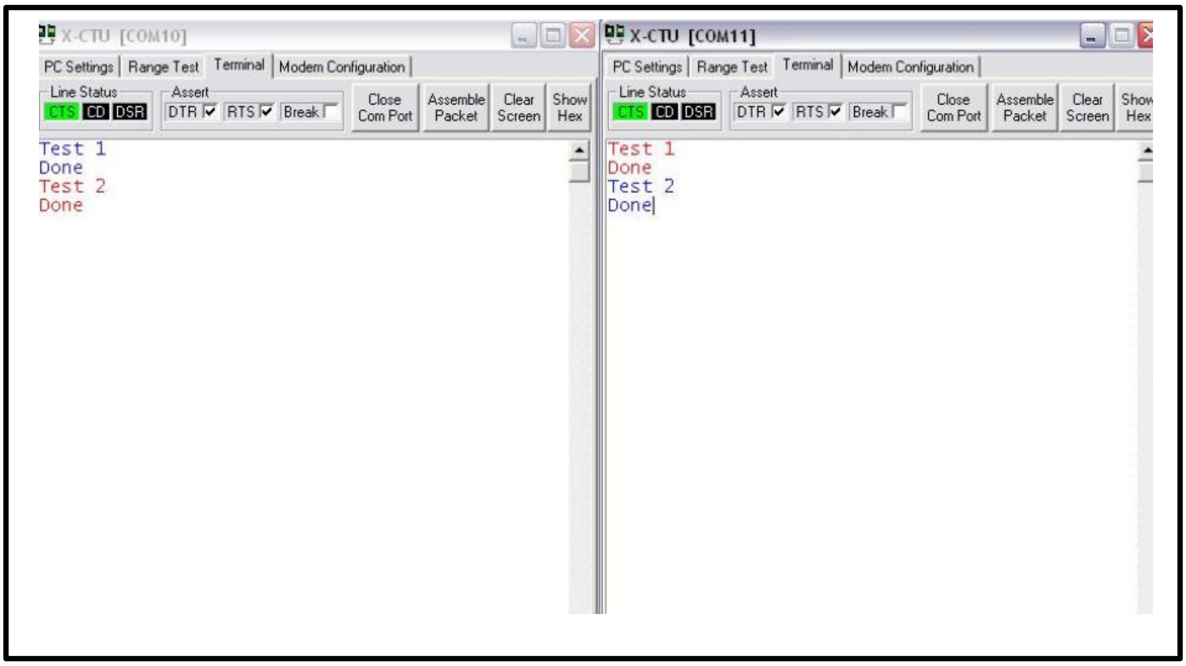

Figure 4.6 :Testing the connection

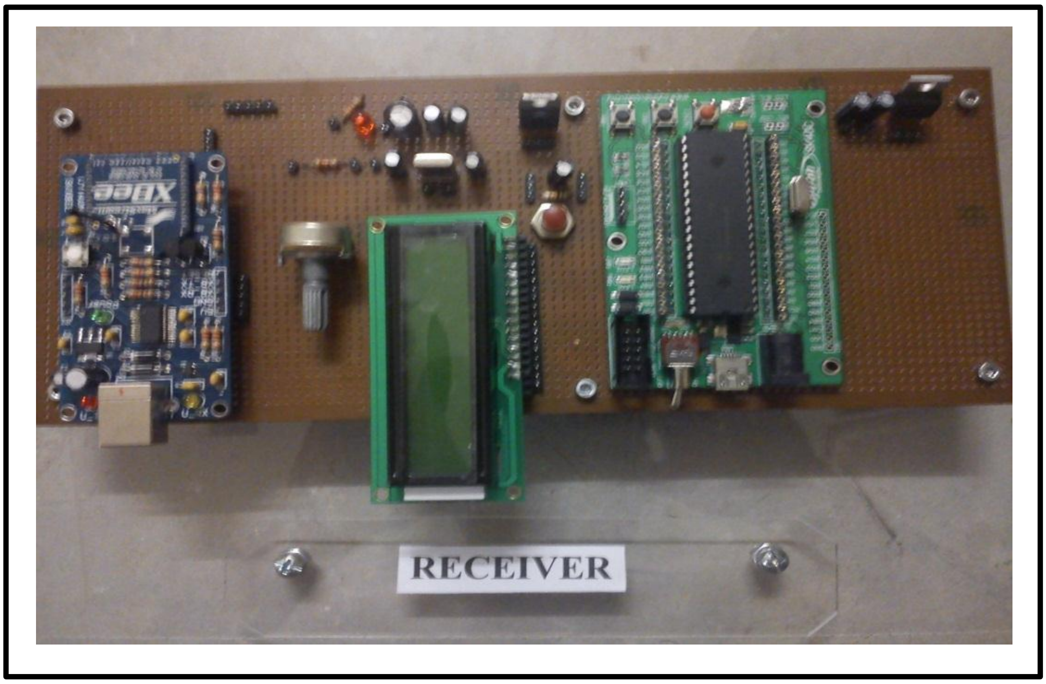

Figure 4.7 : Receiver Part of The Circuit

Every data transmit has no delay but error does occur sometimes and some data are lost at the receiving terminal.

4.1.3 Conclusion

Based on Figure 4.6, it shows the connection between the two XBEE module. The conclusion is, the XBEE module was functioning well. The data was transmitted and received successfully.

4.2 Interfacing LCD Display with PIC Microcontrollers

The purpose of this process is to communicate LCD display with the PIC microcontroller by using C Compiler software. It is to check connections between LCD display and PIC microcontrollers.

4.2.1 Hardware Connection

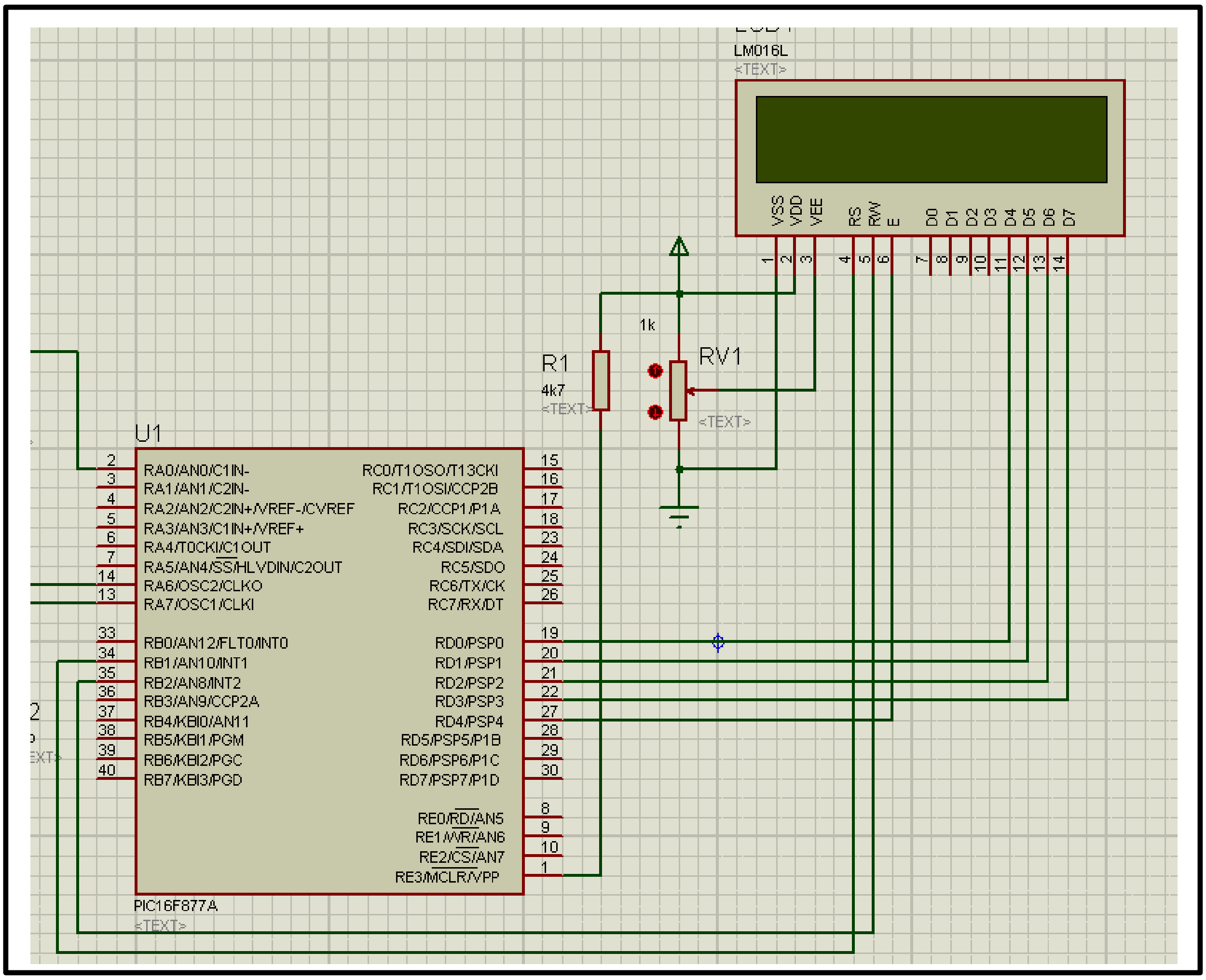

Figure 4.8: My LCD Display Interface with PIC Microcontroller

4.2.2 Software Connection

The LCD display need to be initialized by calling the function LCDInit(). This step will setup the LCD display.

4.2.3 Result

From the result, the words on LCD screen is the same as written in the C Compiler program. In conclusion, LCD display and PIC microcontroller has been interfaced and connected to each other. The connections are success.

4.3 Analog to Digital Converter (ADC)

ADC stands for analog to digital converter. It convert a voltage to a number so that it can be processed by digital systems. To interface the sensor with PIC microcontroller ADC need to be used to convert the voltage number into digital system. In PIC 16 there are two reference voltages, one is Vref- and the other one is Vref+. The input signal Vref- is applied to analog input channel then the result of conversion will be 0 and if voltage equal to Vref+ is applied to the input channel the result will be 1023 which is the maximum value for 10 bit ADC.

4.3.1 ADC Calculation

I. Example for Temperature Calculation

10mV = 1 ºC

1) Assume the temperature is 25 ºC

Vsig: 25 * 10mV = 0.25V

(0.25V * 0.48876 * 1024) / 5 = 25 ºC

2) Assume the temperature is 30 ºC

Vsig : 30 * 10mV = 0.30V

(0.30 * 0.48876 * 1024) / 5 = 30 ºC

II. **Example of Humidity Calculation**

48.6mV = 1%

1) Assume the humidity is 5%

Vsig: 5 * 48.6mV = 0.243V

(0.243V * 0.1 * 1024) / 5 = 4.999%

2) Assume the humidity is 10%

Vsig: 10 * 48.6 = 0.486V

(0.486V * 0.1 * 1024) / 5 = 9.953%

4.3.2 Result

The program of ADC channel 0 and ADC channel 1 will be read and display its value on LCD screen. The voltage has been converted to digital system. The process of converting analog to digital system to view on LCD display is successful.

4.4 Interface Temperature and Humidity Sensor with PIC 16F877A

The objective is to check the string that sensors will be sending to PIC. The analog signal received by the sensor will be convert to be display on LCD.

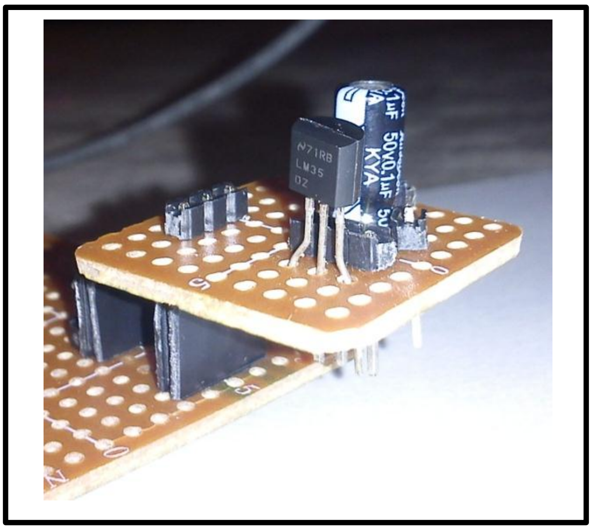

Figure 4.9 Temperature Sensor use at the circuit

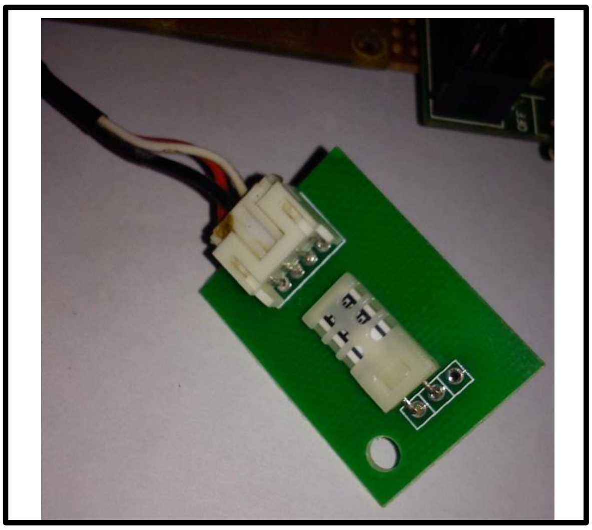

Figure 4.10 Humidity Sensor use at the circuit

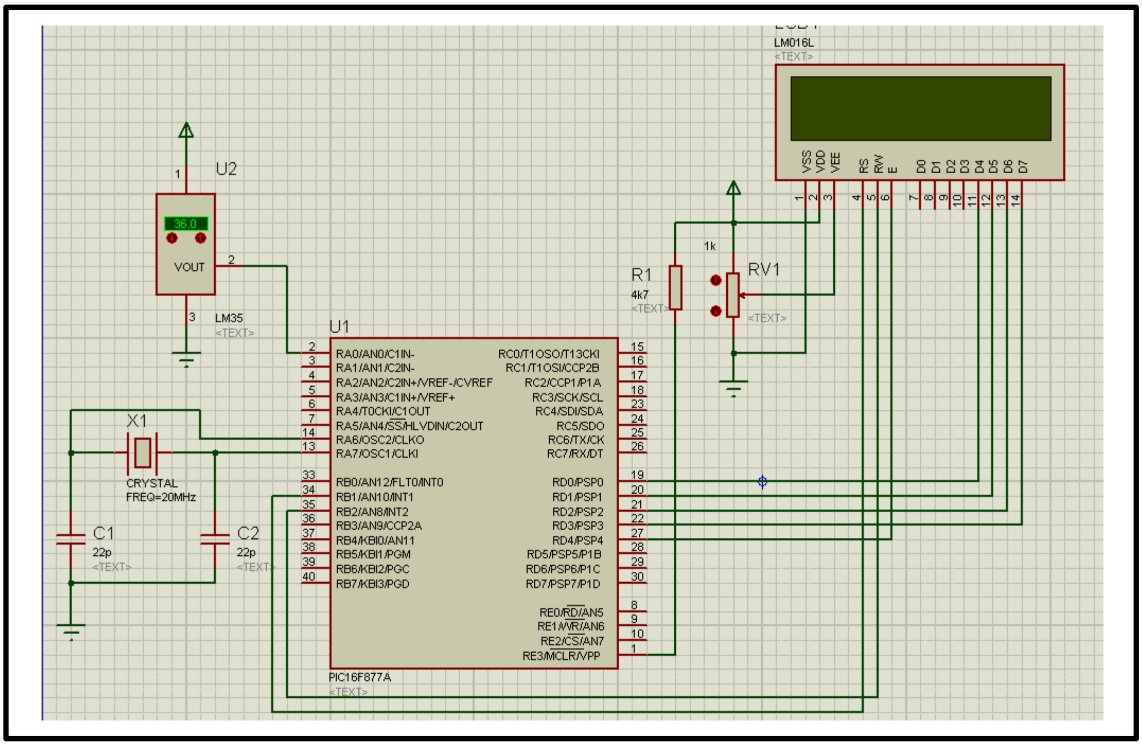

Figure 4.11: Schematic for the Circuit Design of sensors

4.5 Record Data for Temperature and Humidity received

The experiment has been done to monitor the temperature and humidity in UMP Pekan environment. The objective for this experiment is to make sure that the embedded sensor network that was design is functioning well and the data can be record correctly every one hour. The data has been taken for five days on 28th May 2012 until 1st June 2012 from 10.00 am until 10.00 pm everyday from that date. The experiment has been done in the same time and the location:

4.5.1 Result of Temperature data, graph and analysis

Date: **28 May 2012**

Time : 10.00 a.m untill 10.00 p.m

Experimental area: Residential College Area,Pekan

Experiment duration: 12 hours.

DAY 1

TIME	TEMPERATURE (CELCIUS)
10 AM	**29**
11 AM	**27**
12 PM	**29**
1 PM	**30**
2 PM	**30**
3 PM	**31**
4 PM	**28**
5 PM	**29**
6 PM	**28**
7 PM	**27**
8 PM	**26**
9 PM	**26**
10 PM	**26**

Table 4.1

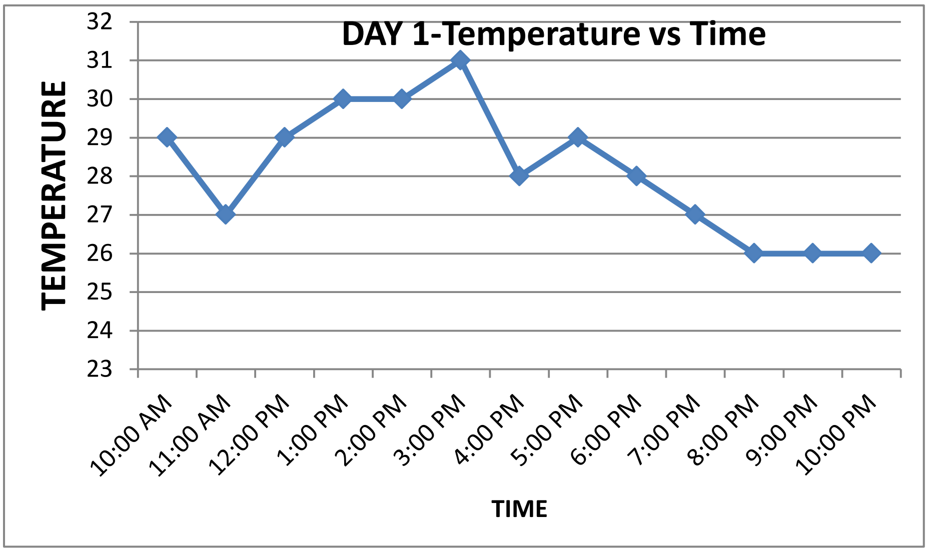

Figure 4.12 : Day 1 Graph Temperature vs Time

Table 4.1 shows the temperature of the environment in UMP Pekan at day 1 and the result is shown by converting the table to graph form. Figure 4.12 shows the temperature versus time in hours at day 1. The experiment starts on 10 a.m, the temperature in the morning is under 30◦C . The temperature keeps increasing after 12 p.m. until 3.00 pm. After 5 p.m the temperature decreased due to rainy day outside.The temperature continue to drop because rain continuosly until midnight. For this day 1 experiment, temperature variation measurements of the air in UMP Pekan are taken.

Date: **29 May 2012**

Time : 10.00 a.m untill 10.00 p.m

DAY 2

TIME	TEMPERATURE (CELCIUS)
10 AM	**27**
11 AM	**27**
12 PM	**30**
1 PM	**30**
2 PM	**30**
3 PM	**30**
4 PM	**28**
5 PM	**29**
6 PM	**28**
7 PM	**27**
8 PM	**27**
9 PM	**26**
10 PM	**27**

Table 4.2

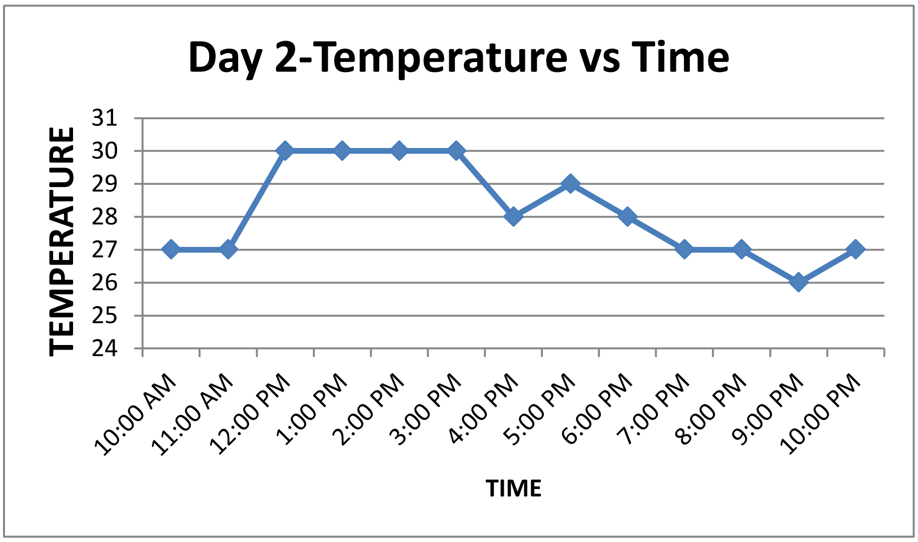

Figure 4.13 : Day 2 Graph Temperature vs Time

Table 4.2 shows the temperature of the environment in UMP Pekan at day 2 and the result is shown by converting the table to graph form. Figure 4.13 shows the temperature versus time in hours at day 2. The experiment starts on 10 a.m, the temperature in the morning, 10am until 11.59am is usually under 30◦C . The temperature are keeps constant at 30◦C after 12 p.m. until 3.00 pm due to hot weather. After 5 p.m the temperature decreased due to cold air at night.The temperature continue to drop because rain continuosly until midnight. For this day 2 experiment, variables temperature measurements of the air in UMP Pekan are also obtained.

Date: **30 May 2012**

Time : 10.00 a.m untill 10.00 p.m

DAY 3

TIME	TEMPERATURE (CELCIUS)
10 AM	**26**
11 AM	**28**
12 PM	**28**
1 PM	**29**
2 PM	**30**
3 PM	**29**
4 PM	**28**
5 PM	**29**
6 PM	**28**
7 PM	**27**
8 PM	**26**
9 PM	**25**
10 PM	**25**

Table 4.3

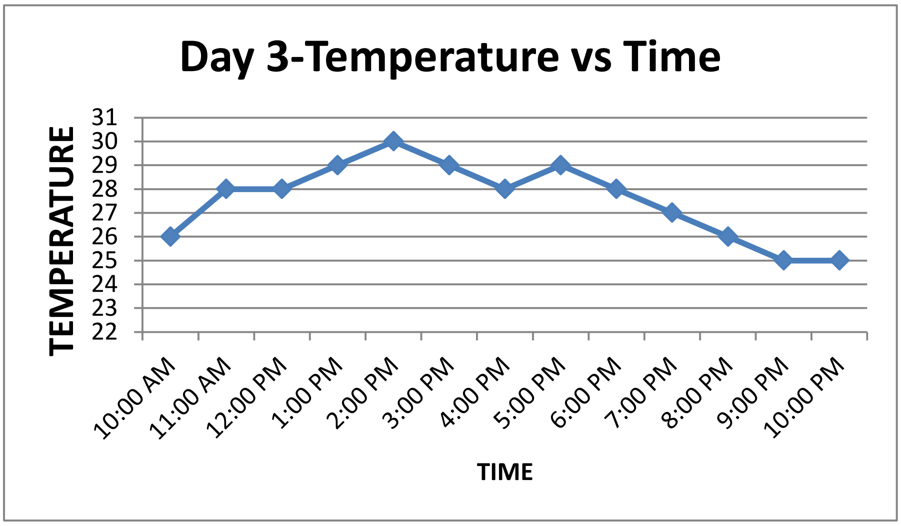

Figure 4.14 : Day 3 Graph Temperature vs Time

Date: **31 May 2012**

Time : 10.00 a.m untill 10.00 p.m

DAY 4

TIME	TEMPERATURE (CELCIUS)
10 AM	**27**
11 AM	**27**
12 PM	**29**
1 PM	**31**
2 PM	**31**
3 PM	**29**
4 PM	**28**
5 PM	**29**
6 PM	**28**
7 PM	**27**
8 PM	**27**
9 PM	**26**
10 PM	**27**

Table 4.4

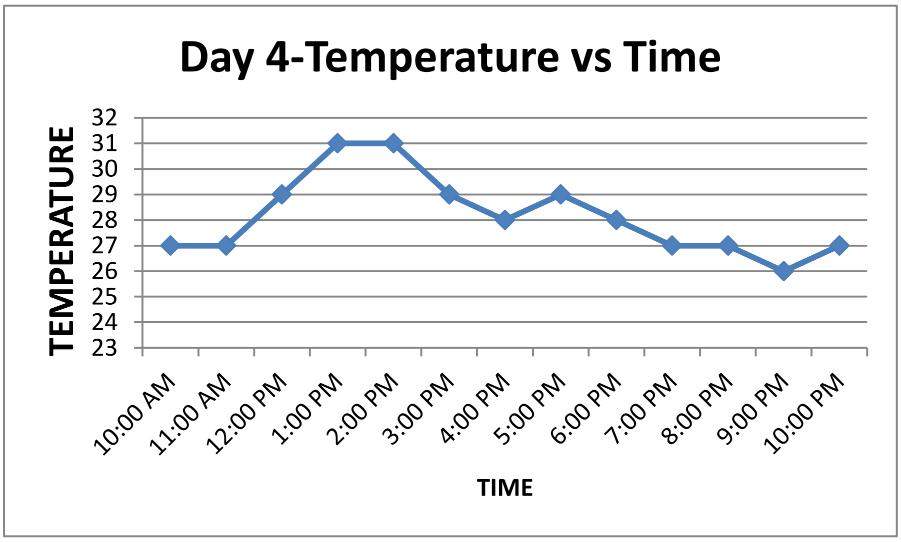

Figure 4.15 : Day 4 Graph Temperature vs Time

Date: **1 June 2012**

Time : 10.00 a.m untill 10.00 p.m

DAY 5

TIME	TEMPERATURE (CELCIUS)
10 AM	**24**
11 AM	**26**
12 PM	**29**
1 PM	**28**
2 PM	**28**
3 PM	**29**
4 PM	**28**
5 PM	**29**
6 PM	**28**
7 PM	**26**
8 PM	**24**
9 PM	**25**
10 PM	**24**

Table 4.5

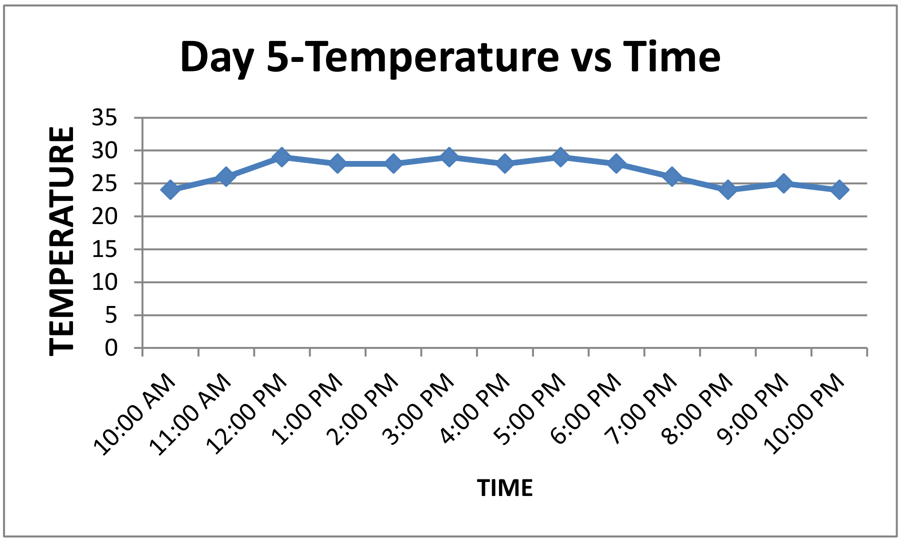

Figure 4.16 : Day 5 Graph Temperature vs Time

Table 4.5 show the result of temperature that is collected from the experiment day 5 and Figure 4.16 shows the graph of temperature versus time. The stable temperature in the air is below 30 degree Celsius have been obtained. From the experiment, the reading temperature on that day is stable but at morning before 10 am , the temperature is drop because it was raining early at that time. The temperature drops and maintain below 30 degree Celsius during that day of experiment.

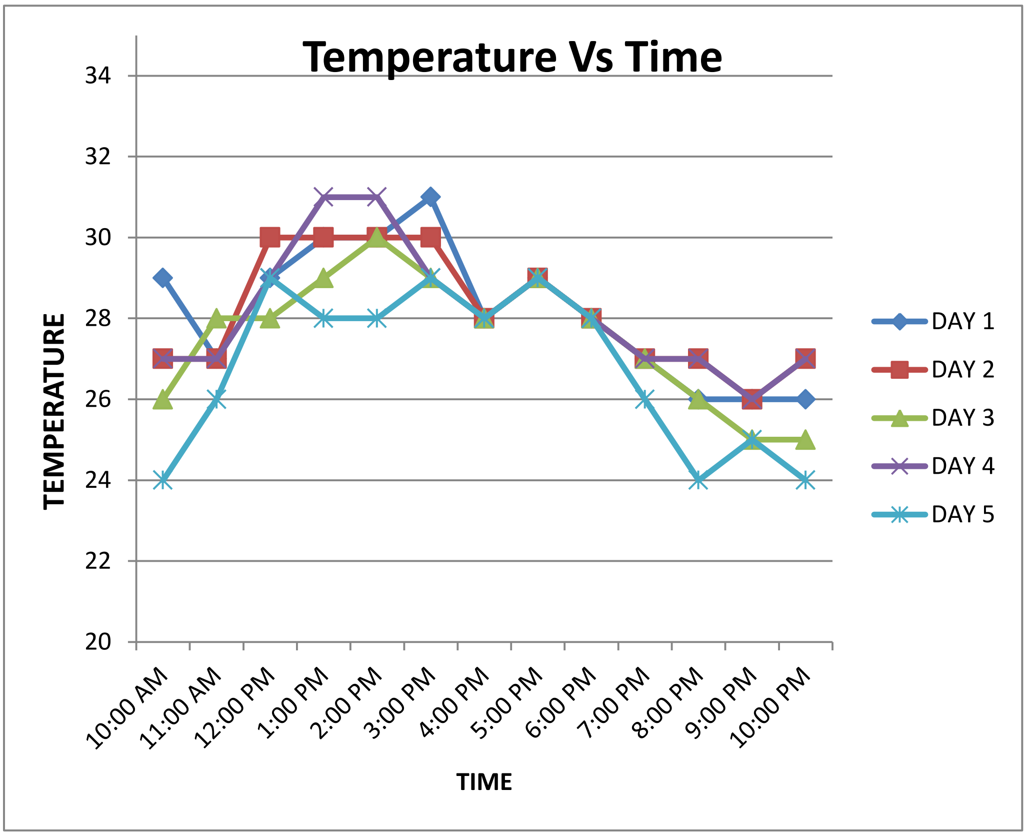

Figure 4.17 : 5 Day Graph Temperature vs Time

4.6 Summary

In this chapter, it is all basically focusing in the result from the experiment and the process of the interfacing all the program equipment to be burned to PIC. During completing this project, several problems have been faced before this project finished and working as planned. The first problem is to interface the two XBee with the PIC because suddenly the Xbee did not response to any input. It because the XBee is very sensitive, it cannot contact with other metal and maximum voltage that XBee can accept is only 3.3v. The next problem is the error in the programming matter. To overcome these problems, more research programme were done to make the project a success.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Introduction

This chapter will describe the overall performance of the project. There were few problems and limitation that came up during the project duration and were stated and defined as recommendations for future development of this project. There are also some discussions on the needs and suggestion for further work to improve the system.

5.1 Conclusion

Nowadays, developments in wireless technology provide a wide range scope of applications for weather forecasting system. In this matter this project explore another application of embedded sensor network which is for forecasting purpose.

The important part of the system which is the temperature and humidity sensor have successfully collected data from surrounding environment and sent the data to microcontroller. The data was transmitted from transmitter to receiver and LCD screen displayed the collected data. This process allows the system to monitor the condition of temperature and humidity in the UMP Pekan. To make the receiver module communicates with transmitter module, Zigbee was used and this task was achieved successfully.

The ZigBee technology can be used to connect devices wirelessly at a very low cost and with little energy consumption, which makes it particularly well-suited for being directly integrated into small electronic appliances. Zigbee, which operates on the frequency band of 2.4 GHz and on 16 channels, can reach transfer speeds of up to 250 Kbps with a maximum range of about 100 meters. In ZigBee, there are two version of module. One is Xbee and the other is Xbee PRO. The only different is transmit power which is 1 mW maximum for the XBee and 63 mW maximum for the XBee PRO. The problems in this project are due to hardware part and software part. This project a prototype that can be used to inform the public that embedded sensor network technology can be used for weather forecasting purposes.

The design of this weather monitoring system circuit was a success story. Overall, the system functions as expected even though faced a lot of difficulties throughout the completion. The objective of the project is successfully achieved.

5.2 Problem and Limitation

I. PIC 16 series – The microcontroller (PIC 16F877A) that students used has its own limitation in terms of memory to put many sensor or input. The program also play a main role for the circuit to operate correctly

II. Zigbee – The distance of the Zigbee wireless on transmitter module and receiver module has its own limit which able to communicate within 100 meter range.

III. LCD Display – Sometimes the LCD display did not display the same reading which means, sometimes there are differences in the data transmitted and received because of signal interference around or noise.

IV. Humidity Sensor – This sensor is too sensitive with water vapor which sometimes gives difficulties to take the reading because the reading keeps changing.

V. Design – This project did not focus too much on the designing concept but more into the technical concept. Even though the design is complete, but it is not in a perfect shape.

5.3 Recommendation

5.3.1 System

The function of the system should be upgraded so that it can collects more data and be able to control the condition by using computer, the target is to build a environmental monitoring system so that the weather forecasting data is always be monitored continuously.

5.3.2 Hardware

I. The wireless Xbee transmitter and receiver module need a higher technology device for communication system such as Xbee PRO that can exceed more that 1.0 KM communication range.

II. The system need to be build in compact design to put in strategic places and reduce the interference signal in the environment.

III. Use more sensor to measure the temperature and humidity in various places inside UMP Pekan from point to point. The temperature and humidity sensors can give more the detail output for this system.

5.3.3 Software

The data based for the monitoring part will be designed . For example, using visual basic to monitor data received at base station. From the data received, the base station can automatically stored the data and it will be very convenient for monitoring the changes of the temperature and humidity rather than monitor it manually.

5.4 Summary

Conclusions are summarised here. The data is gathered to acquire information about techniques on how to interface the two PICs using XBee. Lots of research is done in implementing this project. By using embedded sensor network, the cost of maintenance is reduced. It would be very costly if using the wire technology in implementing this embedded sensor network. It is more suitable to implement this project by using the wireless technology because it easy to implement around UMP Pekan.

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APPENDIX A

PROGRAM FOR PIC MICROCONTROLLER USING C COMPILER

LCD Interfacing Test Program

```
#include <16F877a.h> // PIC16f877a HEADER FILE
#fuses XT,NOWDT,NOLVP,NOPROTECT // EXTERNAL CLOCK, NO WATCH
DOG TIMER, NO LOW VOLTAGE #use delay (clock=20M) // 20 MHZ
CRYSTAL
#include <lcd.c> // LCD DISPLAY HEADER FILE
//////////////////////////////////////////////////////////////////////////////
// //
// I/O DECLARATION //
// //
//////////////////////////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////////////////////////
// //
// SWITCH //
// //
//////////////////////////////////////////////////////////////////////////////
#define BUTTON1 PIN_B0 // PRESET BUTTON 1
#define BUTTON2 PIN_B1 // PRESET BUTTON 2
#define BUTTON3 PIN_B2 // PRESET BUTTON 3
//////////////////////////////////////////////////////////////////////////////
// //
// LCD DISPLAY //
// //
//////////////////////////////////////////////////////////////////////////////
#define LCD_E PIN_D0 // PIN E
#define LCD_RS PIN_D1 // PIN RS
#define LCD_RW PIN_D2 // PIN RW
#define LCD_D4 PIN_D4 // PIN D4
#define LCD_D5 PIN_D5 // PIN D5
#define LCD_D6 PIN_D6 // PIN D6
#define LCD_D7 PIN_D7 // PIN D7
//////////////////////////////////////////////////////////////////////////////
void main()
{
//////////////////////////////////////////////////////////////////////////////
// //
// PORT INITIALIZE //
// //
//////////////////////////////////////////////////////////////////////////////
set_tris_b(0xFF); // SET ALL PORT B AS INPUT PORT
output_b(0xFF); // RESET PORT B
lcd_init(); // INITIALIZE LCD
```

```
//////////////////////////////////////////////////////////////////////////////
// //
// MAIN PROGRAM //
// //
//////////////////////////////////////////////////////////////////////////////
while(TRUE) // always repeat program below
{
if (!input(BUTTON1)) // when press button 1
{
lcd_putc("\fBUTTON 1 PRESS"); //message display at LDC display
}
else if (!input(BUTTON2)) // when press button 2
{
lcd_putc("\f"); //feed empty message at LCD display 1st line
lcd_putc("\nBUTTON 2 PRESS"); //feed message at LCD display 2nd line
}
else if (!input(BUTTON3)) // when press button 3
{
lcd_putc("\f"); //feed empty message at LCD display 1st line
lcd_gotoxy(5,1); //set starting target point
lcd_putc("BUTTON 3"); //message display starting from target point
lcd_gotoxy(5,2); //set next target point
lcd_putc("PRESS"); //message display starting from target point
}
else
{
}
}
}
```

Analog to Digital Convertor Interfacing Test Program

```
#include <16F877a.h> // PIC16f877a HEADER FILE
#fuses XT,NOWDT,NOLVP,NOPROTECT // EXTERNAL CLOCK, NO WATCH
DOG TIMER, NO LOW VOLTAGE #device adc=10 // USE 10 BIT ADC
QUANTIZATION
#use delay (clock=20M) // 20 MHZ CRYSTAL
#include <lcd.c> // LCD DISPLAY HEADER FILE
//////////////////////////////////////////////////////////////////////////////
// //
// I/O DECLARATION //
// //
//////////////////////////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////////////////////////
// //
// LED //
// //
//////////////////////////////////////////////////////////////////////////////
#define LED1 PIN_B4 // LED 1
```

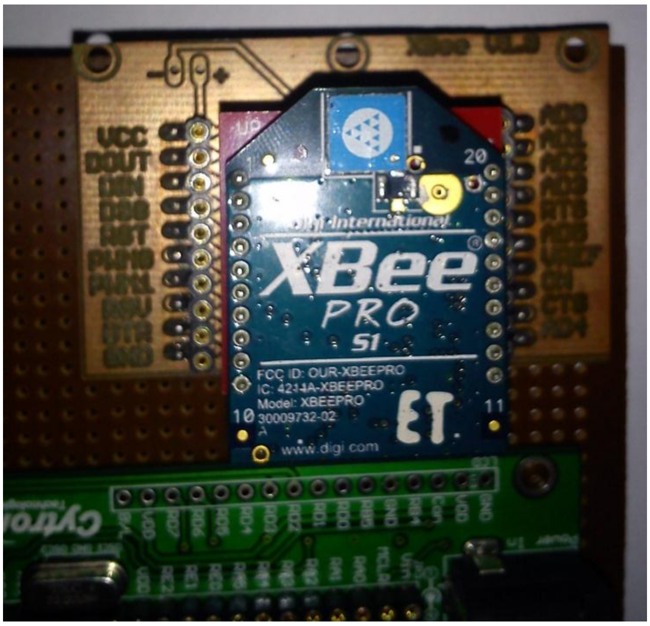
```
#define LED2 PIN_B5 // LED 2
#define LED3 PIN_B6 // LED 3
#define LED4 PIN_B7 // LED 4
//////////////////////////////////////////////////////////////////////////////
// //
// ANALOG INPUT //
// //
//////////////////////////////////////////////////////////////////////////////
#define VR_AI1 PIN_A0 // VARIABLE RESISTOR
#define TEMP_AI2 PIN_A1 // TEMPERATURE SENSOR
//////////////////////////////////////////////////////////////////////////////
// //
// LCD DISPLAY //
// //
//////////////////////////////////////////////////////////////////////////////
#define LCD_E PIN_D0 // PIN E
#define LCD_RS PIN_D1 // PIN RS
#define LCD_RW PIN_D2 // PIN RW
#define LCD_D4 PIN_D4 // PIN D4
#define LCD_D5 PIN_D5 // PIN D5
#define LCD_D6 PIN_D6 // PIN D6
#define LCD_D7 PIN_D7 // PIN D7
//////////////////////////////////////////////////////////////////////////////
void main()
{

//////////////////////////////////////////////////////////////////////////////
// //
// LOCAL VARIABLE //
// //
//////////////////////////////////////////////////////////////////////////////
int32 AI1;
int32 VR;
//////////////////////////////////////////////////////////////////////////////
// //
// PORT INITIALIZE //
// //
//////////////////////////////////////////////////////////////////////////////
setup_adc(ADC_CLOCK_INTERNAL); // SET INTERNAL CLOCK FOR ADC
setup_adc_ports(AN0_TO_AN1); // SET PORT RE0 AND RE1 AS ANALOG
INPUT
set_tris_b(0x00); // SET ALL PORT B AS OUTPUT PORT
output_b(0x00); // RESET PORT B
lcd_init(); // INITIALIZE LCD
//////////////////////////////////////////////////////////////////////////////
// //
// MAIN PROGRAM //
// //
//////////////////////////////////////////////////////////////////////////////
while(TRUE)
```

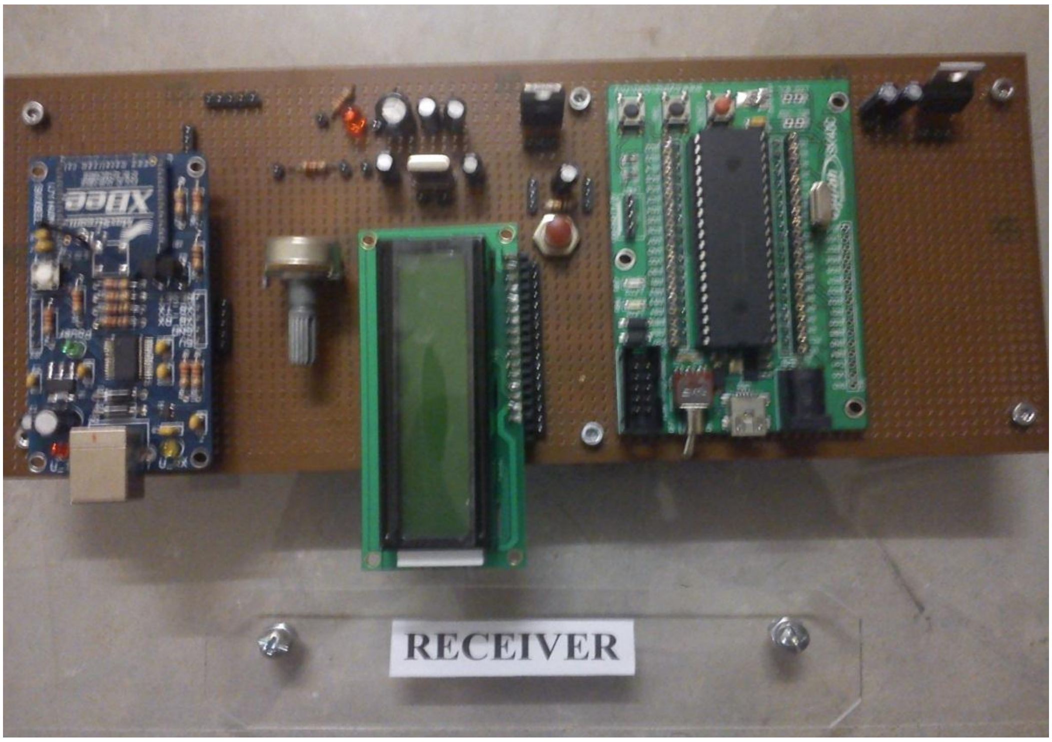
```
{
delay_ms(200);
set_adc_channel(0); // POINTS ADC AT CHANNEL 0
delay_us(10); // DELAY TO GET ANALOG VALUE
AI1=read_adc(); // READ ANALOG INPUT 1
VR=AI1*100/(1024-1); // SCALLING TO RANGE 0% TO 100%
printf(lcd_putc,"\fAI 1 = %u%%",(int)VR); // DISPLAY VR VALUE AT LCD
DISPLAY
if ((VR>=0) && (VR<=25)) // RANGE FROM 0 TO 25
{
output_high(LED1); // LED 1 ON
output_low(LED2); // LED 2 OFF
output_low(LED3); // LED 3 OFF
output_low(LED4); // LED 4 OFF
lcd_putc("\nLED1 ON"); //feed message at LCD display
}
else if ((VR>=26) && (VR<=50)) // RANGE FROM 26 TO 50
{
output_high(LED2);
output_low(LED1);
output_low(LED3);
output_low(LED4);
lcd_putc("\nLED2 ON"); //feed message at LCD display
}
else if ((VR>=51) && (VR<=75)) // RANGE FROM 51 TO 75
{
output_high(LED3);
output_low(LED1);
output_low(LED2);
output_low(LED4);
lcd_putc("\nLED3 ON"); //feed message at LCD display
}
else if ((VR>=76) && (VR<=100)) // RANGE FROM 76 TO 100
{
output_high(LED4);
output_low(LED1);
output_low(LED2);
output_low(LED3);
lcd_putc("\nLED4 ON"); //feed message at LCD display
}
else
{
}
}
}
```

APPENDIX B

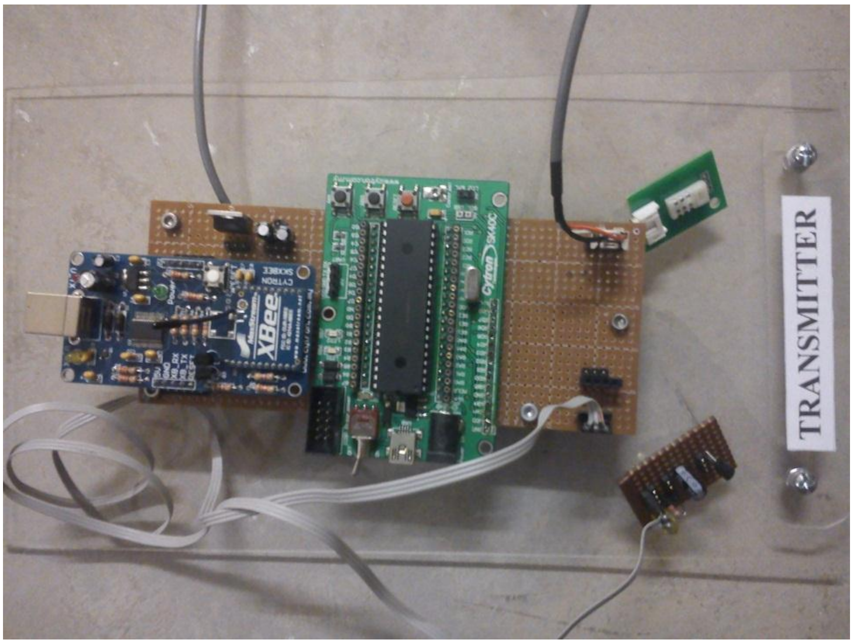
SCEMATIC DIAGRAM AND CIRCUIT OVERVIEW



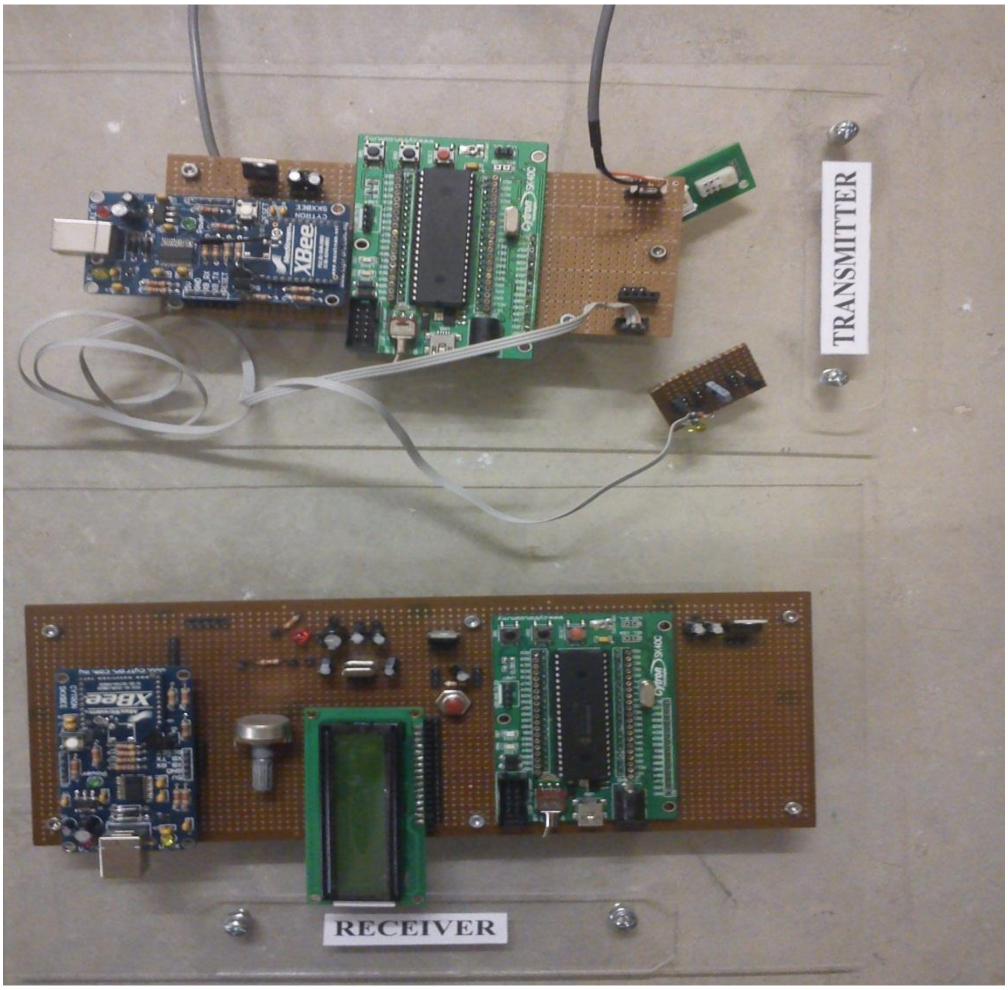
XBEE PRO MODULE



RECEIVER PART



TRANSMITTER PART



COMPLETE CIRCIUIT FOR TRANSMITTER AND RECEIVER