بسم الله الرحمن الرحيم

Palestine Polytechnic University
College of Engineering & Technology
Electrical & Computer Engineering Department

Graduation project
Child Tracking using ZigBee and GPS Technologies

Project team:

Bayan Ayoub   **Reem Aljabari**
Haneen Halahlah   **Yasmeen Abuayyash**

Project supervisor:
Dr. Murad AbuSubaih

Hebron – Palestine
June,2012

Electrical and Computer Engineering Department

Communication Engineering Program

Bachelor Thesis

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This Under-Graduate Project Report submitted to Computer and Electrical engineering Department in College of Engineering and Technology

Palestine Polytechnic University

For accomplishment the requirements of the bachelor degree in Engineering field at Communication Engineering

Palestine Polytechnic University
Hebron – Palestine

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جامعة بوليتكنك فلسطين

الخليل – فلسطين

كلية الهندسة و التكنولوجيا

دائرة الهندسة الكهربائية والحاسوب

اسم المشروع

Child Tracking using ZigBee and GPS Technologies

أسماء الطلبة

حنين حلاحلة	بيان ايوب
ياسمين أبوعياش	ريم الجعبري

بناء على نظام كلية الهندسة والتكنولوجيا و إشراف المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية و الحاسوب و ذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة الاتصالات.

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

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CHAPTER ONE 1

Introduction

1.1 Overview

Our children are our life, so we need to be careful about them. Imagine yourself in a crowded place with your child, and then you are surprised that your child is disappeared!
What will you do? How can you know where he is?

Of course this event is dangerous, the mother will be shocked! She will harry up in order to find her child!
So, why we do not take the advantages of today's technology and get our children safety?

In the last years, the world witnessed a rapid and huge development of communication networks, especially wireless networks, while the technology is found to make our life much easier. This is the goal of this project, to alleviate the problem of missing children, we need something that always connect parent with his child.

This project aims to develop a Child Tracking System. The system will be based on the new ZigBee technology for exchanging information between mother side and child side. GPS used only at the child side, which gives the coordinator of fixed point in the first time. Then compares the movement of child to this reference point. The innovation of this project is developing model of statistical power to determine where are the child location with respect to his parent.

The system is flexible, it is not limited only for children. In fact, it can be used for numerous applications. For example, it can be used for people who cannot express themselves like autism persons, elders, also in hajj seasons, the companies can use it with pilgrims to determine their locations and communicate with them. Also, to determine where our personal things like car keys, and anything we want it.

1.2 Project Objectives

This project aims to alleviate the problems faced by children to express themselves, especially children whom suffer from autism, by alarming the parent when his child is faraway, and determine the direction and the distance of the child. In addition, our goals is to practice a new technology (ZigBee), and use it combined with GPS.

1.3 Motivation

Tracking your child, through this project will help parents to know where their child is located, so they can certain that their child is in safe mode or not. This project aims to reduce the complexity, and cost with respect to other child location applications by using ZigBee technology with one GPS device.

It is our intention to work with a new communication technology that is mainly designed for monitoring applications.

1.4 Requirements

1.4.1 Hardware:
1) Zigbee device.
2) GPS device.
3) Microcontroller.

1.4.2 Software:
Programming software by using MPLAP and MikroC to program the microcontroller which responsible for many tasks.

1.5 Challenges

There are many problems obstructed and change some ideas in the project. We can summarize them below:
1) GPS accuracy:
   GPS systems do not give us the desired accuracy because Intentional jamming by occupation.
2) Availability of electronic chips.
3) Software:
   How to program microcontroller to achieve the goals on hardware.
4) Dealing with a new technology (ZigBee).

1.6 Literature Review

Many projects and papers have been developed in monitoring and tracking child system, but no one had been used ZigBee technology. An example is the project entitled by "A Multipurpose Child Tracking System Design and Implementation"[1], which shows an approach of child tracking system, in indoor and outdoor environments, using GPS for outdoor, and strength of RF signals for indoor based in GSM network.

Another similar project which also based on GSM network entitled by "child locator" [2], it was developed a system to track number of child locations with respect to their parent using GPS technology.

In another paper entitled by "Mobile RFID Tracking System" [3], this paper describes the design of an Radio Frequency Identification (RFID) Kids Tracking System. It is designed to track a moving child in a wide area using RFID technology. This design includes of an RFID active tag, RFID tag reader, web server and database server. Where the communication between the web server and the tag readers through wireless LANs.

Another paper entitled by "Indoor Child Tracking in Wireless Sensor Network using Fuzzy Logic Technique" [4], which discusses the child tracking application using fuzzy logic as a position technique. At first the signal measurement is done by sensors. Then calculate the distance to the target, and specify the direction using trilateration method. Where fuzzy logic accepts a range of values to estimate the position.

We provide several differences from previous works, in case of reach more usable and more flexible system which alerts the user directly at any time.

Our system used ZigBee technology which is more reliable from GSM, for many reasons related to fast connection, and no underlying network required to establish the communication. Also, it can use RSSI to determine the child range for indoor environment. In addition, it differs in form that this system stays far away from traditional GSM system which may has defects, regard the cost of the system.

1.7 Project Plan

The project will be divided into the following phases:

Phase 1: Preparing the project
  In this phase, the idea of the project is selected. Then the required information will be collected. Discussions with supervisor, and dividing tasks between the members of the group.

Phase 2: Analysis overview
  Here, a deep and complete study for all options of the project will be made.

Phase 3: Study of the principles
  In this phase, we study the GPS, ZigBee, microcontroller, and any other technologies or information needed.

Phase 4: Documentation and writing
  Writing and preparing the documentation of the project was start from the first phase, and will continue till the end of the project.

Phase 5: Measurements
  Here we will do some measurements with GPS systems, to determine the accuracy of the system, in order to choose the better option.

Phase 6: Microcontroller programming
  The programming of project codes are started, then downloaded to microcontroller.

Phase 7: Preliminary Measurement
  Many experiments was taken the values of received signal strength in Xbee to develop system with accurate result and avoid false alarms.

Phase 8: Implementation and Testing
  Here the system will be implemented and tested to conclude the system performance (false positive and false negative).

Phase 9: Writing documentation
  The documentation will continue from the first phase till the end in parallel.

Task	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Phase 1	■	■												
Phase 2	■	■	■	■	■									
Phase 3				■	■	■	■							
Phase 4			■	■	■	■	■	■	■	■	■	■	■	■
Phase 5									■	■	■	■	■	■

Table 1.1 : Summary of the Project Plan for first semester

Task	Weeks													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Phase 6		■	■	■	■	■	■	■	■					
Phase 7			■	■	■	■	■							
Phase 8							■	■	■	■	■	■	■	
Phase 9						■	■	■	■	■	■	■	■	■

Table 1.2 : Summary of the Project Plan for second semester

1.8 Estimated cost and budget

The whole estimated cost will be approximately 650 JD (hardware and software), and the table below shows the cost of each hardware component.

Items	Quantity	Price for one item (JD)
Xbee PRO 63mW	2	70
XBee Explorer Dongle	2	20
Channel GS407 Helical GPS Receiver	1	120
PIC18f4550	2	20

Table 1.3 : Estimated cost and budget

1.9 Report Contents

Documentation of the project will be divided into seven chapters, each of them describes specific part of the project as following:

Chapter One: Introduction
This chapter provides a general overview about the project, it is objectives, importance, related works, challenges, project plan, estimated cost, and at the end the report contents.

Chapter Two: Theoretical Background
In this chapter, we introduce the theoretical background of the main ideas of the project.

Chapter Three: Conceptual Design
This chapter introduces the system design and discusses the different possible design options.

Chapter Four: Detailed System Design
This chapter explains how each unit connects with other units in the system in specific details.

Chapter Five: Hardware and Software Implementation

This chapter contains software programming that downloaded to PIC18F4550 to achieve the purpose on hardware components, that means how to operate each part independently, in addition how to interface and test these parts.

Chapter Six: Preliminary Measurements

This chapter contains the results and analysis of GPS measurement, and Xbee power.

Chapter Seven: System Testing

This section is to test the whole system work. It should be tested to conclude system performance, false positive (how many times buzzer make alarm when child near to his parent), and false negative (how many times buzzer does not make alarm when child is far from his parent).

Chapter Eight: Conclusion and Recommendation

This chapter will consider system achievement, real outcome, and recommendation for developing the system in future.

CHAPTER TWO 2

Theoretical Background

2.1   ZigBee Theory

2.2   GPS architecture

2.3   Serial Port

2.1 ZigBee Theory

2.1.1 Introduction

The past several years have shown a rapid development of wireless networking. However, up to now wireless networking has been mainly focused on high speed communications, and long range applications, such as the IEEE 802.11 Wireless Local Area Network (WLAN) standards. And there are many wireless monitoring and control applications in industrial and home environments, which require longer battery life, lower data rate and less complexity than the existing standards. So, the ZigBee Alliance and the IEEE decided to join forces, and ZigBee is the commercial name for this new technology.

2.1.2 ZigBee Alliance

ZigBee alliance is a group of companies that produce wireless communication devices, where these companies are working together to give secure, flexible, low power, and monitoring products. Where the members can be any type of companies, like universities, well known public companies, such as Philips, LG, Motorola, and Samsung. Moreover, it is used in industrial, commercial, and residential monitoring applications. Where the number of Alliance members are increasing rapidly, and reach more than 200 companies. In addition, any product must satisfy the ZigBee certification program, to carry ZigBee Alliance logo.

2.1.3 The name of ZigBee

The name of ZigBee is coming from the zig-zagging patterns of bees between flowers to communicate information to hive members, and that what are engineers are trying to achieve in this protocol, to communicate number of devices in the network with each other, where the ZigBee network component similar to bees network.

2.1.4 OSI Model

OSI is Open Systems Interconnection, which is a standard reference model for communication between two end users in a network, and it set up by the international standards organization (ISO). This model is used in developing products and understanding networks.

OSI divides telecommunication into seven layers; the layers are in two groups. The upper four layers are used whenever a message passes from or to a user. But, the lower three layers are used when any message passes through the host computer.

Messages intended for this computer pass to the upper layers. Messages destined for some other host are not passed up to the upper layers but are forwarded to another host.
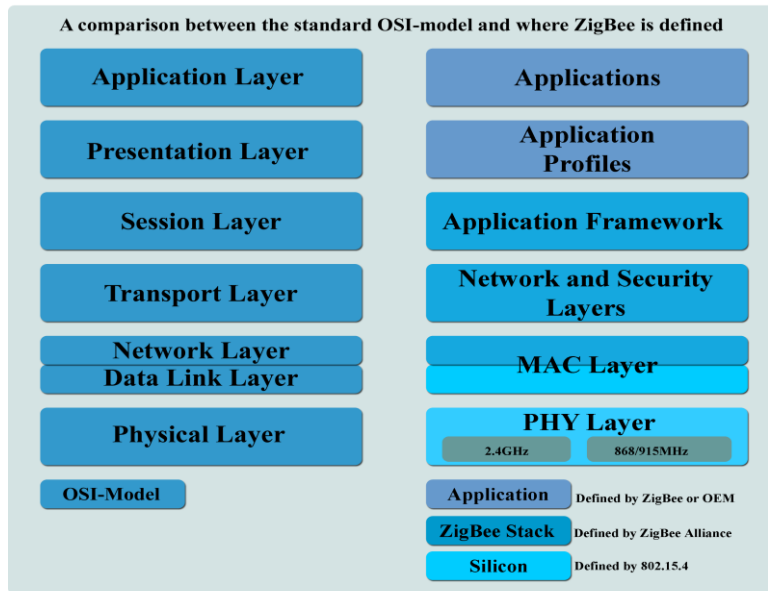

Figure 2.1 : OSI versus ZigBee

2.1.4.1 Physical Layer (PHY)

The PHY layer specification means how 802.15.4 devices may communicate with each other over the wireless channel. It defines three frequency bands with varying data rates. The bit rates are 20 kbps in the European 868 MHz band, 40 kbps in the North American 915 MHz band, and 250 kbps in the worldwide 2.4 GHz band.

Physical layer is concerned with the interface to the physical transmission medium, exchanging data bits with this medium, as well as exchanging data bits with the layer above (the MAC sub-layer).

PHY (MHz)	Frequency band (MHz)	Bit rate (Kbps)	Modulation	Chip rate (k chip/s)	Centre frequency (MHz)	Number of channels (N)
868	868-868.6	20	BPSK	300	868	1
915	902-928	40	BPSK	600	915	10
2450	2400-2483.5	250	O-QPSK	2000	2450	16

Table 2.1 : Frequency bands and data rates

2.1.4.2 Medium Access Control Layer (MAC)

Responsible for providing reliable communications between a node and its immediate neighbors, helping to avoid collisions and improve efficiency. The MAC Layer is also responsible for assembling, and decomposing data packets and frames.

2.1.5 ZigBee Network

ZigBee can be used mesh network, which may extend over a large area and contains thousands of nodes. Each FFD in the network also acts as a router to direct messages. The routing protocol optimizes the shortest and most reliable path through the network, and can dynamically change. This enables an extremely reliable network, since the network can heal itself if one node is disabled.

ZigBee networks are primarily intended for low duty cycle sensor networks. Where a new network node may be recognized and associated in about 30ms. Waking up a sleeping node takes about 15 ms, as also for accessing a channel or transmitting data. ZigBee applications benefit from the ability to quickly attach information, and when nothing to do, it go to deep sleep, which give low power consumption and longer battery life.

ZigBee networks include these following types of devices:

1) Coordinator, this device organizes and controls the network, where it is starts network information, and there is only one coordinator required for each Zigbee network.

2) Router, these devices can extend the network area coverage, where it can connect to coordinator and other routers, and it is provide backup routes if we have congestion in the network, also it is responsible for passing data to other devices.

3) End devices, this kind of devices must be connected to coordinator or router, where it can transmit or receive data, but it cannot do any routing operation, they sleep most of the time and wake up regularly to collect and transmit data, then go back to sleep, to minimize the power consumption.
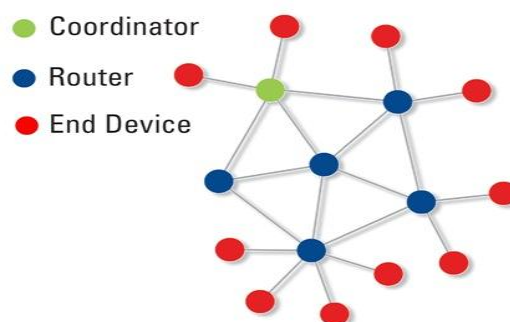

Figure 2.2 : ZigBee network devices

2.1.5.1 Network Topologies

IEEE 802.15.4 can specify two types of networks, star topology or peer to peer topology. In Zigbee, these two topologies can be combined to build mesh networks.

2.1.5.1.1 Peer to peer topology

It is a type of network topologies, we have only one PAN coordinator, where any device can communicate with any other device with the same network to connect with each other, and directly access to each other. It also allows multiple hops to route messages from any device to any other device in the network. So, it can provide reliability by multipath routing.
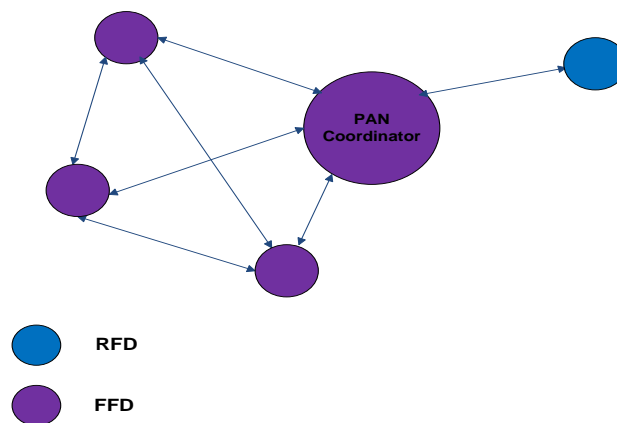
Figure 2.3 : Peer to peer topology

2.1.6 ZigBee Channels and Frequencies [5]

The RF spectrums and available channels for ZigBee (802.15.4) and Wi-Fi (802.11b/g) overlap. You can avoid interference by selecting ZigBee channels that use the free space between two neighboring 802.11 channels, plus channels 25 and 26.

2.1.6.1 ZigBee, Wi-Fi & Bluetooth Channels

In the image below, 802.15.4 Orange channels have more substantial overlap with Wi-Fi channels 1, 6 & 11, while Grey channels have less overlap with Wi-Fi channels 1, 6 & 11.
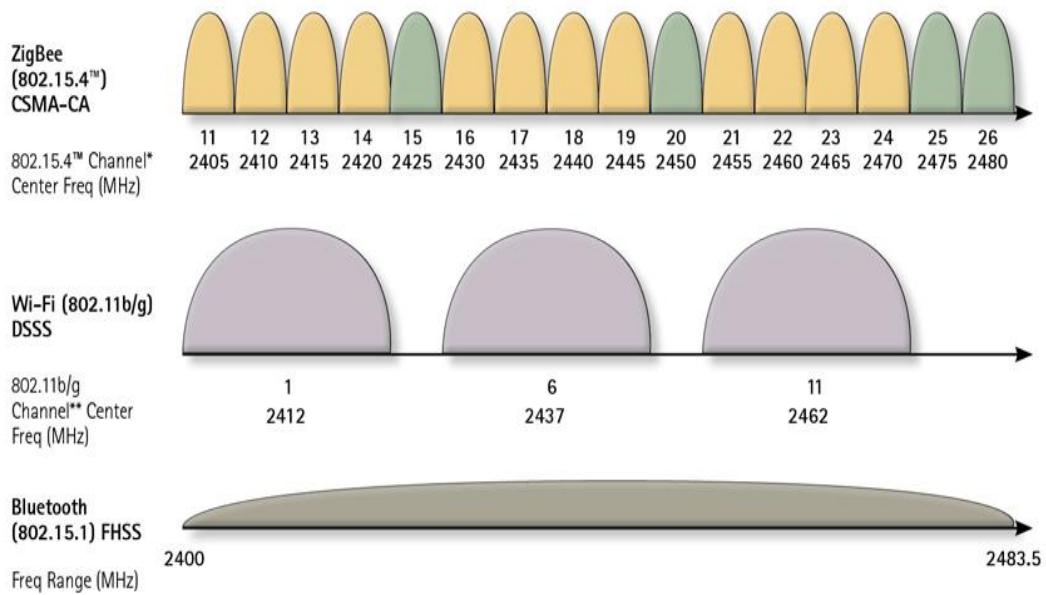
Figure 2.4 : ZigBee, Wi-Fi & Bluetooth Channels

Channels 1, 6 & 11 are recommended for use in the USA. Only 2.4 GHz channels are shown above. Different countries have different 802.11 b/g channels.

2.2 GPS architecture

2.2.1 What is the GPS?

These three characters GPS is an abbreviation of the words: Global Positioning System.

It is a navigation system composed of a network of satellites up to 24 satellites in fixed orbits of outer space defined by the U.S. Department of Defense. The main objective of this network of satellites purely military target, but in 1980 the government allowed the U.S. to have this system available for civilian use. The GPS system works under all types of weather conditions, and everywhere in the world, 24 hours a day, and you must subscribe in order to get this service as it's free.

2.2.2 GPS segments

The Global Positioning System consists of three major segments as follows:
1) Space segment, the satellite or space vehicles.
2) Control segment, ground station run by DOD (Department Of Defense).
3) User segment, all users and there GPS receivers.
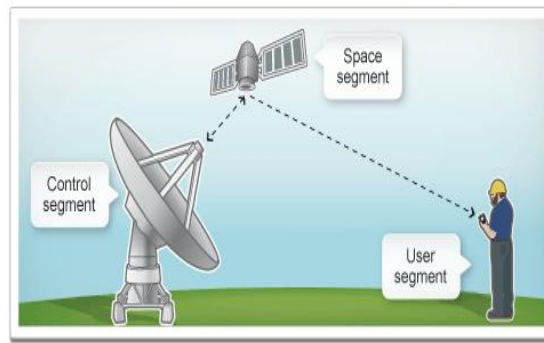
These three segments are illustrated in the figure below.

Figure 2.5 : GPS Segments

2.2.3 GPS signals

Each GPS satellite has several accurate atomic clocks on broad. The clocks operate at a fundamental frequency of 10.23MHz. This is use to generate the signals that are broadcast from the satellite. The satellites broadcast two carrier waves constantly. These carrier waves are in L-Band (used for radio), and travel to earth at the speed of light. These carrier waves are derived from the fundamental frequency, generated by a very precise atomic clock

L1 carrier is broadcast at 1575.42 MHz (10.23*154).

L2 carrier is broadcast at 1227.60 MHz (10.23*120).

The L1 carrier then has two codes modulated upon it. The C/A Code or Coarse/Acquisition Code is modulated at 1.023MHz (10.23/10) and the P-code or Precision Code is modulated at 10.23 MHz The L2 carrier has just one code modulated upon it. The L2 P-code is modulated at 10.23 MHZ.

2.2.4 Difference between GPS tracking and navigation

2.2.4.1 GPS Navigation

GPS device which performs the function of navigation is GPS receiver, which is receiving signals sent from GPS satellites system, and then making the calculation necessary to determine the coordinate of the position on the ground. From there, use the software necessary to show the coordinates of points on the screen of the device. The information that GPS can collect not limited on that was used to determine the coordinate of the position, but t can collect data about velocity and direction. GPS navigation system commonly used by drivers of vehicles in order to know their instantaneous position.

2.2.4.2 GPS tracking system

   Global positioning system tracking is a method of working out of where something is.

This type of GPS system consist two parts:
   1) GPS receiver which performs the function of navigation.
   2) Wireless network to send the information was collected by GPS to interested organization.

2.2.5 Sources of error in the signal of the GPS

   The GPS devices in recent years have become a very highly accurate. Thanks to the development of programs and spare receiver inside the device, that it was not without some obstacles that may affect the accuracy of the devices GPS, and perhaps the most important sources of error in this area include:

1) Errors due to the slow signal from the satellite, because the signal less speed when passing the atmosphere on its way to the device, usually equipped with GPS receivers calculate the rate of delay in order to correct this error.

2) Errors caused by the reflection or echo signal as a result of a collision with impediments such as buildings or long-rocks and mountains, and so on. This would increase the speed of transmission of the signal and thus cause errors.

3) Errors that occur because of the accuracy of the information sent by the satellite for its location in space.

4) Number of satellites that the device can see it; The greater the number of satellites increased accuracy and vice versa; The buildings and the electric and magnetic fields cause you do not see the device for satellites and thus cause cut the signal and cause errors in the selection or even an inability of the device at the location permanently.

5) Errors are caused due to the internal clock of the device, because this time is not accurate that the automatic clock in the satellite, and for that there may be errors due to timing.

2.3 Serial Port

In order to make two devices communicate, whether they computers, microcontroller, or any other form of integrated circuit, we need a method of communication and an agreed-upon language. The most common form communication between electronics devices is serial communication. Communication serially involves sending a series of digital pulses back and forth between devices at mutually agreed-upon rate. The sender sends pulses representing the data to be sent at the agreed-upon data rate, and the receiver listens for pulses at the same rate.

Communication as defined in the RS232 standers is an asynchronous serial communication method. The world serial means, that the information is sent one bit at a time. Asynchronous tells us that the information is not sent in predefined time slots. Data transfer can start at any given time and it is the task of the receiver to detect when a massage start and ends.

CHAPTER THREE   3

Conceptual Design

3.1 Introduction

After what has explained in the previous chapter about the theoretical background, this chapter describes the general block diagram of the whole system, and the system elements.

Usage of hardware and software to achieve the aim of the project. Where a hardware will be built using the GPS, ZigBee network, display and microcontroller. Also, the explanation will include the work design methodology.

3.2 System Functions

The project aims to achieve the following objectives:
1) Tracking the child location using the GPS Technology.
2) Building a system that takes the RSSI values at child and his parent to detect if the child exceeds the desired value or not, where if the child exceed this value the alarm will be on, otherwise off. Also, the system will take the coordinates of the child and his parent at first time as a reference value by GPS at the child to determine the distance, and the direction of the child with respect to his parent.

3.3 How does the system work?

In this system, the GPS device will be used only at the child side, when the GPS become ready to send data, it will send the first coordinates as an initial position value for both child and his parent, then as the child moving his coordinates will change, and the microcontroller at mother side will compare the child coordinates with the reference coordinates to determine the direction and the distance.

Also the Xbee devices will be used at both sides, the Xbee at the child side transmit the GPS data as packets to the Xbee at parent side through node to node ZigBee network. Where these packets carry RSSI value, then pass it to PIC microcontroller to compare the RSSI value for both Xbee devices with a threshold value, to detect if the child is close to his parent or not which will indicate as alarm. Where RSSI values give the project some features like working indoor.
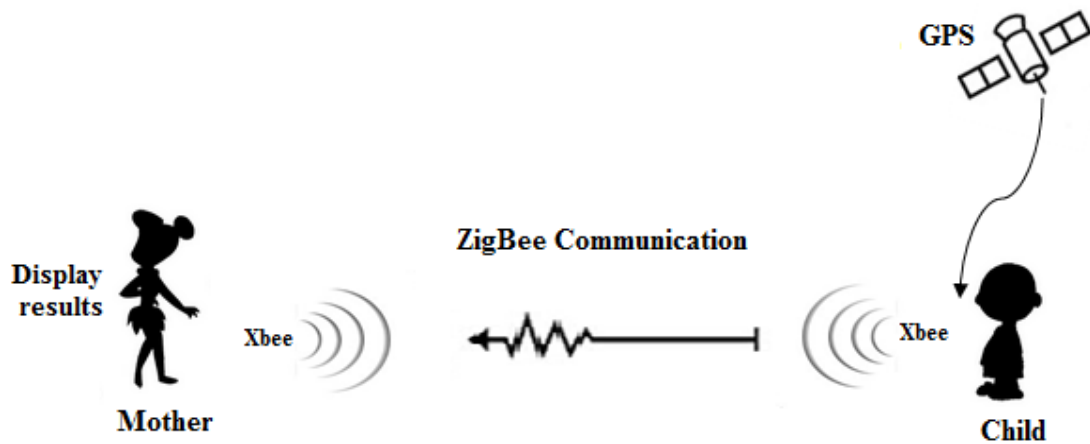
Figure 3.1 : Whole System

3.4 System Entities

Here a brief description for each device that will be used in the system. The aim of this section is not to explain how in details each device interacts with each other, but it is an introduction to the components in the blocks, and more detailed analysis will follow in the next chapter.

1) GPS tracker device at child side, used for tracking the child location by taking his latitude and longitude coordinates from GPS satellites, and updating his location automatically when he moved from one place to another. Also get the reference value as position for parent.
GS407 receiver will be used in our project, and it is characteristics are:
   • Smallest.
   • Most powerful.
   • High sensitivity.
   • usage of a newer helical antenna, which makes the overall length a bit smaller.
   • The module can be configured to an amazingly powerful 2Hz Update rate,
   with 50 satellite tracking channels for fast acquisition.

Figure 3.2 : GS407 module

2) Microcontroller, using PIC microcontroller to program the overall system, by using C programming language. Where there are two modes; in alarm mode if the child goes away from his parent, or in regular mode if the child is in safe and near to his parent. Now that the parent location and the child location is known, the distance and the direction from parent to child is calculated in microcontroller. Also it is used to convert the analog signals to digital signals to be accepted.

In this project PIC18F4550 will be used, this is due to:

- Economical price.
- Enhanced Flash program memory.
- All of the devices in the PIC18F4550 reduce power consumption during operation.
- The module supports both low-speed and full-speed communication for all supported data transfer types.
- It also incorporates its own on-chip transceiver and 3.3V regulator and supports the use of external transceivers and voltage regulators.
- 10-Bit A/D Converter.
- Enhanced Addressable USART: This serial communication module is capable of standard RS-232 operation.

The PIC18F4550 has all what is needed for the implementation of this project, enough I/O Ports, ADC, timers, and serial communication USART.

Figure 3.3 : PIC18F4550

3) Display, it will be used on parent side to display the distance and direction information of the child. So the parent will follow the direction of the index that

appears on the display which is led to find the child location, and the distance will appear on seven segment.

4) Xbee transceiver device at the child side, which takes the data, then send it to the parent side by ZigBee network.

5) Xbee transceiver device at parent side, it is form the communication link between the parent side and child side. Where it receives the data that sent from child side by using ZigBee network, and passes these data to the parent microcontroller.

In this project Xbee 1mW Chip Antenna will be used, and it is characteristics are:
  • Allow a very reliable and simple communication between microcontrollers, computers, systems, and anything with a serial port.
  • Point to point and multi-point networks are supported.
  • Built-in antenna.
  • 6 10-bit ADC input pins.

Figure 3.4 : XBee module

3.5 Software Design

MPLAB IDE and mikroC is a software program that runs on computers to develop applications for Microchip microcontrollers. It is called an Integrated Development Environment or IDE, because it provides a single integrated environment to develop code for embedded microcontrollers. And it is integrated toolset for the development of embedded applications. Where, MPLAB IDE runs as a 32 bit application on Microsoft Windows.

Flowcharting is a tool for analyzing processes. It allows you to break any process down into individual events or activities and to display these in shorthand form showing the logical relationships between processes.

The underlying structure of the two system modules (parent and child) are shown in the following figures.

As shown in figure 3.5, when the parent switches the child module on, the system will be ready to work. Firstly, acquires GPS coordinates for both child and parent. Then, process the coordinates to Xbee, where the GPS data will send in packets to the

Xbee unit at the parent side. This operation will continue on same loop till the parent switch the module off. Where every time the child changes his place, his coordinates will be changed automatically.

Where every time the parent module will send a command to GPS to start sending data we need it for position and distance calculations.
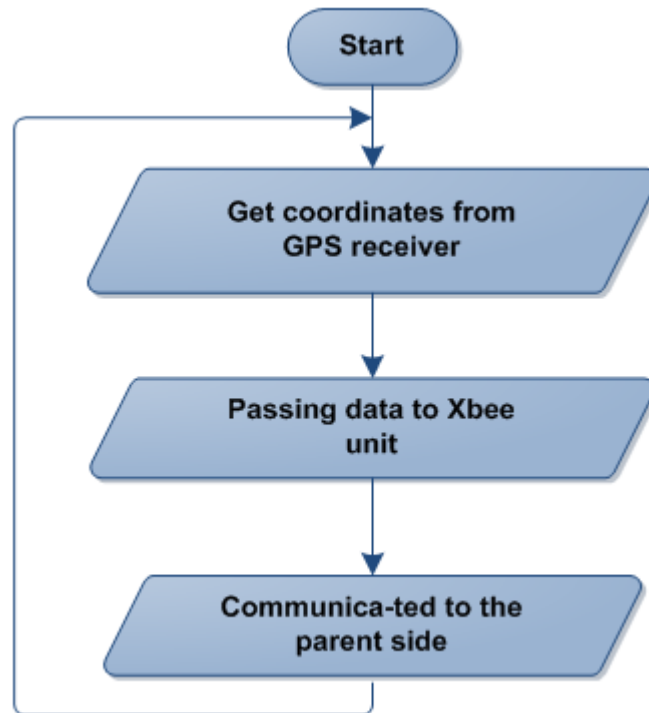

Figure 3.5 : Flowchart of child side

The parent side tasks illustrated in the figure 3.6:

When the parent switches his module on, he will enter the desired value with his child as a threshold value to get alarm, sending a command to GPS and waiting till receiving wanted data from child GPS. After receives the GPS reading, calculate the distance by some equations to determine the distance. The first GPS reading at parent side will acts as reference position to the child. By comparing the RSSI value from Xbee we can determine whether the child is in safe mode or not, by set a threshold value if the comparing result more than the threshold so the alarm will be on, otherwise it will be off.

Now, if the result of the display is not in the safe mode, the alarm will be activated and the result will be on display. These operations will continue on same loop until the parent switch the module off.
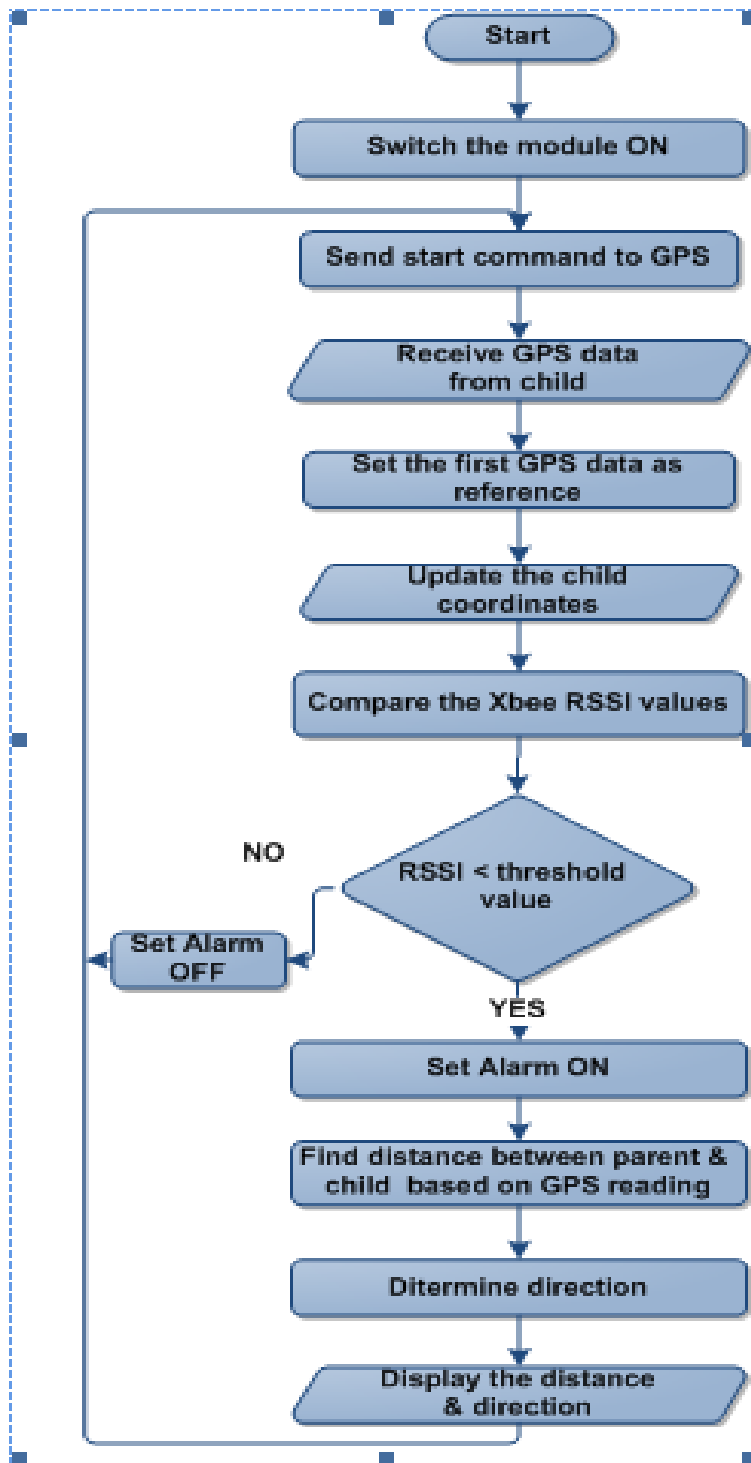
Figure 3.6 : Flowchart of parent side

CHAPTER FOUR

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Detailed System Design

4.1 Introduction

4.2 Detailed Description of the Project Hardware

4.3 Subsystem Detailed Design and Overall System Design

4.1 Introduction

As shown in previous chapter, this system has mainly two sides, transmitter (child side), and receiver (parent part). A division must be made between these parts in order to build the system. This chapter describes designing the whole system, and interfacing between PIC microcontroller and other unit that will need it at two sides.

A general system interfacing block diagram is shown in the following figure. It represents the interfacing of the whole system. Detailed interfacing circuits for each part will be discussed.
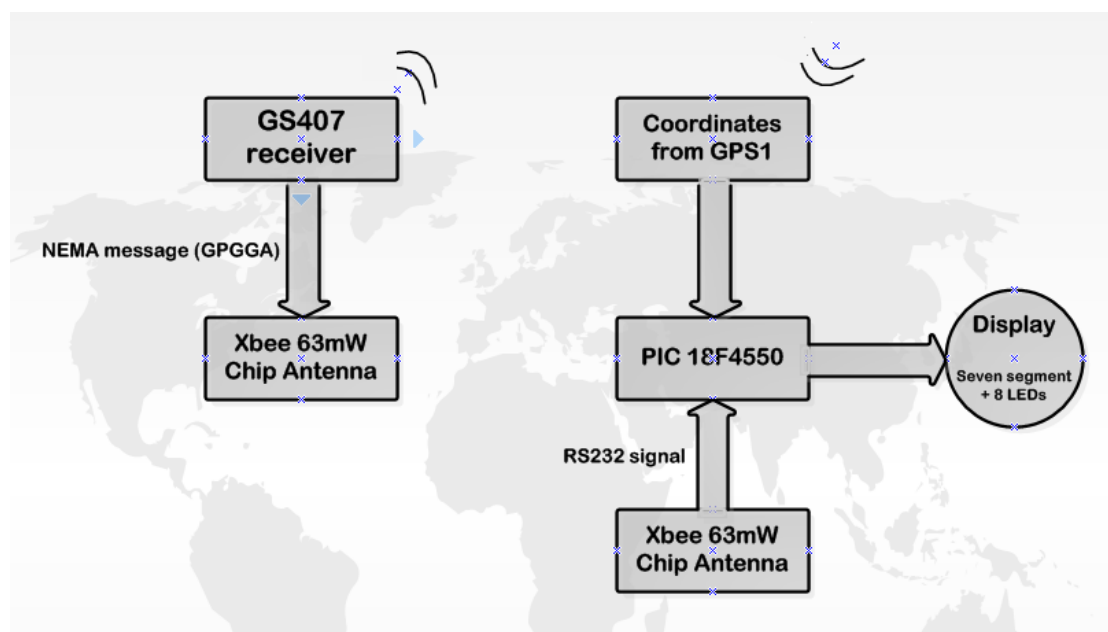

Figure 4.1 : Block Diagram for General System Interfacing

4.2 Hardware Description

In this section, a description for hardware that will use will be explained.

4.2.1 Microcontroller

Microcontroller is a Microchip programmable IC, that controls the inputs and outputs from each device. In our system internal oscillator will be enough to perform the project goals (For more information about PIC18F4550 refers to data sheet in Appendix C).Figure 4.2 shows the pins of PIC18F4550, more explanation for required ports will be illustrated.
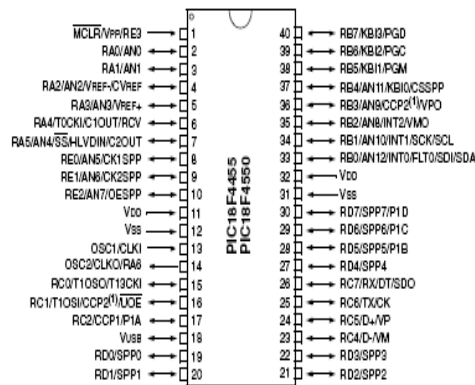
Figure 4.2: Pins out of PIC18F4550

Pin description:

1. **MCLR (pin 1):**
   - Provides method for triggering an external reset of the device.
   - This pin generated by holding the pin low.
   - The MCLR pin is not driven low by any internal reset.

2. **RX (pin 26):**
   - EUSART asynchronous receive.
   - This pin will be used at parent side to receive data from:
     GPS at the child side.

3. **Analog to digital converter (ADC):**
   ADC converts analog signal to digital that can be read by computer. The following steps should be followed to perform an ADC conversion:
   - Configure the ADC module
     - Configure analog pins, voltage reference and digital I/O (ADCON1).
     - Select ADC input channel.
     - Select ADC acquisition time.
     - Select ADC conversion clock.
     - Turn on ADC module.

4. **Oscillator frequency:**

   The operation of the oscillator in PIC18F4550 devices is controlled registers. Configuration registers, select the oscillator mode. As Configuration bits, these are set when the device is programmed and left in that configuration until the device is reprogrammed. The OSCCON register selects the Active Clock mode; it is primarily used in controlling clock switching in power-managed modes.

Oscillator Types:
   PIC18F4550 devices can be operated in twelve distinct oscillator modes. From these mode we use internal oscillator that have 8MHz.

Serial port:
   PIC 18F4550 has two major serial modules : the master synchronous serial port and Universal Synchronous Asynchronous Receiver Transmitter (USART).

Calculation needed
(Note : equation find for USART part of serial port section)
8 MHz oscillator
9600 baud asynchronous
For BRGH = 1
SPBRG = 4000000/(16 x 9600) - 1 = 51.08
For BRGH = 0
SPBRG = 4000000/(64 x 9600) - 1 = 12.02

Best choice is BRGH = 0, SPBRG = 12.02
As of a baud rate calculation, the microcontroller operating at 8 MHz and we use 9600 baud to communicate with a serial port on XBee. USART used in asynchronous mode. We choice BRGH = 0, because less error than BRGH = 1.

4.2.2   Xbee Pro

   From one of the main objective on this tracking child system, XBee module will use as communication channel to make parent able to monitor their child location in far case. In this project Xbee Pro 63mW Chip Antenna will be used. (For more information about Xbee 63mW Chip Antenna refers to data sheet, Appendix A).
This module has the following features, which are important in this system:
   - 3.3V at 50 mA.
   - 250 kbps Max data rate.
   - 63mW output (18dBm).
   - 300 ft (90m) range.
   - Built-in antenna.
   - AT or API command set.

Output power:
   It is the actual amount of power (in watts) of radio frequency energy that a transmitter produces at its output.

Data rate:
   Number of bits can send per second, this module is able to send 250 kbps, and this is enough for the system because we need about 9600 bps.

AT command set:
   To modify or read RF Module parameters, the module must first enter into Command Mode, a state in which incoming characters are interpreted as commands.

Pins description:
   Figure 4.3 shows the pins of XBee Pro 63mW Chip Antenna. More explanation for required ports will be illustrated. (For more information about Xbee 63mW Chip Antenna refer to data sheet, Appendix A).

Figure 4.3 : XBee module

1. **DIN (Pin 3):**
   - UART data in.
   - Serial data enters the RF module through the DI pin.
   - This pin will be used at:
     - ✓ Transmitter (child side): to receive data from GPS that contains information about child location
     - ✓ Receiver (parent side): acts as antenna receives the signal that transmits from XBee at child side.

2. **DI (Data In) buffer:**
   Place where is the serial data will be stored after it enters through DI pin.

3. **DO (Data Out) Buffer:**
   - Data which was received 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.

4. **VCC (pin 1):**
   - Provide power to the RF module.
   - XBee need 3.3 volt.

5. **DOUT (pin 2):**
   - UART data out.
   - Used to send serial data to a host device.
   - This pin will be used to:
     At transmitter (child side): transmit data wireless.
     At receiver (parent side): move data to PIC18F4550.

6. **PMW0/RSSI (pin 6):**
   Will be used to read the received signal strength.

7. **GND (pin 10):**
   Connect it to ground.

   Design note:
   1. Before connecting XBee module there are things must be drawn to it.
   2. Minimum connections: VCC, GND, DOUT & DIN.
   3. Signal Direction is specified with respect to the module.

4.2.3 GPS Receiver:

Child Locator uses GPS technology to acquire both the parent and child devices location. It can operate in any outdoor environment in the world.
This unit receives RF (radio frequency) signal, which it analyzes in order to determine it is own location

GPS receiver will be used is 50 Channel GS407 Helical GPS Receiver. (For more information about 50 Channel GS407 Helical GPS Receiver refer to data sheet, Appendix B).

This module has the following features:
   - 2 Hz Update rate.
   - Fifty satellite tracking channels for fast acquisition.
   - Supports UBX data protocol at various standard baud rates.
   - Filtering effect of the antenna gives high immunity to RF interference.
   - Wide antenna Beam width.
   - Low power: 3.3V @ 75mA.
   - Sensitivity less than -160dBm.
   - Support NMEA protocol.

Sensitivity:

It is the minimum magnitude of input signal required to produce a specified output signal having a specified signal to noise ratio, or other specified criteria.
GPS signals are already very weak when they arrive at the Earth's surface. The GPS satellites have transmitters that only deliver 27 W from a distance of 20,200 km in orbit above the Earth. By the time the signals arrive at the user's receiver, they are typically as weak as −160 dBW, equivalent to one tenth of a millionth billionth of a watt. This is well below the thermal noise level in its bandwidth. Outdoors, GPS signals are typically around the −155 dBW level.

Standard NMEA- 0183:

NMEA 0183 is a combined electrical and data specification for communication between marine electronic devices such as echo sounder, sonar's, anemometer, gyrocompass, autopilot, GPS receivers and many other types of instruments. It has been defined by, and is controlled by, the U.S. based National Marine Electronic Association.

Figure 4.4 shows 50 Channel GS407 Helical GPS Receiver. (For more information about 50 Channel GS407 Helical GPS Receiver refer to data sheet, Appendix B).

Figure 4.4 : 50 Channel GS407 Helical GPS Receiver

GS407 Breakout Board

This is a breakout board to allow simple access to the tightly pitched pins on the GS406 and GS407 GPS units. This board breaks out all of the necessary pins to a row of standard 0.1 spaced header to allow for easy bread boarding and simple connection. Figure 4.5 shows the pins of GS407 Breakout Board.

Figure 4.5 : GS407 Breakout Board

4.3 Subsystem and Overall System implementation

After design option of the project was introduced and the components that will be needed to implement the system defined. In this part we will talk about interfacing between all component.

4.3.1 Interface at transmitter (child side)

In this part the interface between GPS receiver and Xbee will be shown, this interface can be explained as the following:

1) Connection between Xbee and GPS Receiver:

Through this interface ASCII, serial data from GPS will pass to transceiver according to the request from microcontroller at parent side and stored and stored at DIN buffer in order to be transmitted . Note that this connection will be direct without need to any interface between them.
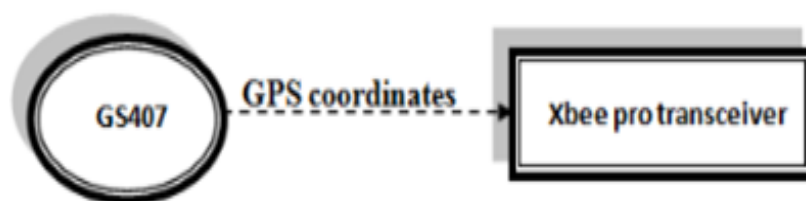

Figure 4.6 : Type of message transfer by GPS to Xbee

Figure below shows connection between Xbee to GPS as explained previously.
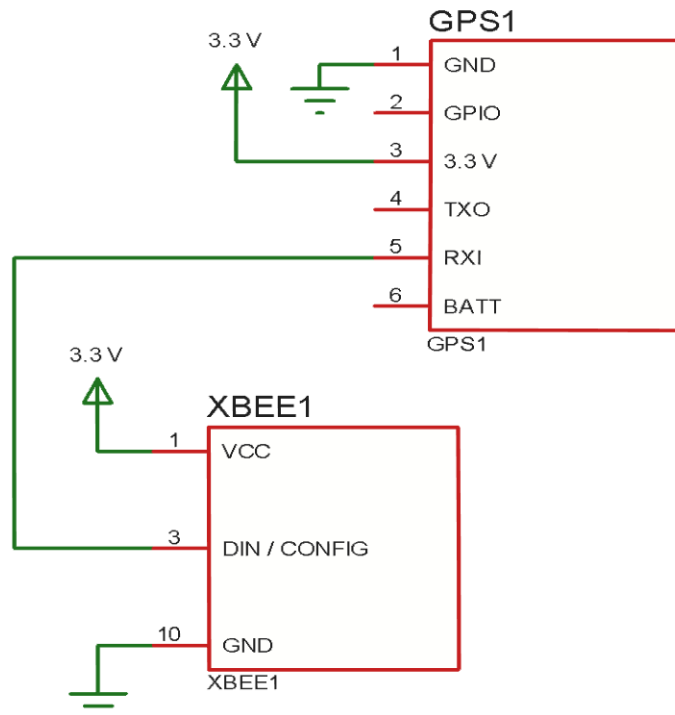

Figure 4.7 : Interface between GPS and XBee at child side

4.3.2 Interface at Receiver (Parent side)

In this part detailed description for the connection between XBee and Microcontroller will be shown at receiver, this interface can be explained as the following.

1) Interface between PIC18F4550 and XBee pro module.

Used Xbee at parent side aims to pass two main messages to PIC18F4550 as shown in figure. GPS coordinates passes to transceiver in digital format this received packet can be employed to calculate the distance and direction according to Latitude and longitude for far situation ,also if we depend on RSSI of these packet we can control the operation of alarm at near situation.

Power threshold:
The threshold value of RSSI is -70 dBm. If it is reach with value lower than this threshold, alarm will activate to indicate the child is far.
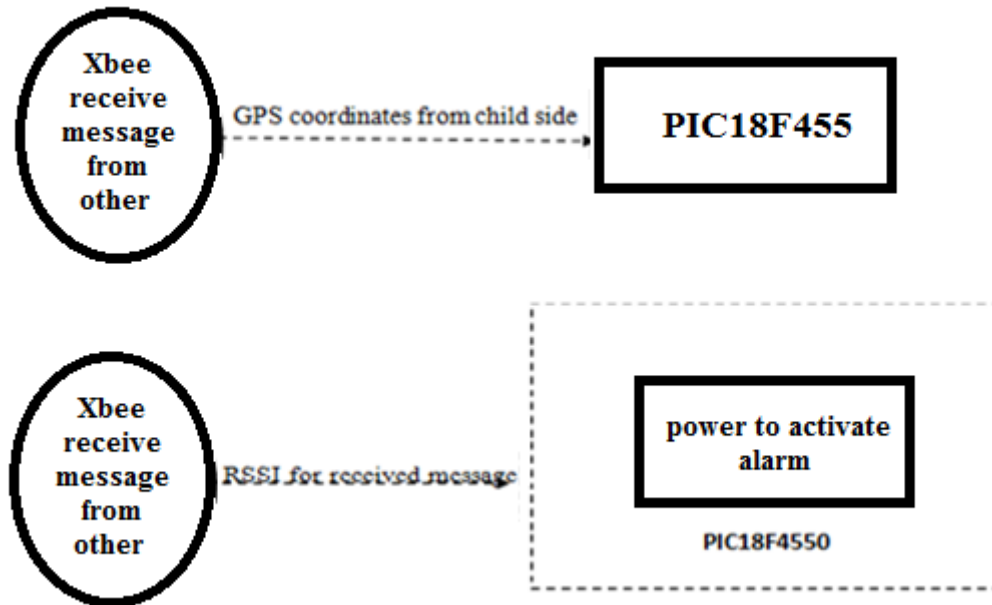
Figure 4.8 : Block diagram for dataflow between Xbee and PIC18F4550

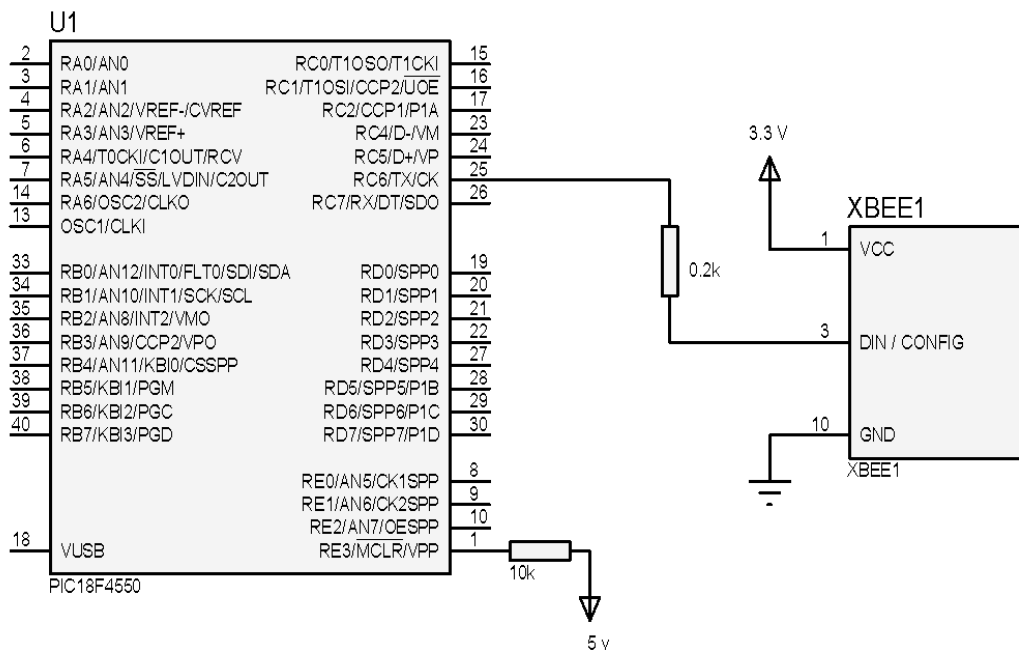Figure below shows how connect Xbee to PIC as explained previously.

Figure 4.9 : Interface between PIC18F4550 and XBee at parent side

2) Connection between PIC18F4550 and buzzer.

Dependent on power threshold parent can monitor his child if he far away or near so buzzer will be activate or not.
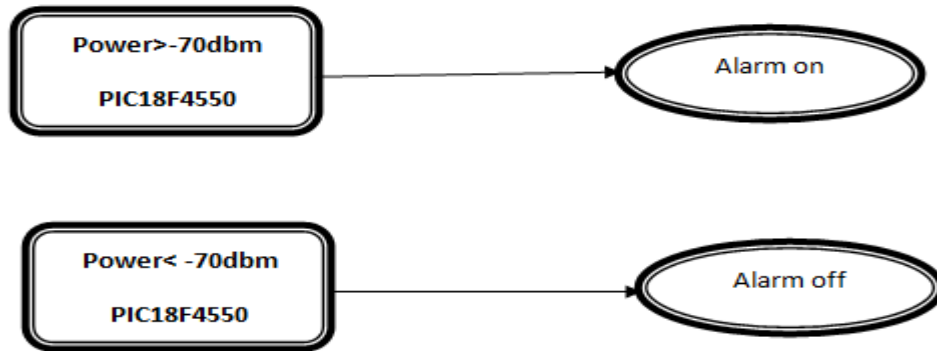

Figure 4.10 : Block diagram for PIC18f4550 and alarm

3) Connection between PIC18F4550 and seven segment.

Seven segment will use to display distance between child and her parent in loss case. It will connect to port B at pic18f4550.

Figure below shows the connection between PIC18F4550 with seven segment and buzzer.
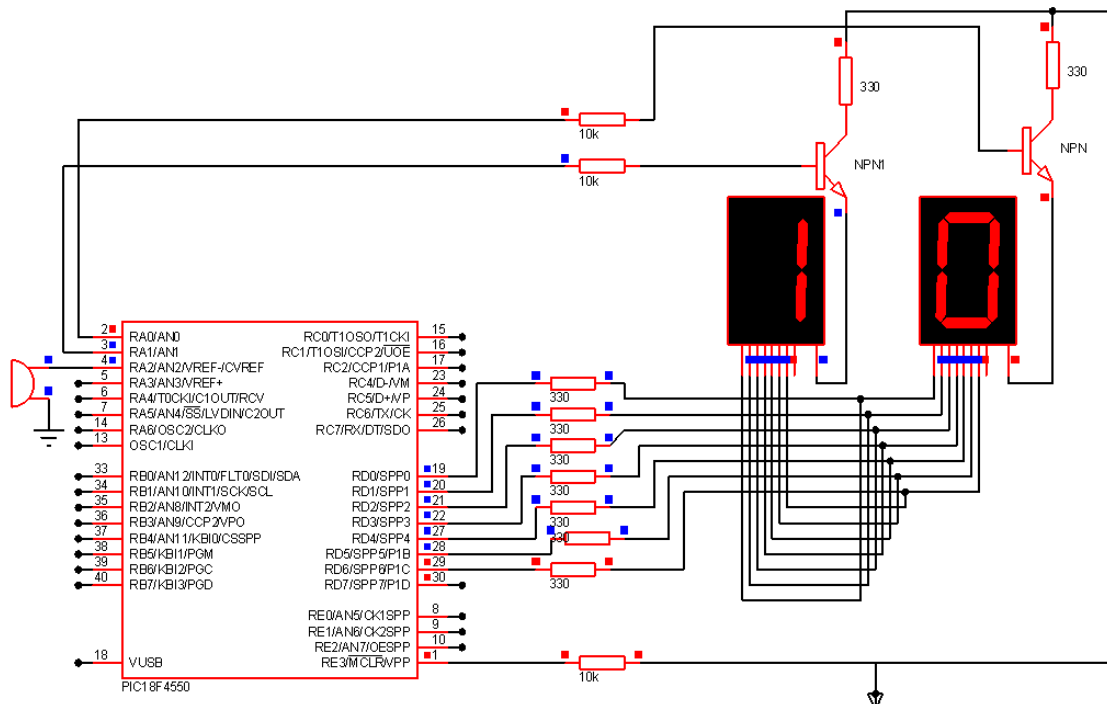
Figure 4.11 : Interface between Seven segment and buzzer with PIC18F455

4) Connection between 8 LED's and PIC18F4550.

According to GPS coordinates and after PIC18F4550 determine direction parent can know the child movement in any direction (south, east, north, east, northeast, northwest, southeast, southwest).
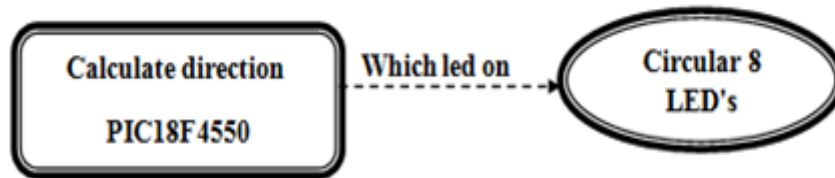
Figure 4.12 : Block diagram for PIC18f4550 and circular 8 led's
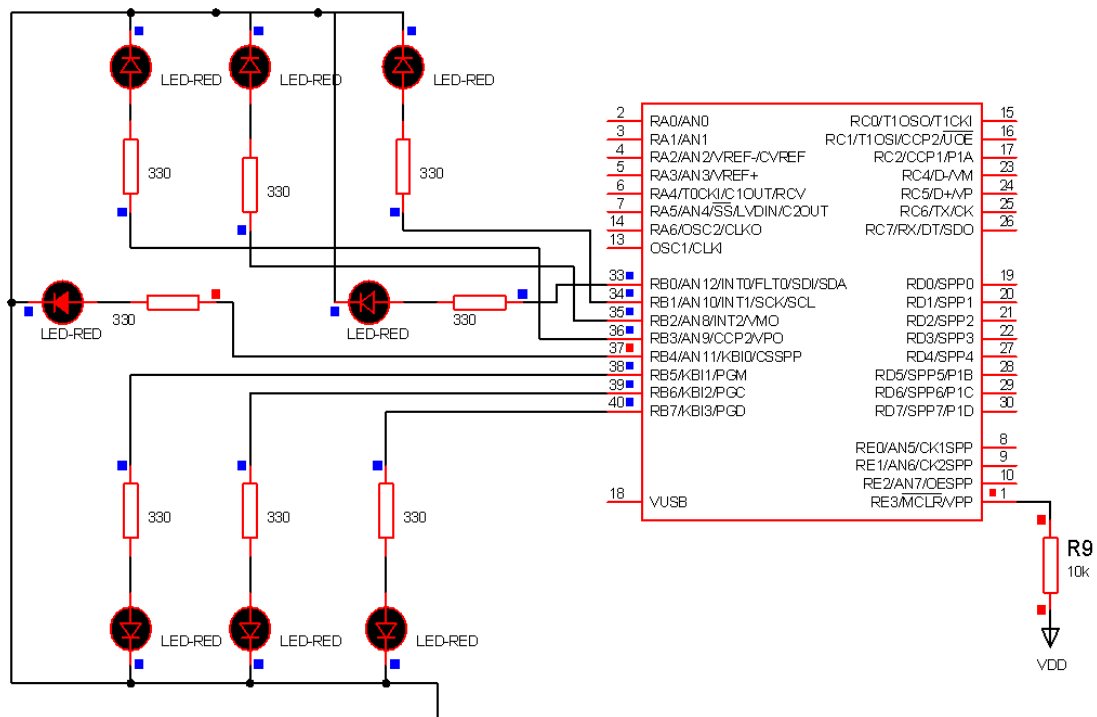

Figure 4.13 : Interface between LED's and PIC18F4550

5) Total system interface at receiver side:
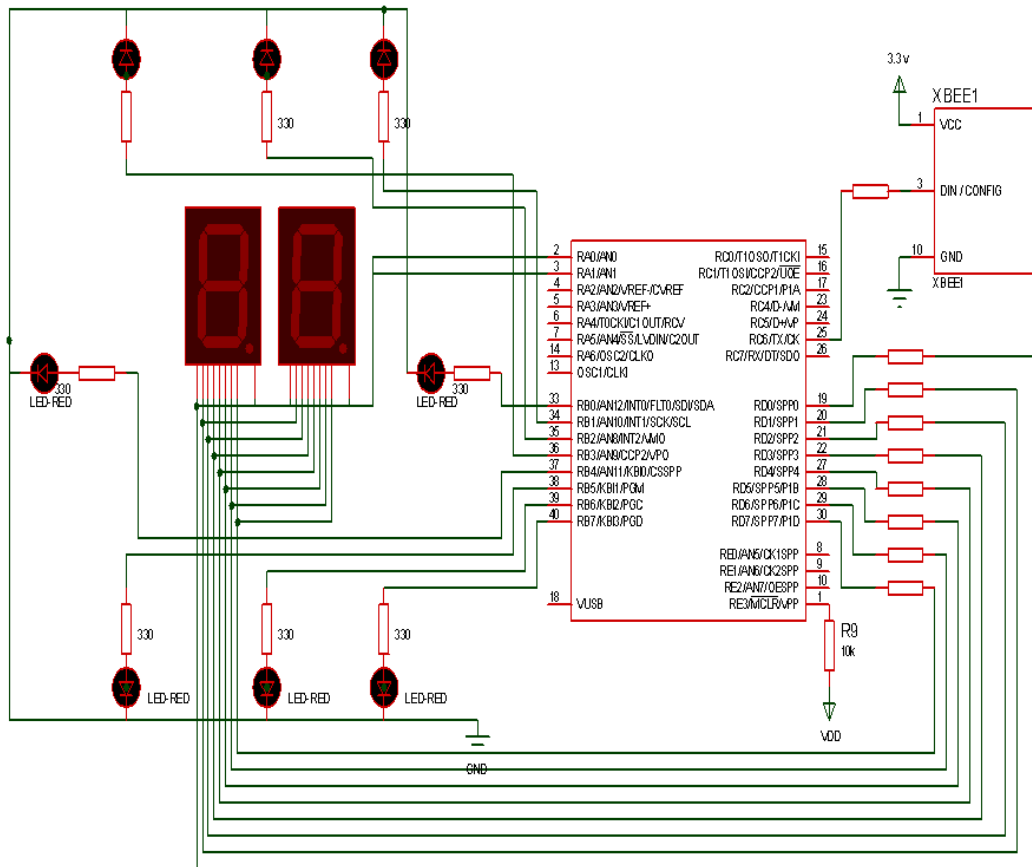
Figure 4.14 : Total system interface at receiver (parent side)

CHAPTER FIVE 5

Hardware and Software Implementation

5.1 Introduction

5.2 Hardware Environment

5.3 Preparing Xbee and GPS modules

5.4 Software Environment

5.5 Conclusion

5.1 Introduction

This chapter will present project software and hardware in details, The whole building and constructing stage will be described, that means how to operate each part independently, in addition how to interface and test these parts.

5.2 Hardware Environment

There are different applications and tools used to implement the hardware system, which used for the project implementation, processing, and testing.

5.2.1 X-CTU

A convenient tools for Xbee module programming offered by Digi International. With this software, the user will be able to upgrade the firmware, update the parameters, perform communication testing easily.
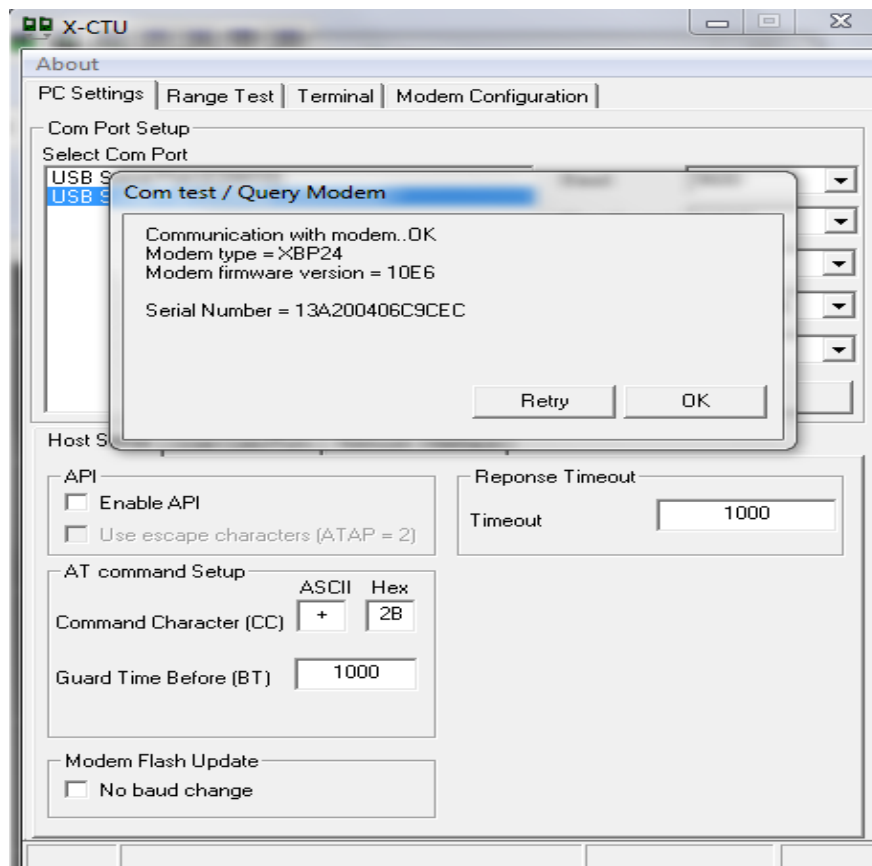
Figure 5.1 : X-CTU program

5.2.2 U- center 6.21

This is a powerful GPS Evaluation Software, it allows end user to assess and test u-blox GPS receiver for navigation and positioning performance. The purpose of u-center is to enable users to:

- Conduct performance tests on u-blox and other GPS receivers.
- Configure u-blox GPS receivers.
- Access and download Firmware updates.
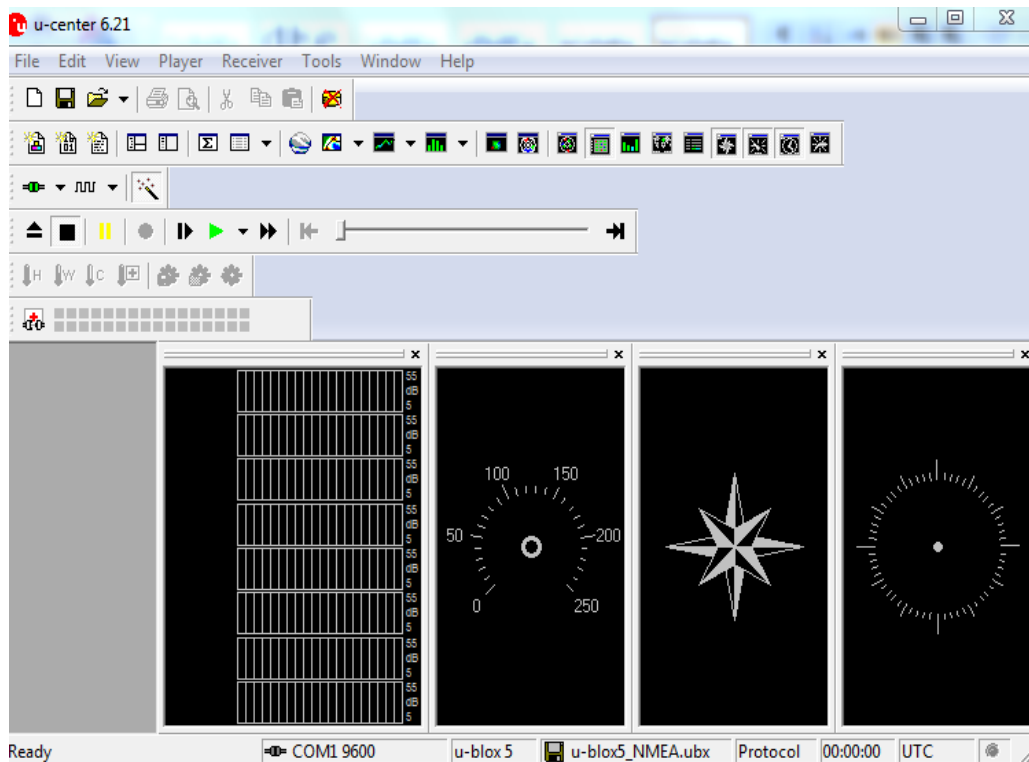
Figure 5.2 : U-center 6.2.1 software

5.2.3 Proteus 7.8

Proteus is a complete tool for the design of electronic circuits, based on the models of electronic components in PSpice. A distinctive feature of the package Proteus Professional is the possibility of modeling of the programmable devices: microcontrollers, microprocessors, DSP.
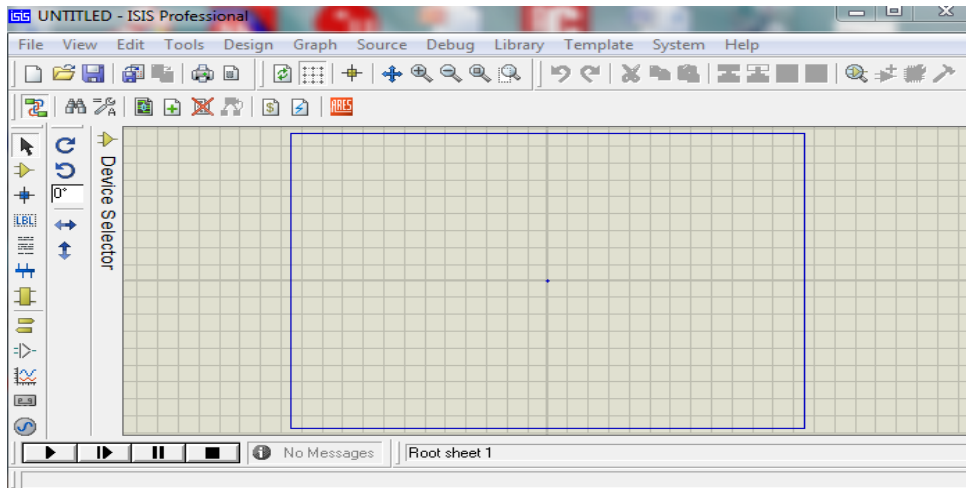
Figure 5.3 : Proteus 7.8 program

5.3 Preparing Xbee and GPS modules

Preparing GPS and Xbee modules aims to achieve that both modules are enable to work independently before we interface each of them with other device.

5.3.1 Xbee configuration

Zigbee will be used as communication technology in this system, so it's important to make the communication between sender and receiver available. X-CTU software will be used to make the modem configuration, we enter to the modem through AT command, and change only PAN ID to (1111) at two sides. Note that it is not necessary to change the destination and source address because we have one sender and receiver only so (0000) will be enough to make them communicate with each other.
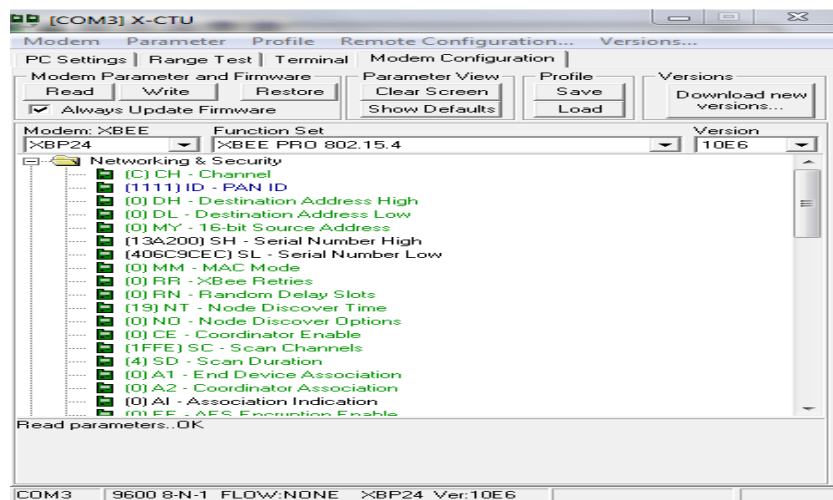
Figure 5.4 : Xbee modem configuration using X-CTU

5.3.2 Xbee testing

After the configuration for Xbee modems has been made, testing must be applied to ensure the communication between them. To perform this test one Xbee connected to the PC using the Xbee USB adapter, and a remote Xbee with power and a loopback will be used. For the loopback, DOUT is connected to DIN which will cause any received data to be transmitted back the PC. As shown in the figure below, we connect LEDS (Red) to the circuit to give indication about the status if this led on that mean Xbee receives data from Xbee connected to PC.
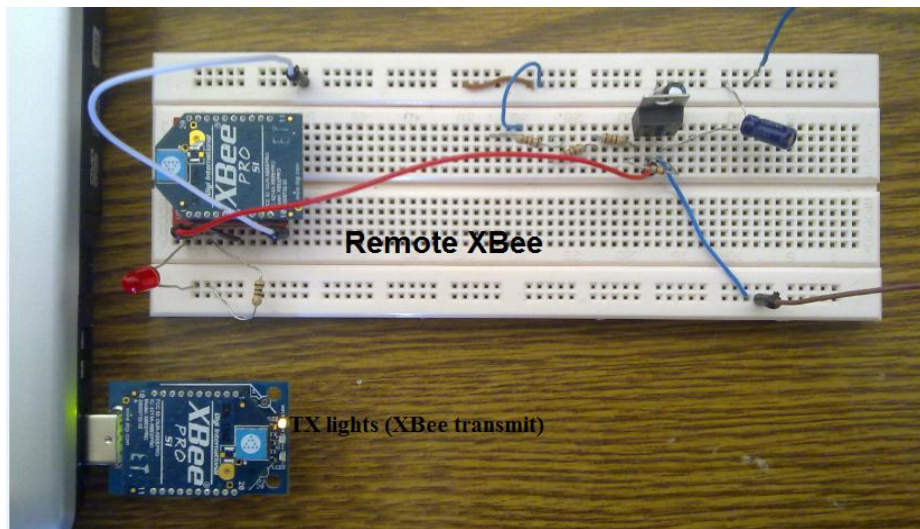
Figure 5.5 : Remote Xbee with Loopback

5.3.3 GPS testing

The purpose from this test is to ensure that GS407 receiver able to see the satellites and receive the coordinates from them. This test has been done via FTDI cable with USB entrance connected to PC as shown in figures below.

Figure 5.6 : GS407 connected to FTDI cable
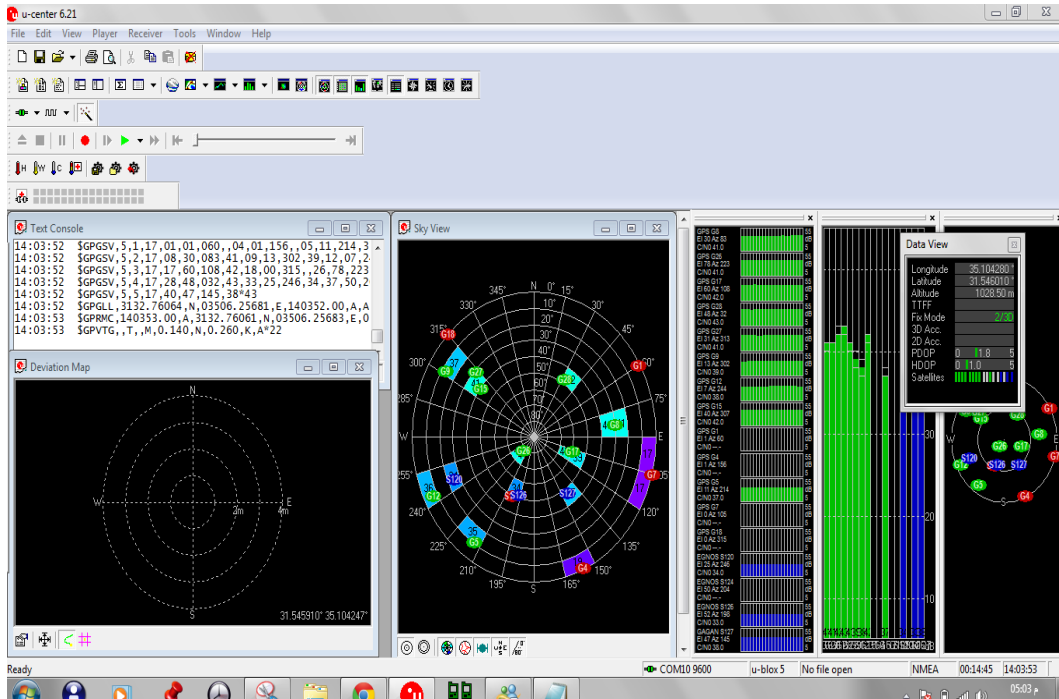
Figure 5.7 : GS407 as shown on u-center6.2.1

As shown in figure below, GREEN color indicates for satellites that GPS ready, and RED color indicates there is no signal reach to GPS.
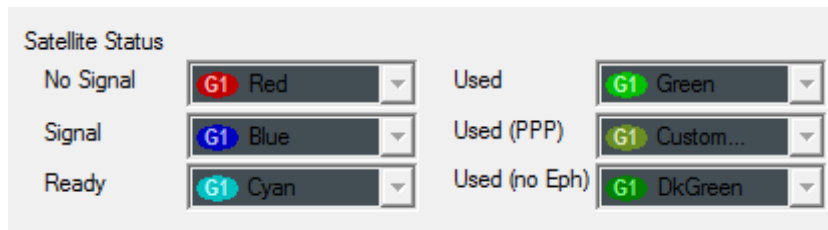
Figure 5.8 : Satellite Status

5.4   Software Environment

The software is written in C language and compiled using C compiler.

5.4.1   MPLAB IDE v8.76

  MPLAB IDE is a software program that runs on computers to provide a
development environment for embedded microcontroller design.

The design cycle for developing our project is:

1) Determine design based on the associated hardware circuits.

2) Knowing which peripherals and pins control hardware to write the software. We
use a compiler that allows more natural language for creating programs. With these
Language Tools we can write and edit codes.

3) Compile or assemble the software using a Language Tool to convert code into
machine code for the PIC device.

4) Download and test code. Usually a complex program does not work exactly the
way might has imagined, so we need to download and test always to verify that it
executes correctly.

  MPLAB contains untitled workspace which contains needed file after create project,
every needed file contains main three parts:

Source File : add file that contains the code of the project.

Header File (gamelinit.h).

Linker File (p18f4550.lkr).

Output window to be sure that your code executes correctly.
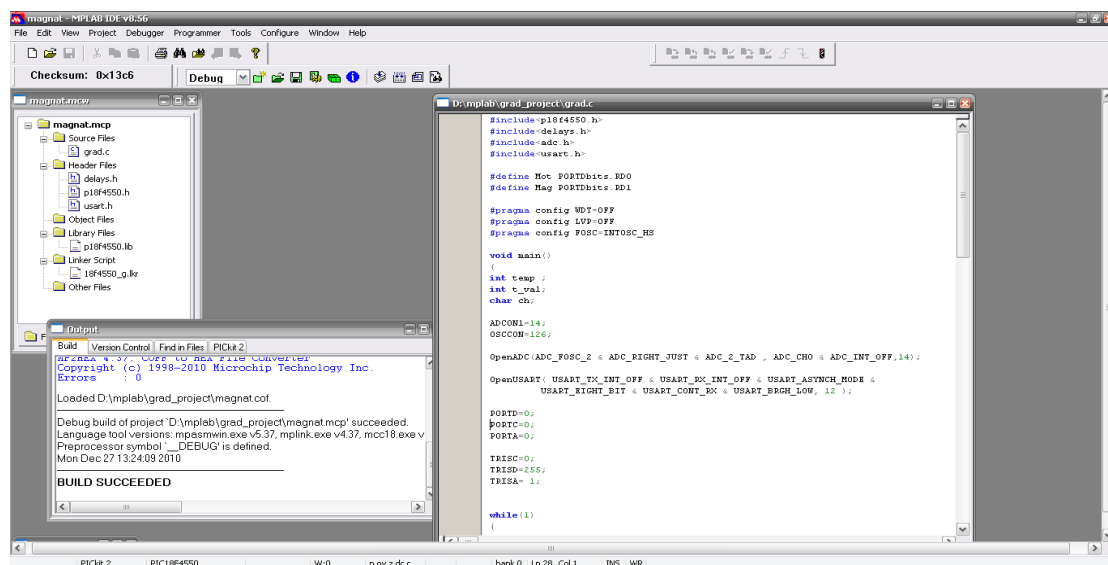
Figure 5.9 : MPLAB Environment

After we complete the code, we can use memory usage gauge to know how much the program take capacity from the memory as shown in following figure:
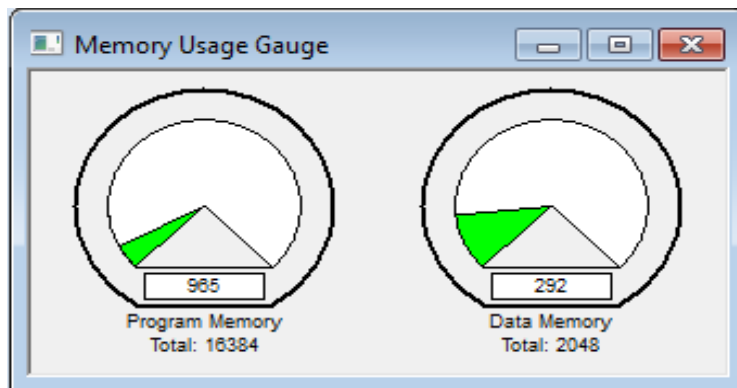
Figure 5.10 : Memory Usage Gauge

For downloading program in PIC, we can use one of programmer reference in MPLAB, in this project we use MPLAB ICD 2.

5.4.2 MPLAB ICD2

The MPLAB ICD2 is an In circuit debugger (ICD) and In Circuit Serial Programmer (ICSP). Which is used in evaluation, debugging and programming in a laboratory environment. It allows debugging and programming of PIC microcontrollers using the powerful graphical user interface of the MPLAB Integrated Development Environment (IDE). The MPLAB ICD2 is connected to the design computer using USB or RS232 interface and can be connected to the target which is PIC via an ICD connector.
It supports many device families like; PIC10F, PIC12F, PIC16F, and PIC18F.

Figure 5.11 : MPLAB ICD2

And in this project, we learn how to built a programmer device by ourselves to download the project codes at home, which is shown as in the following figures:
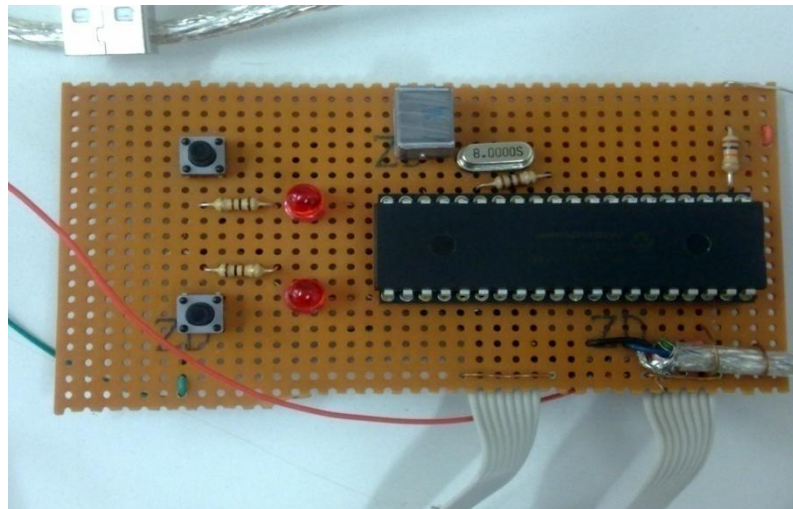
Figure 5.12 : Project programmer

The following figure shown the programmer device when we connect it with computer to download the code, when we connect it to computer; if the red led light, so the computer recognizes the programmer and it is ready for downloading. Where the orange led is lighting when the code is still downloading.
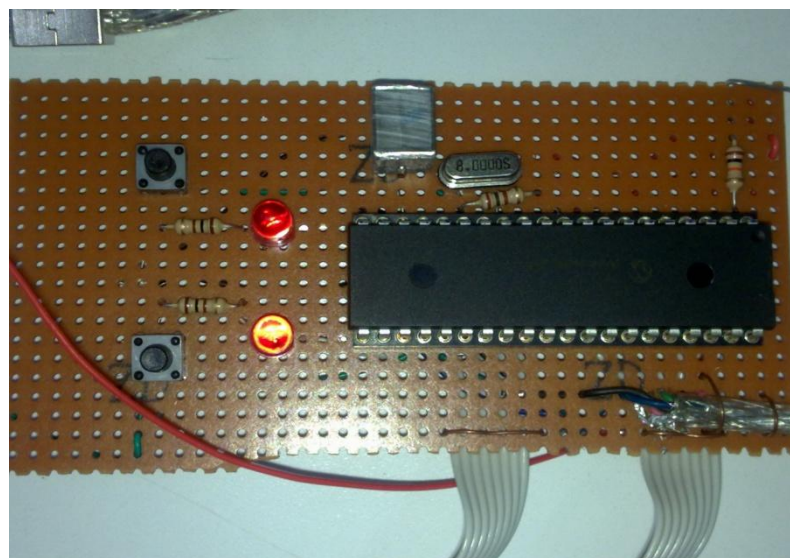
Figure 5.13 : Programmer in downloading

Code will be explained in appendix D, but we explain main code function here. In our code we use main two libraries that ADC library, and USART library as shown in the following figures.

5.4.3 ADC library

  Analog to digital converter library can be found on(ADC.h). Following figure shows the main function used in ADC.
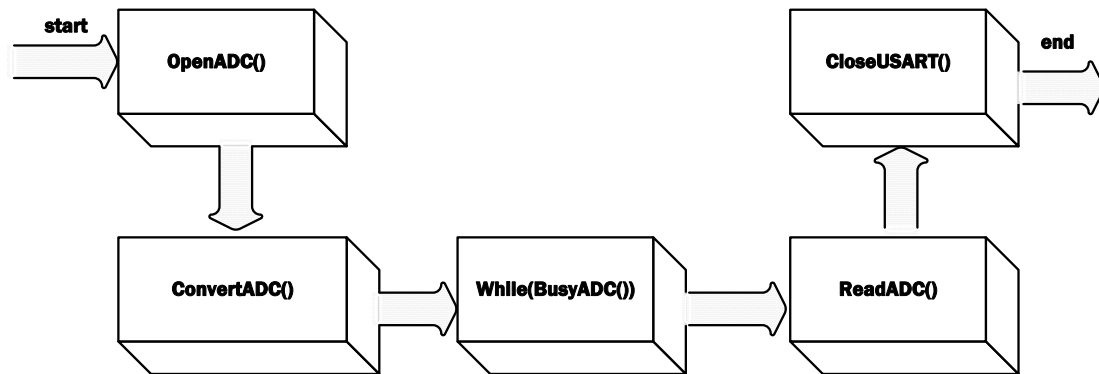
Figure 5.14 : Steps ADC Conversions

OpenADC include:
ADC_RIGHT_JUST: there are two registers store value of conversion, so we can determine if read left justified or else.
ADC_2_TAD: 4 Tad.
ADC_CH0: Channel 0 (AN0).
ADC_INT_OFF: Interrupts disabled.

5.4.4 USART library
Main step for USART using C18 library as shown in figure.
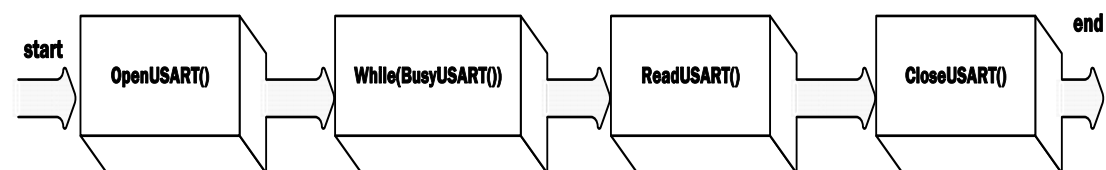
Figure 5.15 : USART Library

OpenUSART include:
USART_TX_INT_OFF: Transmit interrupt OFF.
USART_RX_INT_OFF: Receive interrupt OFF.
USART_ASYNCH_MODE: Asynchronous Mode.
USART_EIGHT_BIT: 8-bit transmit/receive.
USART_CONT_RX: Continuous reception.
USART_BRGH_LOW: Low baud rate.
SPBRG: Set the clock cycle to the value we want for the baud rate.
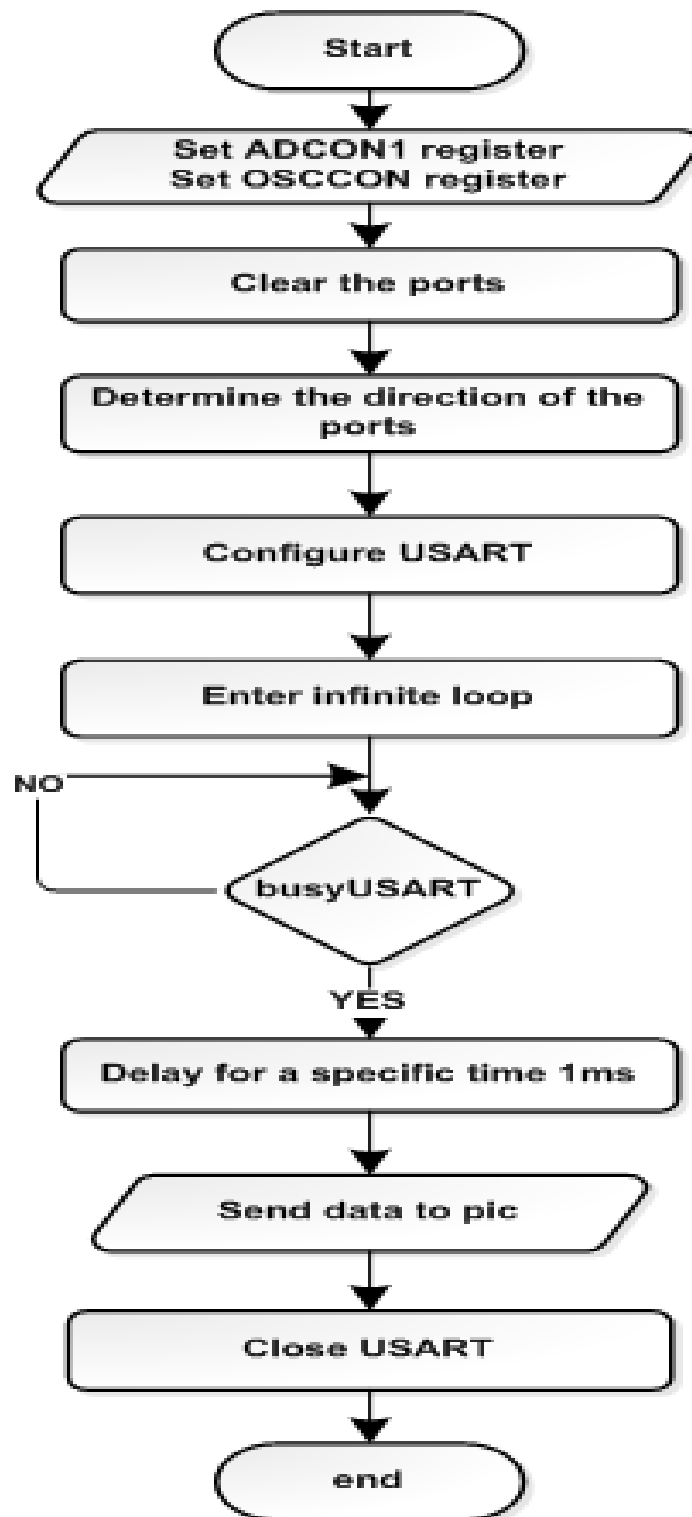
Figure 5.16 : Flowchart for serial communication

5.4.5 MikroC program

MikroC is one of the powerful and easy to use software for programming PIC microcontrollers in embedded C. MikroC is a powerful, feature rich development tool for PIC microcontroller. It is designed to provide the customer what the easiest possible solution for developing applications for embedded systems, without compromising performance or control. Applications can be developed quickly and easily using MikroC for PIC microcontrollers. It provides a simple windows based point and click environment for developing applications.

PIC and C fit together well; PIC is the most popular 8-bit chip in the world, used in a wide variety of applications, and C prized for its efficiency, is the natural choice for developing embedded systems. MikroC provides a successful match featuring highly advanced IDE, ANSI complaint compiler, broad set of hardware libraries.

Figure 5.17 : MikroC program

5.4.6 Software Description of GPS

The GPS receiver in normal mode will be off, and if we want GPS data (latitude and longitude), a command must send from microcontroller at parent to GPS at child side to send it is data.

```
While(1)

for(j=0;j<750;j++)

{

if(txt[j]=='G'&&txt[j+1]=='P'

   &&txt[j+2]=='G'&&txt[j+3]=='L'

   &&txt[j+4]=='L')

}
```
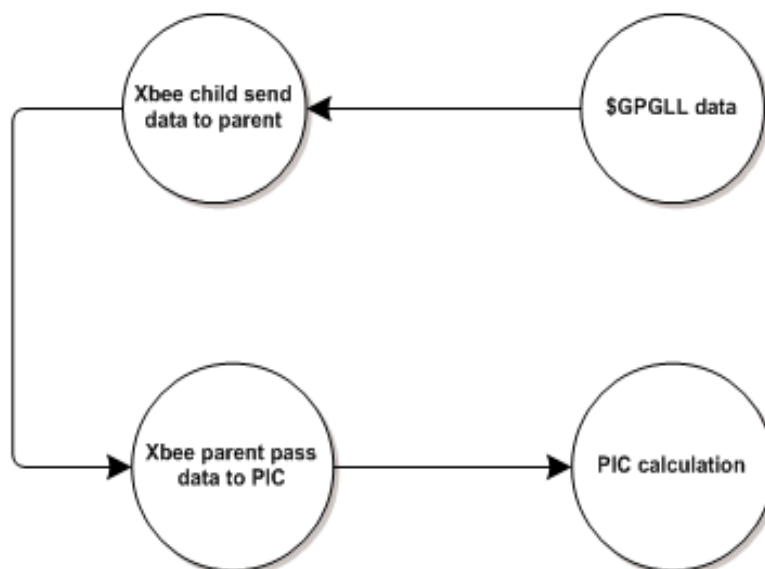

Figure 5.18 : Asking for GPS data

5.4.7 Software Description of Xbee

   Xbee is used to send data from child side to the mother side, and receive this data at parent side.
Xbee at child side will send the $GPGLL data on packets to Xbee at parent side.
Xbee at parent side will send command from PIC microcontroller to GPS at child side to allow it to send data. Also, Xbee here will receive power strength that is get from packets send from Xbee at child side.

```
while(1)

{

uart1_write_text("Lat=");

for(j=0;j<5;j++)

uart1_write(Lat[j]);

}
```
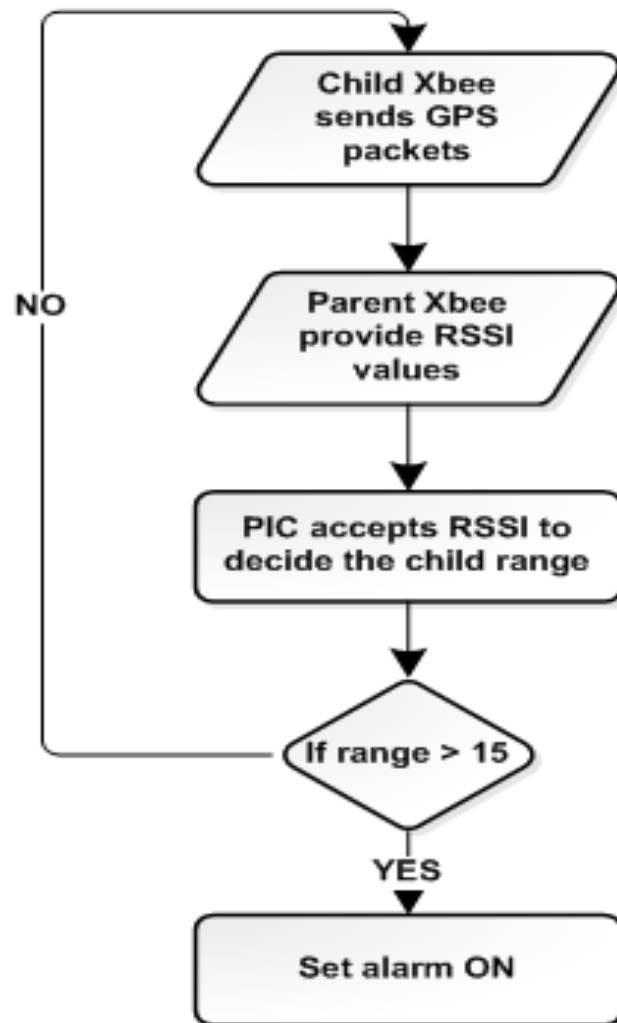

Figure 5.19 : Alarm decision

5.4.8 Software Description of seven segment

We used two Seven segment at parent side to display the distance between the child and the his parents. And the description below shows the programming of the first seven segment.

```
if(SEVEN_A==0)PORTB=20;

else if(SEVEN_A==1)PORTB=126;

else if(SEVEN_A==2)PORTB=152;

else if(SEVEN_A==3)PORTB=88;

else if(SEVEN_A==4)PORTB=114;

else if(SEVEN_A==5)PORTB=81;

else if(SEVEN_A==6)PORTB=17;

else if(SEVEN_A==7)PORTB=116;

else if(SEVEN_A==8)PORTB=16;

else if(SEVEN_A==9)PORTB=80;
```
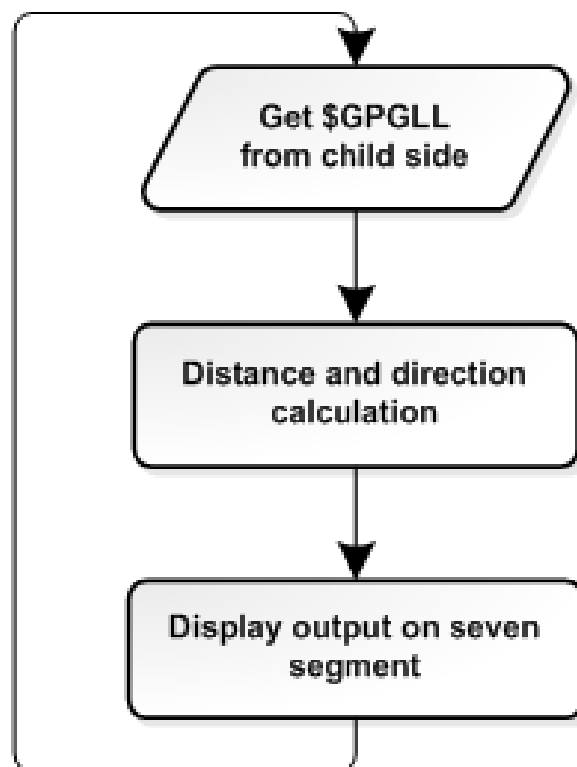

Figure 5.20 : Displaying distance

5.4.9 Software Description the direction

We use slope method to determine the direction from using threshold value, and depend on the threshold value we decide the direction (North, East, West, South, Northeast, Northwest, Southeast, Southwest).

```
while(1)

{

if(D4>0&&D4<=22)Dir_LED(3);

else if(D4>22&&D4<=67)Dir_LED(4);

else if(D4>67&&D4<=112)Dir_LED(5);

else if(D4>112&&D4<=157)Dir_LED(6);

else if(D4>157&&D4<=202)Dir_LED(7);

else if(D4>202&&D4<=247)Dir_LED(8);
```

5.5 Conclusion

This chapter and after preparing the required software and configure the XBee and GPS devices. Many tasks will follow this stage of system such as developing demo for the system in order to improve model from RSSI values, models that using to determine distance and direction which depends on GPS reading.

Then we must prepare the whole system implementation, and finally do tests to insure from the system performance.

CHAPTER SIX   6

Preliminary Measurements

6.1   Overview

6.2   Experimental Measurements

6.3   Conclusion

6.1 Overview

Preliminary measurements in this project is very important task, in order to develop the most accurate outdoor power model by choose and composite different parameters and models. Dependency on the GPS device will not be enough to determine the target distance, so the strength of the signal for the message that is received from child side (RSSI) can be employed in this stage, in order to achieve more accurate result.

On the other hand the GPS reading is very essential task, to ensure that if given coordinates are suitable to specify distance and direction or not.
We must do some experiments on GPS device, and calculate required parameters based on different models and formulas to choose the most accurate of them.

6.2 Experimental Measurements

6.2.1 XBee Testing:

At our sample location we perform XBee Testing at first we will explore X-CTU software for communications, signal strength monitoring and configuration of the XBee. The XBee connected to the PC using the XBee USB adapter and a remote XBee with power and a loopback will be used. For the loopback, DOUT is connected to DIN which will cause any received data to be transmitted back the PC as shown in figure 6.1.
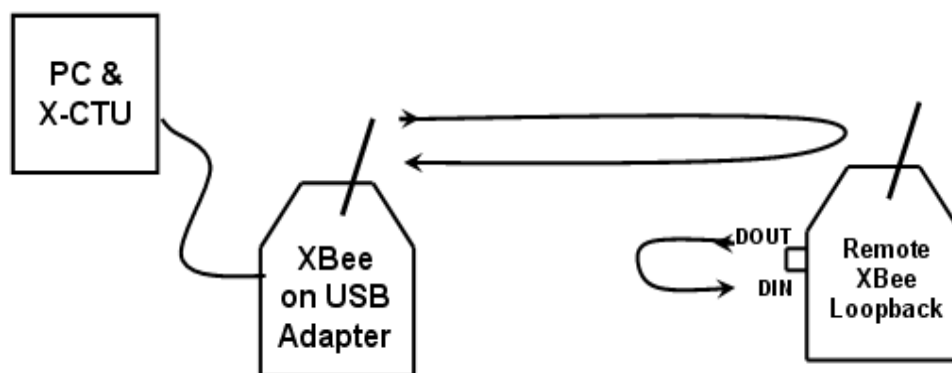
Figure 6.1 : XBee Testing
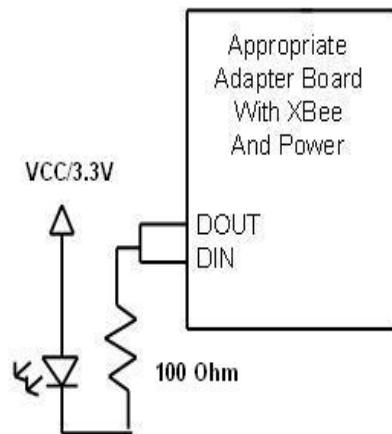
Figure 6.2: Remote XBee with Loopback and optional LED

path loss equation:

Power measurement is statistical. So there is needing to develop path loss equation with most   accurate value and find the parameter that match a variability in the environment in the testing area, In order to achieve minimum error between actual and measured distance.

In this project We employ log-distance path loss model [6]. In this model, received power RSSI (in dBm) at distance D(in meters) from the transmitter is given by:

$$P_r(d) = \overline{P_r}(d) + X_\sigma$$

$$P_r(d) = P_{r0} - 10n \log(d) + X_\sigma \qquad \textbf{Eq.1}$$

P_r represents RSSI value and P_{r0} is the received signal at certain distance in dBm. Where n is path loss exponent and Xα represents Gaussian random variable with zero mean.

Received Signal Strength Indicator value RSSI lies between -40 dBm (the highest recorded value), and -100 dBm (the minimum sensitivity of the XBee). By record the RSSI reading from XBee device at different distances, We can approximate the distance between mother and her child using different ways depend on path loss equation.

In the first we must know about the dispersion in the nature of environment, the following figure shows this:
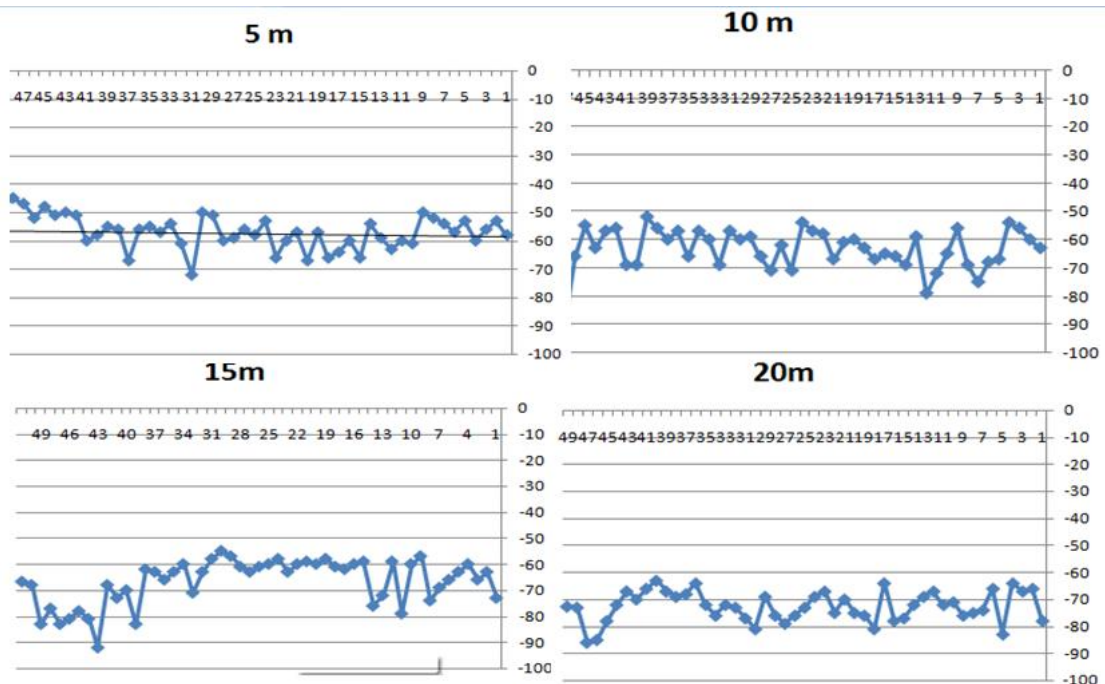
Figure 6.3 : Dispersion of RSSI values at different distances

Using the mean square error analysis we can find value of Xα represents Gaussian random variable and path loss exponent (n) with less percentage of error. The value of the path loss exponent in range (2.134473_ 3.597934). And Xα represents Gaussian random variable with zero mean, which is record values between (33.1573_45.5477) We can average this values to obtain better results represent the statistical nature.
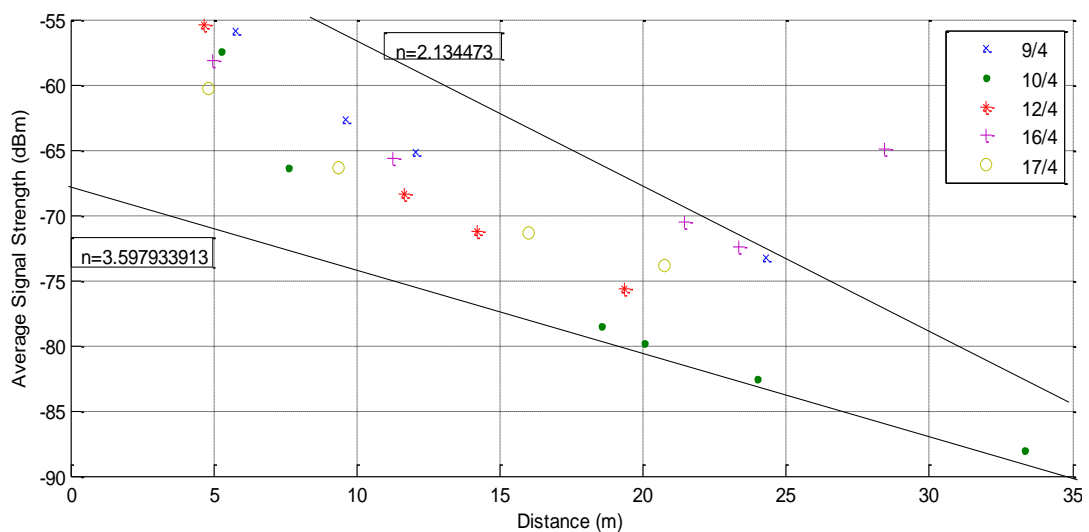
Figure 6.4 : Variability of values of path loss exponent

As shown in the following figures Note that the power record values at 10m will be around (-65, -67, -70) dBm, by average these value we obtain the approximate power at 10 m.
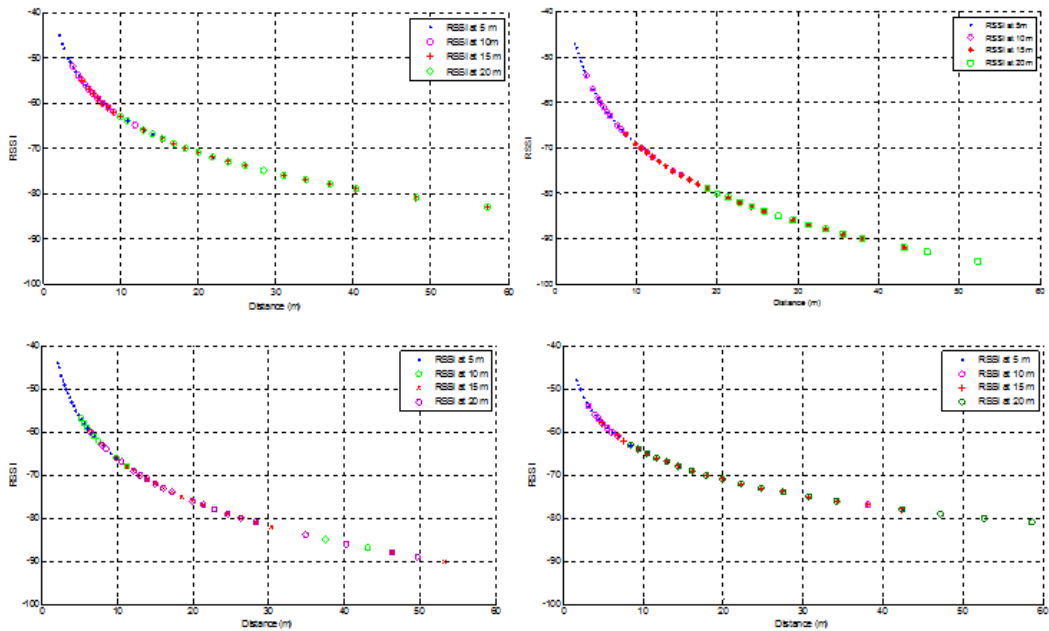
Figure 6.5 : RSSI values in dBm versus Distance (m)
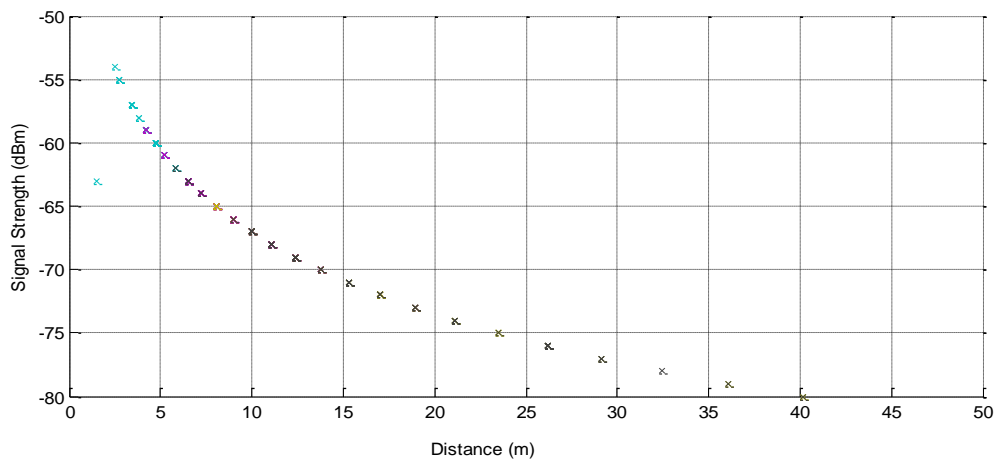
Figure 6.6 : Change of RSSI values at near scale

From the previous figure, note that at different distances the value of average power summary in the following table below:

Distance	first day	second day	third day	fourth day	fifth day
5	-55.9464	-57.4074	-55.46	-58.1373	-60.2449
10	-62.6596	-66.339	-68.44	-65.6863	-66.4082
15	-65.2115	-78.4915	-71.22	-70.5098	-73.8367
20	-73.2143	-87.9818	-75.6	-64.9216	-71.4082

Table 6.1 : Power average for different distance for five days

Average:

One way is to taking the average of all values in different weather, which were the average of many of values to obtain most accurate results:

Distance	average power
5	-57.4392
10	-65.90662
15	-71.8539
20	-74.62518

Table 6.2 : Summary for Average value of RSSI at different distances

As shown in the previous table, we can use this table in programming the PIC18F4550 to translate RSSI to Distance and where is the child relatively close or relatively far.

The next figure shows the values of RSSI versus certain values of distance.
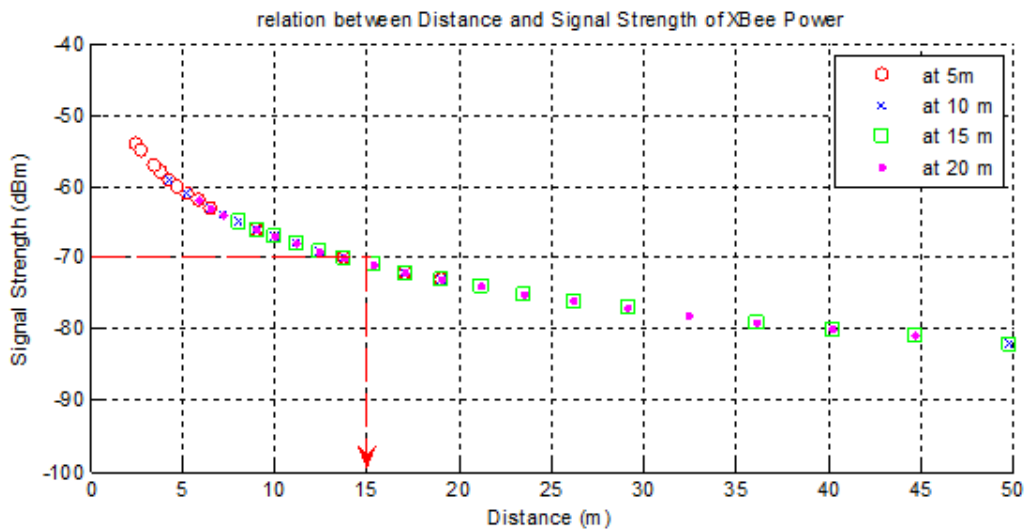
Figure 6.7 : RSSI versus certain distances.

Using variance:

Through this method we can find the variance of power. According to variance we can decide if the Child is far with large variance or near from her mother with low variance, different value for variance at different distance found as shown in next table.

Distance	Variance 1	Variance 2	Variance 3	Variance 4
5m	5.874921	7.447668	5.967277	8.037461
10m	6.197042	6.589185	6.530421	7.046957
15m	11.90102	6.458929	10.70007	7.137199
20m	6.334951	4.945138	7.733046	7.451964
25m	5.254215	5.424828	5.443588	5.955916

Table 6.3 : Calculated variance of power at different distance

As we note from this table 3 the variance of power is not suitable to determine the child location because the variation in variance is random.

6.2.2 GPS Reading and Testing

The preliminary measurements of the project starts by taking many coordinates at two different point using the GPS device from the communication lab.
The first test starts by calculating the distance between measured coordinates for two point and comparing the results of the measurement distance and the desired distance which will be specified from parent, then calculating the error percentage using the following formula:

$$\text{Percent error} = \left| \frac{measured \text{ value} - \text{desired value}}{desired \text{ value}} \right| *100\%$$

Eq.2

6.2.2.1 Option formula

To calculate the measured distance (between the parent and child), there is different formulas can be obtained. So there is a necessary to apply it in order to select the best formula which has the highest accuracy.

Haversine Formula:

The Haversine formula remains particularly well-conditioned for numerical computation even at small distances.

$$D = R * C$$

Eq.3

$$R = 6371 \text{ km} = earth \text{ radius}$$

$$\Delta \text{lat} = \text{lat} 2 - \text{lat} 1$$
$$\Delta lon = lon 2 - lon 1$$
$$a = \sin^2\left(\frac{\Delta \text{lat}}{2}\right) + \left(\cos(\text{lat} 1) * \cos(\text{lat} 2) * \sin^2\left(\frac{\Delta \text{lon}}{2}\right)\right)$$

$$C = 2 * \arctan^2\left(\sqrt{a}, \sqrt{(1-a)}\right)$$

(Note that angles need to be in radians to pass to trig functions).

Pythagoras Theorem:

$$D = \sqrt{x^2 + y^2}$$

Eq.4

Where:

$D = \text{distance}$

$$x = 69.1 * (lat2 - lat1)$$

$$y = 53.0 * (lon2 - lon1)$$

Great Circle Distance Formula (GD):
by using radians can be calculated as below

$$GD = 3963 * \arccos\left(\sin(lat1) * \sin(lat2) + \cos(lat1) * \cos(lat2) * \cos(lon2 - lon1)\right)$$

Eq.5

6.2.2.2 Experimental results

We did the following scenario; at our sample location we take to points separated by 5m and 30m, and we read there GPS coordinates by using GPS device. After that the distance between these points calculated using different formula.
Note that:
In these measurements we use GGA-Global Positioning System Fixed Data
As NMEA Output Command .
It has a (latitude dd mm.mmm & longitude ddd mm.mmmm).
          Where : d is degree.
                  m is minuet.

The following tables show the results which obtain after making some GPS measurements at our sample location, which was near to building B in the PPU university.
These experiments was done to examine the formulas. Then select the best which has less percentage error.

Lat of first point	Lat of second point		Long of first point1	long of second point
3130.3714	3130.3738		3505.4205	3505.419
3130.3728	3130.3739		3505.4203	3505.4193
3130.3729	3130.3742		3505.4195	3505.4203
3130.3731	3130.3742		3505.4208	3505.4211
3130.3723	3130.3746		3505.4198	3505.4204
3130.372	3130.3745		3505.4196	3505.4204
3130.3718	3130.3743		3505.4207	3505.4202
3130.3722	3130.3743		3505.4207	3505.4207
3130.372	3130.3743		3505.4206	3505.4206
3130.3721	3130.3743		3505.4208	3505.4206
3130.3723	3130.3754		3505.4209	3505.4174
3130.3723	3130.3736		3505.4208	3505.4183
3130.3722	3130.3735		3505.4212	3505.4184
3130.3717	3130.3735		3505.4225	3505.4184
3130.3716	3130.3736		3505.4229	3505.4184

Table 6.4 : Latitude and longitude of two point at distance=5m

Result:

Calculate the distance using the first formula:

D = R.c
5.039856133
2.579411564
2.720871197
2.039314955
4.363008723
3.971136047
4.262101538
4.273847399
4.07640601
6.972522296
4.951073634
7.286349804
7.918150452
Average 4.650311519m

Table 6.5 : The distance using Haversine Formula

$$\text{Percent error} = \left| \frac{measured \ \text{value} - \text{desired value}}{desired \ \text{value}} \right| *100\%$$

$$\text{Percent error} = \left| \frac{4.650311519\text{-}5}{5} \right| *100\% = 6.994\%$$

Which is acceptable result.

Calculate the distance using the second formula:

Distance =sqrt(x2 + y2)
5.34975E-05
2.69578E-05
2.88973E-05
2.21185E-05
4.71078E-05
4.29083E-05
4.62268E-05
4.633E-05
4.42128E-05
7.32732E-05
4.94441E-05
7.28296E-05
7.90029E-05
Average   4.86774E-05 miles

Table 6.6 : The distance using Pythagoras Theorem in miles

$$Percent\ error = \left| \frac{measured\ value - desired\ value}{desired\ value} \right| *100\%$$

$$Percent\ error = \left| \frac{0.090101867\text{-}5}{5} \right| *100\% = 98.198\%$$

Which is not acceptable results.

Great Circle Distance Formula (GD):

GD=6,378.8* arccos[sin(lat1) * sin(lat2) + cos(lat1) * cos(lat2) * cos(lon2 - lon1)] Km.
0.005045795
0.002582185
0.002723521
0.002043055
0.004368236
0.003976291
0.004267803
0.004278375
0.004080579
0.006980951
0.004957281
0.007294856
0.007927548
Average   0.004655883 Km

Table 6.7 : The distance using Great Circle Distance Formula (GD) in Km

$$\text{Percent error} = \left| \frac{measured \text{ value} - desired \text{ value}}{desired \text{ value}} \right| * 100\%$$

$$\text{Percent error} = \left| \frac{4.655883\text{-}5}{5} \right| * 100\% = 6.88\%$$

Which is acceptable result.

Table 6.8 show the latitude and longitude for two different points, which has actual distance 30m.

Latitude of first point	Latitude of second point		Longitude of first point	Longitude of second point
3130.3714	3130.3598		3505.4205	3505.4115
3130.3728	3130.3599		3505.4203	3505.4123
3130.3729	3130.3596		3505.4195	3505.4117
3130.3731	3130.3589		3505.4208	3505.416
3130.3723	3130.3587		3505.4198	3505.4121
3130.3722	3130.359		3505.4196	3505.4114
3130.372	3130.3593		3505.4207	3505.4112
3130.3721	3130.3594		3505.4207	3505.411
3130.3723	3130.3594		3505.4206	3505.4109
3130.3723	3130.3594		3505.4208	3505.4109
3130.3722	3130.3596		3505.4209	3505.4109
3130.3717	3130.3597		3505.4208	3505.411
3130.3716	3130.3599		3505.4212	3505.4109

Table 6.8 : Latitude and longitude of two point at distance = 30m

Haversine Formula:

D= R.C
25.77510629
27.04278579
27.5530258
27.52154423
27.98719416
28.53699981
27.830746
28.02041476
25.67968491
28.56971047
28.61490251
28.71853587
28.97181612
Average =27.75557436

Table 6.9 : Calculate distance using Haversine' formula

$$\text{Percent error} = \left| \frac{measured \ \text{value} - \ \text{desired value}}{desired \ \text{value}} \right| *100\%$$

$$\text{Percent error} = \left| \frac{27.75557436\text{-}30}{30} \right| *100\% = 7.48\%$$

Which is acceptable result.

Pythagoras' Theorem:

Distance =sqrt(x2 + y2) miles
0.013359824
0.014857012
0.015314414
0.016353395
0.015663347
0.015202676
0.014627115
0.014511787
0.01462674
0.014857284
0.014627259
0.013821137
0.013614164
Average =0.014725858 mile.

Table 6.10 : The distance using Pythagoras' theorem in miles

$$\text{Percent error} = \left| \frac{measured \text{ value} - desired \text{ value}}{desired \text{ value}} \right| * 100\%$$

$$\text{Percent error} = \left| \frac{27.25756316\text{-}30}{30} \right| * 100\% = 9.1415\%$$

Which is acceptable result.

Great Circle Distance Formula (GD):

GD=6,378.8* arccos[sin(lat1) * sin(lat2) + cos(lat1) * cos(lat2) * cos(lon2 - lon1)
0.025806446
0.027076175
0.027586894
0.027555272
0.028021667
0.028571958
0.027864854
0.028054696
0.025711043
0.028604667
0.028649798
0.028753676
0.029007384
Average = 0.027789579

Table 6.11 : Calculate distance using Great Circle Distance Formula (GD) in Km

$$\text{Percent error} = \left| \frac{measured \text{ value} - desired \text{ value}}{desired \text{ value}} \right| * 100\%$$

$$\text{Percent error} = \left| \frac{27.789579\text{-}30}{30} \right| * 100\% = 7.37\%$$

Which is acceptable result.

6.3 Conclusion

  The RSSI values are statistical depending on environment so we can't depend upon it to determine exactly distance, but we can treat with them to specify the child range in order control the alarm.
  And from the importance of GPS accuracy in this system. We perform many experiments in order to choose the best formula to find proper distance.

Refer to the previous work we conclude the following :
  As we see in this way the better solution is to use the path loss equation with averaging the values of path loss exponent and Gaussian variable parameter because the nature changes, and combine this equation using the average.
We can't use the variance in this model because there is random change at its values.

  Haversine' formula and Great Circle Distance Formula (GD) are suitable to apply for short and long distances.
  Pythagoras' theorem is suitable for long distance however it will be not good to when it apply for short distance.

CHAPTER SEVEN 7

System Performance

7.1   Introduction

7.2   ZigBee Network

7.3   Subsystem Testing

7.4   System Performance

7.5   Operating Currents and Battery Life

7.1 Introduction

In the stage of designing hardware and software tools, different testing are done on the hardware components, to ensure that the devices are working probably. There are two components must be tested. First component for ZigBee network, to ensure that the Xbee devices are able to communicate with each other and analyze the RSSI values. Second component is GPS receiver to analyze the GPS reading.

7.2 ZigBee Network

The main aim of this testing is to prove that the two node of this network able to send a message to each other.
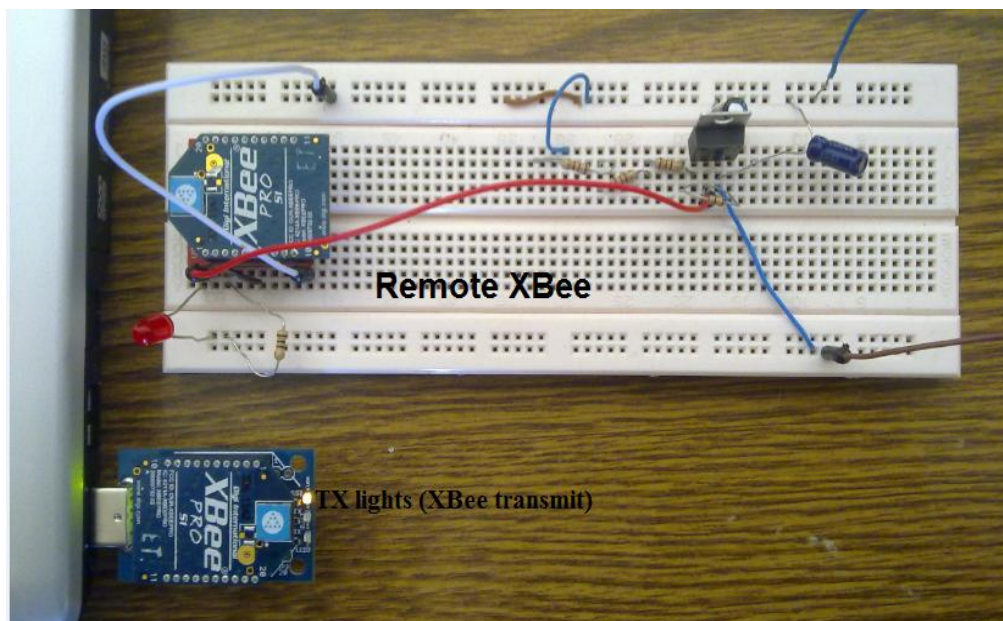
Figure 7.1 : Communication between XBee nodes

The figure below illustrates the variation of RSSI values as shown in X-CTU program
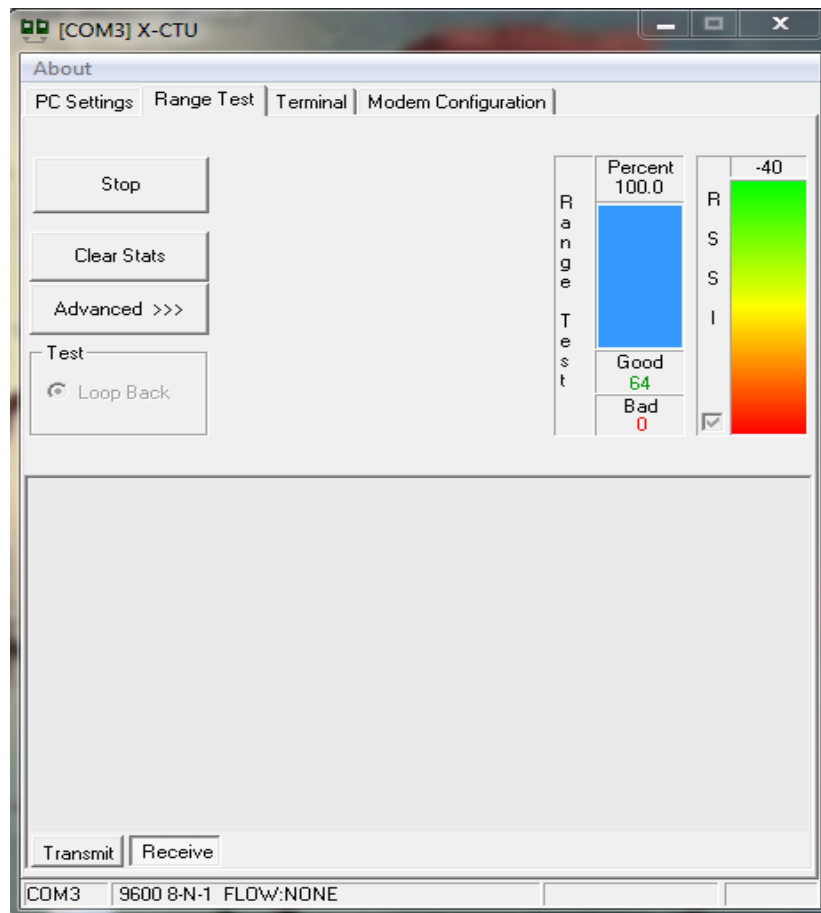
Figure 7.2 : Variation of RSSI Values

This figure shows the number of good messages (arrival message), and the number of bad messages (lost message or time out message), we note that the number of good message is 64 on the other hand the number of bad message which is zero that's mean no messages is lost.

7.2.1 Problems

We faced many problems when Xbee working was done :
- Sensitivity of Xbee from weather condition.
- Using a voltage source with variable output voltage .

For these previous reasons, timeout problem was produced as shown in the figure bellow.
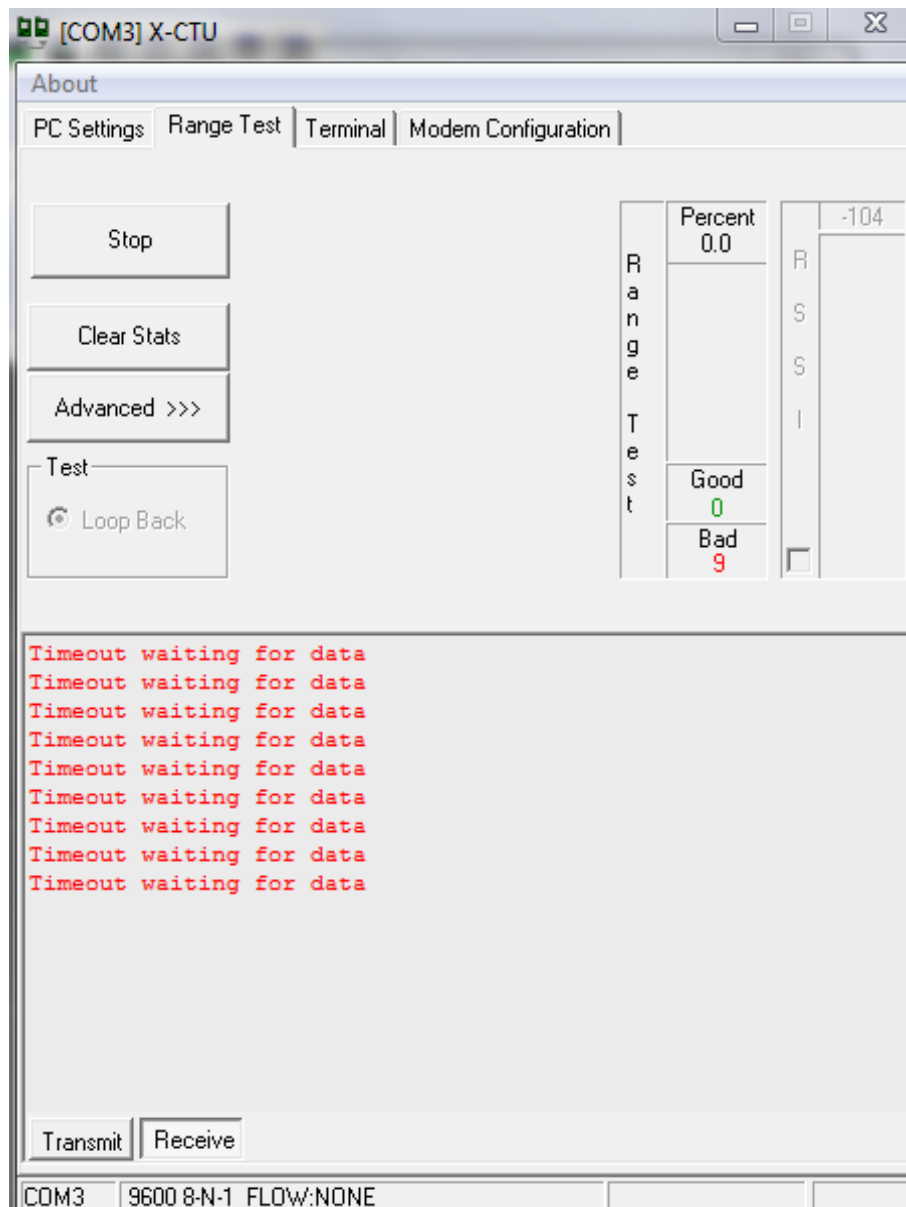
Figure 7.3 : Timeout problem

7.2.2 GPS Testing

The testing of the GPS device is done in the PPU university in building B.
The GPS is taken cold start time up to connect with all GPS satellites to give correct coordinates, as the previously mentioned that the blue satellites give invalid signal and the green satellites give valid signal.

Figure 7.4 : GPS reading on u-center

7.3 Subsystem Testing

There are five main operations in the system must be tested to ensure correct response between components. The first operation, the GPS sends the coordinates to Xbee, the second is exchanging packets between transceivers, the third is sending message to PIC18F4550 for processing and calculation, the fourth is displaying results (direction and distance) on seven segment and Led's, the last operation is to specify the child rang throughout three ranges (safe range, critical range, dangerous range) for indoor and outdoor environments.

7.3.1 Testing scenario:

Two testing scenarios will be performed to conclude the system performance.

✓ Testing based on power for indoor :
In this scenario we will confirm that the alarm activates when the child is close to critical range, depending on the power to determine the child range, where three ranges are :
- Safe range
- Critical range
- Dangerous range

When the connection between the mother and child is disconnect the dangerous range activate.

✓ Testing based on GPS and Power for outdoor :

In this scenario we will confirm that alarm activates when the range greater than about 15m. the power working incompatible with GPS device.

The following figures shows the different system for outdoor situations :
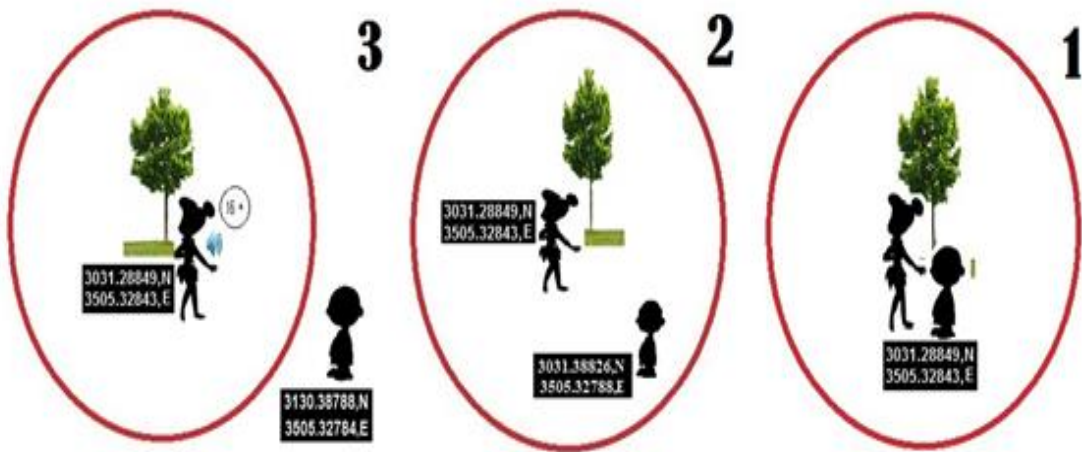
Figure 7.5 : outdoor scenario based on GPS

Figure 7.6 : outdoor scenario based on Power

The figure 7.6 illustrates the situation when mother and her child go away from reference location. While the result that shown on the display specify distance depends on the last reference location. But the alarm activate depends on the range between them.

7.4 System Performance

In this project we measure system performance based on direction, distance which are determined using GPS for outdoor environment, and the number of False Alarms that are depend on RSSI values for indoor and outdoor.

False Alarm is an Alarm that is sent to the mother while the child is physically close her (False Positive), or if an alarm is not sent to mother while the child is far beyond programmed threshold distance (False Negative).

As shown in the following figure we use three Led's to indicate the child ranges, safe range indicates as green led, dangerous as red led ,and in the midst of them critical range as yellow led.
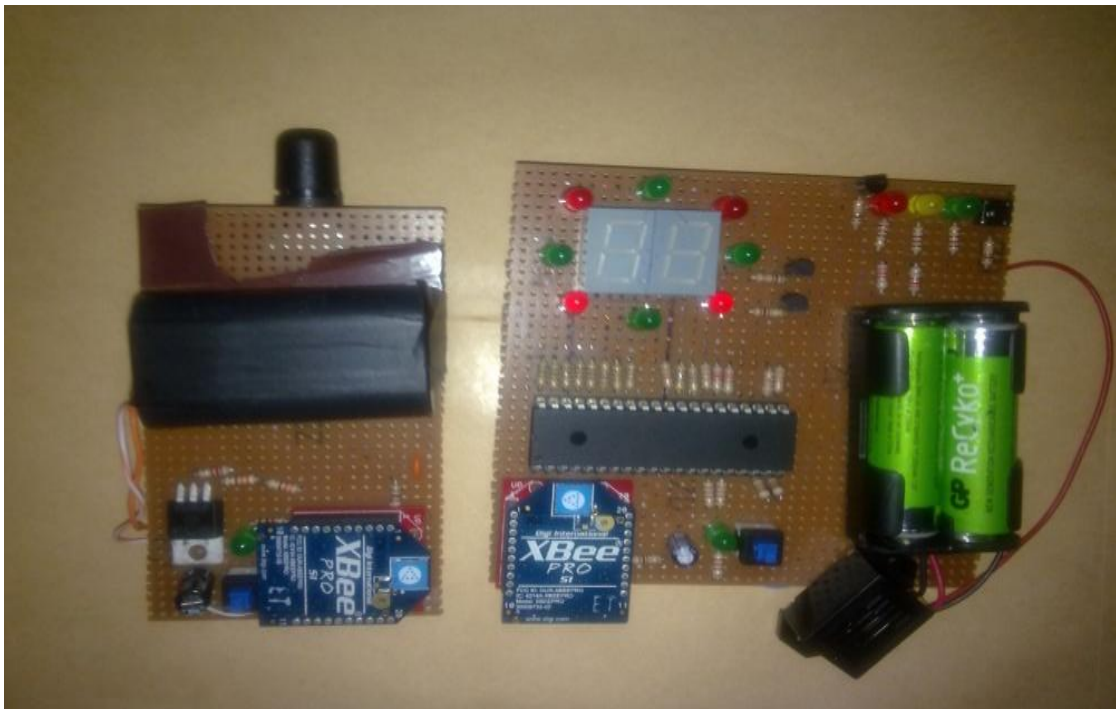
Figure 7.7 : the whole system implementation

7.4.1 Alarm testing:

This test is performed for indoor and outdoor environments, to determine the number of false alarms (positive and negative).

7.4.1.1 indoor testing:

The following figures and tables are shown this test**.**

Figure 7.8 : Indoor Testing

From previous figure Yellow Led Lights and alarm Beeps, that indicates that child is start to be remote from his mother. We note the alarm Beeps at about 10m inside. This is due to obstacles and walls inside the building. And we can note that although the GPS reading is indicate wrong distances, but in actual when the child is far away from his mother the alarm is on.

7.4.1.2 outdoor testing:
In this environment GPS distance is taken into account if the distance is greater than the threshold programmed value for example 18m Yellow and red light to indicate the child is far, also alarm Beeps. Otherwise if the distance is less than threshold value for example 7m green led lights. Figure 7.8 show outdoor testing.
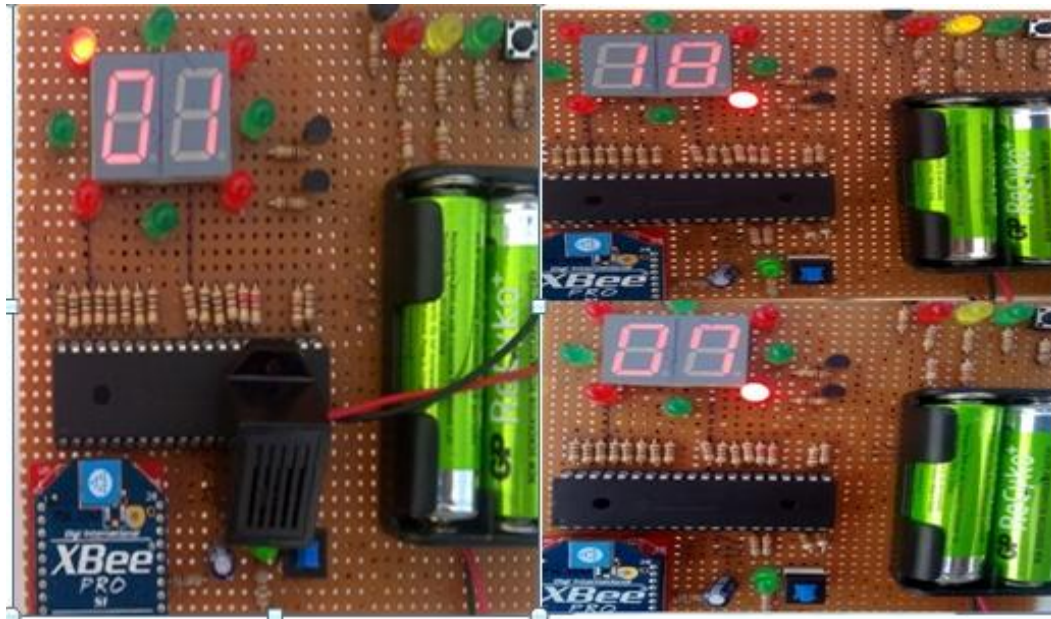
Figure 7.9 : Outdoor Testing

We apply these experiment 20 times for indoor and outdoor. Next table shows these results :

Distance	number of trials	Indoor result	Outdoor result
5m	20	False positive:1 False negative:0	False positive:0 False negative:0
10m	20	False positive:2 False negative:0	False positive:2 False negative:0
15m	20	False positive:0 False negative:2	False positive:0 False negative:3
20m	20	False positive:0 False negative:0	False positive:0 False negative:1
25m	20	False positive:0 False negative:0	False positive:0 False negative:0

Table 7.1 : System Performance

Notes :

- ✓ For indoor environment the alarm Beeps at distance about 10m this is due to obstacles and walls inside the building .
- ✓ For outdoor environment the alarm Beeps at distance about 15m.

7.4.2 Distance and Direction Testing:

   As we illustrated in previous sections this test will perform only for outdoor environment.

   At first we suppose that child is located at 5m north-east from his mother, from GPS reading this distance shown at seven segment equally to 6m and the direction The north-east from his mother.

North-west
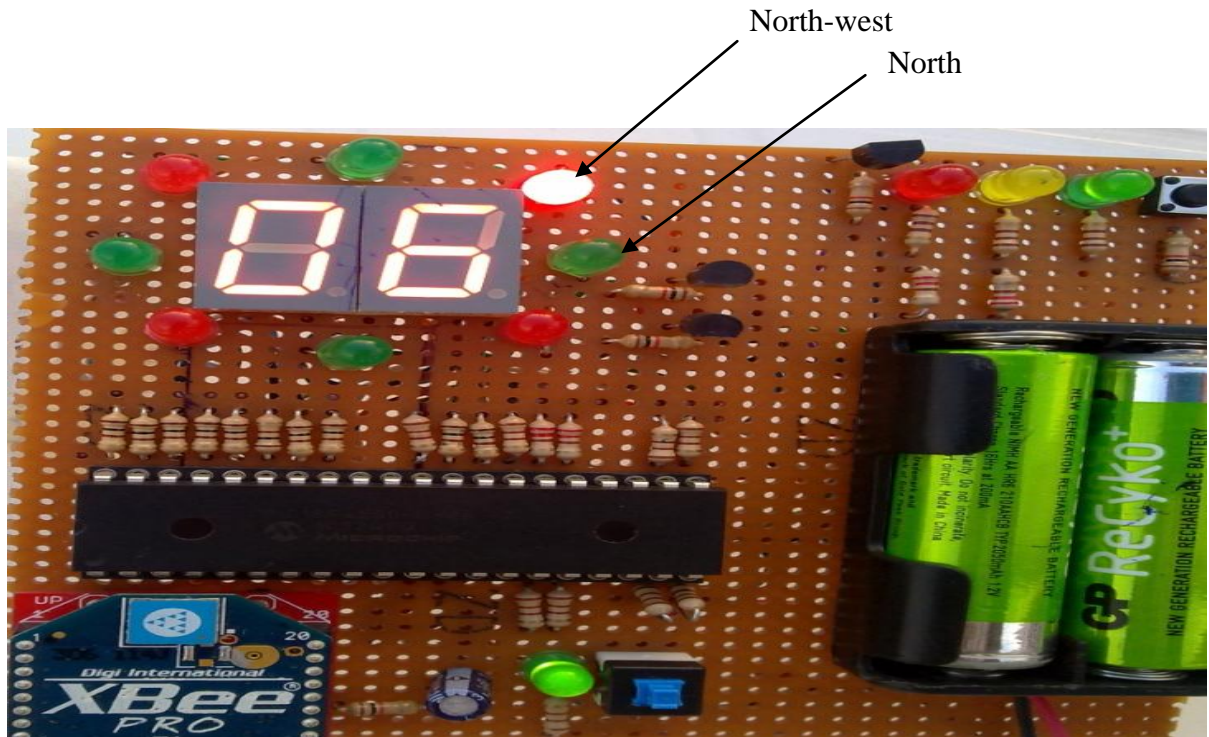
North

Figure 7.10: direction and distance of child at 5m north-east from his mother
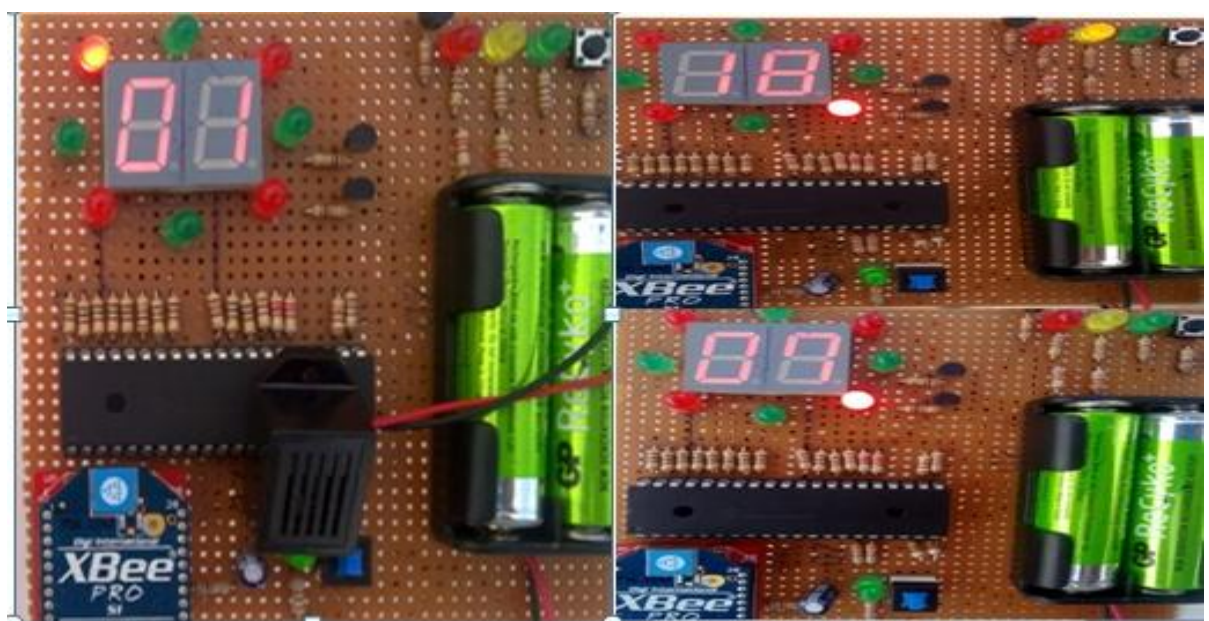
Figure 7.11: Direction and distance for different trials at different distances.

This trials repeated 20times for different distances and directions. Table 7.2 and 7.3 conclude these result.

Distance	number of trials	Average measured distance	Percent error
5m	20	3.84	23.2%
10m	20	8.53	14.7%
15m	20	13.81	8%
20m	20	18.64	6.8%
25m	20	23.86	4.56%

Table 7.2 : system distance and percent error

Actual direction	number of trials	Direction from GPS
East	20	Valid :20 times
West	20	Valid:19 times Invalid:1 times
North	20	Valid:20
South	20	Valid:18 times Invalid:2 times

Table 7.3 :system performance based on child direction.

Notes:

- ✓ GPS accuracy is about 2.5 m.
- ✓ The percent error come from GPS itself and the locations where we took this trial in open or surrounded area .
- ✓ We can depend on GPS to determine child distance and direction.

7.5 Operating Currents and Battery Life

When the parent side is in operating mode the current drawn from the battery is 140 mA. And when the child side is in operating mode the current drawn from the battery is 180 mA.

the capacity of two AA cells to 3V would be 1000 mAh. so the number of hours of the two side can be calculated as:

there are two battery of AA cells in parent side consume 1000 mAh, so:

 #hour of parent side =1000mAh /140 mA =7.143 hour .

And there are four battery of AA cells in Child side consume 909 mAh, so:

 #hour of Child side = 909mAh /180 mA =5.05 hour.

CHAPTER EIGHT 8

Conclusion and Suggestions

8.1 Introduction

8.2 Real Learning Outcomes

8.3 Recommendations

8.4 Conclusion and Future Work

8.1 Introduction

The project has been done step by step, for developing a new idea in Child monitoring and tracking. Meanwhile we have some recommendations and suggestions that can be taken to make the system more efficient and economic in future.

8.2 Real Learning Outcomes

After the implementation of the project we have an improvement in the following points:
- Learning how to use and program 18F4550 microcontroller.
- Learning how to read GPS coordinates.
- Learning how to build complete system using ZigBee technology.
- Facing many problems with communication in the Xbee and learning how to solve it.

8.3 Recommendations

After we working on this project, and facing many problems during the implementation, we as a project team seen that the following points may be a good improvement for this project in order to make it more reliable:
- Reforming the shape of the system to be more reliable for child usage.
- Using GPS receiver with high accuracy, so accurate distance and direction can be obtained.
- Developing model for power that can be applied indoor, so the system will not be limited for just outdoor usage.

8.4 Conclusion and Future Work

All parents wish to shield their children from real dangerous, they will inevitably undergo hard times. Normal behavior of any child depends on the child's age, personality, and at the end the physical and emotional development. A child's behavior may be a problem if it does not match the expectations of the family or if it is disruptive. So, Parents may face many problems with their children, when they let them free without any observation.

There are many child tracking systems available in the present time, these systems use different technologies and different techniques, but each of them has one or more limitation such as not suitable for large areas, or monitor how far the child from their parent without monitoring the environment surrounded the children. While the designed tracking system allows parent to monitor his child and they will be alarmed if child be in danger state, where the alarm has three ranges; safe range, critical range, dangerous range.

After the completion of this project the following conclusions can be drawn:
- ✓ The designed system can be extended and updated to be used in other practical applications as:
  - Monitoring and tracking more than one child.
  - Monitoring patients in hospitals by connecting medical devices to the patient to be in contact with their doctor.
  - Monitoring adults, specially who needs peoples and elderly family members.
  - Monitoring and locating animals, and any dependant who needs special supervision.

- ✓ As a future work, it is better to replace normal seven segment display by Graphical LCD (GLCD) in order to display path of child when child goes out of range in more details.

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الى من ضاقت السطور من ذكرهم فوسعهم قلبي ... صديقاتي

الى من ضحوا بحريتهم من اجل حرية غيرهم ... الاسرى والمعتقلين

الى من هم اكرم منا مكانة ... شهداء فلسطين

الى من احتضنتني كل هذا الكم من السنين ... فلسطين الحبيبة

الى زملائي وزميلاتي في جامعة بوليتكنك فلسطين ...

إلى كل من علمني وأخذ بيدي وأنار لي طريق العلم والمعرفة

إلى كل من شجعني في رحلتي إلى التميز والنجاح إلى كل من ساندني ووقف بجانبي

إلى كل من قال لي : لا ، فكان سببا في تحفيزي

إليكم جميعا نهدي هذا المشروع

كلمة شكر

في مثل هذه اللحظات يتوقف اليراع ليفكر قبل أن يخط الحروف ليجمعها في كلمات ... تتبعثر الأحرف وعبثاً أن يحاول تجميعها في سطور ... سطور كثيرة تمر في الخيال ولا يبقى لنا في نهاية المطاف إلا قليلاً من الذكريات وصورا تجمعنا برفاق كانوا إلى جانبنا ... فواجب علينا شكرهم ووداعهم ونحن نخطو خطوتنا الأولى في غمار الحياة.

ولابد لنا ونحن نخطو خطواتنا الأخيرة في الحياة الجامعية من وقفة نعود فيها إلى أعوام قضيناها في رحاب الجامعة مع أساتذتنا الكرام الذين قدموا لنا الكثير. وإننا نتقدم بأسمى آيات الشكر والامتنان والتقدير والمحبة إلى الذين حملوا أقدس رسالة في الحياة ... إلى الذين مهدوا لنا طريق العلم والمعرفة ... إلى جميع أساتذتنا الأفاضل في كلية الهندسة والتكنولوجيا ونخص بالذكر دائرة الهندسة الكهربائية والحاسوب.

ونتوجه بالشكر الجزيل إلى المشرف على مشروع تخرجنا الدكتور مراد ابو صبيح فله مناكل التقدير والاحترام. وكذلك نشكر كل من ساعد على إتمام هذا المشروع وقدم لنا العون ومد لنا يد المساعدة وزودنا بالمعلومات اللازمة لإتمام هذا المشروع. إلى من زرعوا التفاؤل في دربنا وقدموا لنا المساعدات والأفكار والمعلومات ربما دون ان يشعروا بدورهم بذلك فلهم مناكل الشكر وأخص منهم :

الاستاذ خالد الطميزي ... الاستاذ سامي السلامين

أما الشكر الذي من النوع الخاص فنحن نتوجه بالشكر أيضا إلى كل من لم يقف إلى جانبنا ومن وقف في طريقنا وعرقل مسيرتنا وزرع الشوك في طريقنا فلولا وجودهم لما أحسسنا بمتعة المشروع ولا حلاوة المنافسة الايجابية ولولاهم لما وصلنا إلى ما وصلنا إليه فلهم مناكل الشكر.

كلمة شكر

قبل أن نمضي لا بد أن يقف القلم ليخط كلمات الشكر والتقدير إلى كل من ساعد في اتمام هذا المشروع

الى جامعة بوليتكنك فلسطين

ونخص بالذكر عمادة البحث العلمي لما قدموه لنا من دعم وعون مادي لإتمام المشروع ونجاحه،

فإليهم جميعا نتقدم بجزيل الشكر والتقدير والامتنان لمساهمتهم الملموسة في نجاح المشروع .

الملخص

إن العالم الحالي مبني على التطور التكنولوجي السريع، ففي كل يوم نشهد ظهور تقنية جديدة واختراعات جديدة في مجال الاتصالات، حتى أصبحت هذه التقنيات جزء من حياتنا لا نستطيع الاستغناء عنه، وهنا نخص بالذكر الاتصالات اللاسلكية.

تقنية *ZigBee* من التقنيات اللاسلكية الحديثة والتي يمكن تطبيقها بالعديد من مجالات الحياة مثل الجانب الصناعي والتحكم المنزلي، وتمتلك هذه التقنية العديد من الخصائص، لاسيّما أنها تتميز باستهلاكها القليل للطاقة كما تصل لمسافة أطول من البلوتوث تصل إلى اكثر من100 متر، ويمكن الحصول مستقبلا على العديد من المنتجات التي تعمل بهذه التقنية مثل الهواتف المحمولة، التلفاز، مكيفات الهواء، وغيرها الكثير من تطبيقات التحكم.

فكرة المشروع تتمثل في تصميم جهاز لتتبع وتحديد أماكن تواجد الأطفال، خصوصا أطفال التوحد لأنهم لا يستطيعون التعبير عن أنفسهم بشكل جيد، حيث أن هذا الجهاز يساعد الآباء والأمهات على تحديد أماكن تواجد أطفالهم في حالة فقدانهم خصوصا بالأماكن المزدحمة، فإذا ابتعد الطفل عن والديه مسافة معينة فان الجهاز يعطي تنبيه للوالدين.

ويتكون الجهاز من مرسل عند الطفل، ومستقبل مع احد الأبوين، المرسل يتكون من قطعة *GPS* تقوم بتحديد إحداثيات موقع الطفل ومن ثم تمريرها إلى *microcontroller* الذي يقوم بتحويل الإحداثيات إلى أمواج كهرومغناطيسية، وتقوم قطعة *XBee* بإرسال هذه الأمواج باستخدام تقنية *ZigBee* إلى قطعة *XBee* الموجودة عند المستقبل، ومن ثم يتم تحويلها مرة أخرى إلى إحداثيات لمقارنتها بإحداثيات الوالد وتحديد اتجاه وبعد الطفل عن الوالد، ويعتبر هذا الجهاز باستخدامه لهذه التقنية من آخر التطورات الموجودة في عالم التحكم.

Abstract

This project aims to develop a Child Tracking System. The system will be based on the ZigBee technology and the Global Positing system (GPS). It helps parents to locate their children in case of loss in crowded or open places. It is worth mentioning that this device works as an alarm device by developing a model of statistical power to have alarm. The system consists of transmitter at the child, and receiver with parent. The transmitter consists of a GPS receiver and Xbee device. When the system become on at parent, the GPS determine the coordinates of the child, and then passes these coordinates to Xbee. Xbee at the child sends packets that contain the GPS data to Xbee at the parent by using node to node ZigBee network. Where the Xbee at parent will receive these packets, and pass them to microcontroller. These packets carrying a power value, which will be used by comparing the power values on both Xbee devices, to alert the parent if his child go out of specific range. Then view the direction and the distance of the child at parent display. In this project, the child location with respect to his parent can be specified as direction, distance, and alarm. This system is flexible; it is not limited only for children. In fact, it can be used for monitoring and locating people who needs special supervision.

List of Abbreviations:

Abbreviation	Explanation
ADC	Analog to digital Converter
C / A	Coarse / Acquisition
DI	Data In
DO	Data Out
DOD	Department Of Defense
FFD	Full Function Device
IDE	Integrated Development Environment
I / O	Input / Output
ISO	International System Organization
GND	Ground
GPS	Global Positioning System
GSM	Global System for Mobile Communication
Lat	Latitude
Lon	Longitude
MAC	Medium Access Control
MCLR	Master Clear
NMEA	National Marine Electronics Association
OSI	Open Systems Interconnection
PHY	Physical layer
PWM	Pulse Width Modulation
RF	Radio Frequency
RFID	Radio Frequency Identification
RSSI	Received Signal Strength
RX	Receiver
TTL	Transistor Transistor Logic
USART	Universal synchronous Asynchronous Transmitter
USB	Universal Serial Bus
WLAN	Wireless Local Area Network

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APPENDIXES

APPENDIX   A

XBee®/XBee-PRO® RF Modules

The XBee and XBee-PRO 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.

Key Features

Long Range Data Integrity

XBee

- Indoor/Urban: up to 100' (30 m)
- Outdoor line-of-sight: up to 300' (90 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm

XBee-PRO

- Indoor/Urban: up to 300' (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 1 mile (1600 m), 2500' (750 m) for International variant
- Transmit Power: 63mW (18dBm), 10mW (10dBm) for International variant
- 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

Low Power

XBee

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

XBee-PRO

- TX Peak Current: 250mA (150mA for international variant)
- TX Peak Current (RPSMA module only): 340mA (180mA for international variant)
- 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

Specifications

Table 1-01. Specifications of the XBee®/XBee-PRO® RF Modules

Specification	XBee	XBee-PRO
Performance		
Indoor/Urban Range	Up to 100 ft (30 m)	Up to 300 ft. (90 m), up to 200 ft (60 m) International variant
Outdoor RF line-of-sight Range	Up to 300 ft (90 m)	Up to 1 mile (1600 m), up to 2500 ft (750 m) international variant
Transmit Power Output (software selectable)	1mW (0 dBm)	63mW (18dBm)* 10mW (10 dBm) for International variant
RF Data Rate	250,000 bps	250,000 bps
Serial Interface Data Rate (software selectable)	1200 bps - 250 kbps (non-standard baud rates also supported)	1200 bps - 250 kbps (non-standard baud rates also supported)
Receiver Sensitivity	-92 dBm (1% packet error rate)	-100 dBm (1% packet error rate)
Power Requirements		
Supply Voltage	2.8 – 3.4 V	2.8 – 3.4 V
Transmit Current (typical)	45mA (@ 3.3 V)	250mA (@3.3 V) (150mA for international variant) RPSMA module only: 340mA (@3.3 V) (180mA for international variant)
Idle / Receive Current (typical)	50mA (@ 3.3 V)	55mA (@ 3.3 V)
Power-down Current	< 10 μA	< 10 μA
General		
Operating Frequency	ISM 2.4 GHz	ISM 2.4 GHz
Dimensions	0.960" x 1.087" (2.438cm x 2.761cm)	0.960" x 1.297" (2.438cm x 3.294cm)
Operating Temperature	-40 to 85º C (industrial)	-40 to 85º C (industrial)
Antenna Options	Integrated Whip, Chip or U.FL Connector, RPSMA Connector	Integrated Whip, Chip or U.FL Connector, RPSMA Connector
Networking & Security		
Supported Network Topologies	Point-to-point, Point-to-multipoint & Peer-to-peer	
Number of Channels (software selectable)	16 Direct Sequence Channels	12 Direct Sequence Channels
Addressing Options	PAN ID, Channel and Addresses	PAN ID, Channel and Addresses
Agency Approvals		

Pin Signals

Figure 1-03. XBee®/XBee-PRO® RF Module Pin Numbers

(top sides shown - shields on bottom)
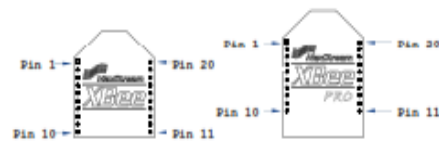
Table 1-02. Pin Assignments for the XBee and XBee-PRO Modules

(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

APPENDIX   B

SPECIFICATIONS

1. Characteristics

	Item	Specifications	Conditions
Electrical characteristics	Rated current	0.5A/contact (Max. 10 A at total contacts)	
	Rated voltage	60V AC/DC	
	Breakdown voltage	150V AC for 1 minute	Detection current: 1mA
	Insulation resistance	Min. 1,000MΩ (initial)	Using 500V DC megger
	Contact resistance	Max. 90mΩ	Based on the contact resistance measurement method specified by JIS C 5402.
Mechanical characteristics	Composite insertion force	Max. 0.981N/contacts × contacts (initial)	
	Composite removal force	Min. 0.0588N/contacts × contacts	
	Post holding force	Min. 0.981N/contact	Measures the maximum load in the post axial direction until removal
Environmental characteristics	Ambient temperature	−55°C to +85°C	No freezing at low temperatures
	Soldering heat resistance	Max. peak temperature of 260°C (on the surface of the PC board around the connector terminals)	Infrared reflow soldering
		300°C within 5 seconds, 350°C within 3 seconds	Soldering iron
	Thermal shock resistance (header and socket mated)	5 cycles, insulation resistance min. 100MΩ, contact resistance max. 90mΩ	Sequence 1. −55$^{-3}_{-0}$°C, 30 minutes 2. ~ , Max. 5 minutes 3. 85$^{+3}_{0}$°C, 30 minutes 4. ~ , Max. 5 minutes
	Humidity resistance (header and socket mated)	120 hours, insulation resistance min. 100MΩ, contact resistance max. 90mΩ	Bath temperature 40±2°C, humidity 90 to 95% R.H.
	Saltwater spray resistance (header and socket mated)	24 hours, insulation resistance min. 100MΩ, contact resistance max. 90mΩ	Bath temperature 35±2°C, saltwarter concentration 5±1%
	H_2S resistance (header and socket mated)	48 hours, contact resistance max. 90mΩ	Bath temperature 40±2°C, gas concentration 3±1 ppm, humidity 75 to 80% R.H.
Lifetime characteristics	Insertion and removal life	50 times	Repeated insertion and removal speed of max. 200 times/hours
Unit weight		Mated height 1.5mm, 20 contacts; Socket: 0.06g Header: 0.04g	

2. Material and surface treatment

Part name	Material	Surface treatment
Molded portion	LCP resin (UL94V-0)	—
Contact/Post	Copper alloy	Contact portion: Ni plating on base, Au plating on surface Terminal portion: Ni plating on base, Au plating on surface (Except for thick of terminal) The section close to the soldering portion has a nickel barrier. (The nickel base is exposed.)

Parameter	Specification	
1. Chip Set	uBlox 5	
2. Antenna	Sarantel SL1206	
	Frequency: 1575.42Mhz	
	Gain: +24 dBic	
	Beamwidth: > 120 Degrees	
	Noise Figure: 1.2 dB	
3. Receiver Type	50 Channel	
	GPS L1 frequency, C/A Code	
	GALILEO Open Service L1 frequency	
4. Time to First Fix	Cold Start (Autonomous)	29s
	Warm Start (Autonomous)	29s
	Hot Start (Autonomous)	<1s
	Aided Starts	<1s
5. Sensitivity	Tracking & Navigation	<-160dBm
	Reacquisition	<-160dBm
	Cold Start (Autonomous)	<-144dBm
6. Horizontal Position	Autonomous	<2.5m
	SBAS	<2.0m
7. Accuracy of Timepulse Signal	RMS	30ns
	99%	<60ns
8. Max Navigation Update Rate		4Hz
9. Velocity Accuracy	0.1m/s	0.1m/s
10. Heading Accuracy	0.5 degrees	0.5degress
11. Dynamics	Weight	<15g
12. Power	3.3V +- 5% DC Input , < 50mVpp	
13. Interface	Baud Rate	9600
	Level	TTL
	Connector Type: Panasonic AXK6F10547YG	
14. Environmental	Operating Temp	-10~50° C
15. Flash	Size	4Mbit
16. AGPS	Support uBlox AssistNow	

PIC18F2455/2550/4455/4550

TABLE 1-3:   PIC18F4455/4550 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
MCLR/VPP/RE3	1	18	18			Master Clear (input) or programming voltage (input).
MCLR				I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP				P		Programming voltage input.
RE3				I	ST	Digital input.
OSC1/CLKI	13	32	30			Oscillator crystal or external clock input.
OSC1				I	Analog	Oscillator crystal input or external clock source input.
CLKI				I	Analog	External clock source input. Always associated with pin function OSC1. (See OSC2/CLKO pin.)
OSC2/CLKO/RA6	14	33	31			Oscillator crystal or clock output.
OSC2				O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO				O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6				I/O	TTL	General purpose I/O pin.

Legend: TTL = TTL compatible input   CMOS = CMOS compatible input or output
　　　　　　 ST   = Schmitt Trigger input with CMOS levels   I   = Input
　　　　　　 O   = Output   P   = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.
　　 2: Default assignment for CCP2 when CCP2MX Configuration bit is set.
　　 3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the DEBUG Configuration bit is cleared.

TABLE 1-3:   PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTA is a bidirectional I/O port.
RA0/AN0	2	19	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	20	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/V_{REF}-/ CV_{REF}	4	21	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
V_{REF}-				I	Analog	A/D reference voltage (low) input.
CV_{REF}				O	Analog	Analog comparator reference output.
RA3/AN3/V_{REF}+	5	22	22			
RA3				I/O	TTL	Digital I/O.
AN3				I	Analog	Analog input 3.
V_{REF}+				I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT/ RCV	6	23	23			
RA4				I/O	ST	Digital I/O.
T0CKI				I	ST	Timer0 external clock input.
C1OUT				O	—	Comparator 1 output.
RCV				I	TTL	External USB transceiver RCV input.
RA5/AN4/$\overline{SS}$/ HLVDIN/C2OUT	7	24	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
$\overline{SS}$				I	TTL	SPI slave select input.
HLVDIN				I	Analog	High/Low-Voltage Detect input.
C2OUT				O	—	Comparator 2 output.
RA6	—	—	—	—	—	See the OSC2/CLKO/RA6 pin.

Legend: TTL = TTL compatible input   CMOS = CMOS compatible input or output
ST = Schmitt Trigger input with CMOS levels   I   = Input
O   = Output   P   = Power

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/AN12/INT0/ FLT0/SDI/SDA	33	9	8			
RB0				I/O	TTL	Digital I/O.
AN12				I	Analog	Analog input 12.
INT0				I	ST	External interrupt 0.
FLT0				I	ST	Enhanced PWM Fault input (ECCP1 module).
SDI				I	ST	SPI data in.
SDA				I/O	ST	I²C™ data I/O.
RB1/AN10/INT1/SCK/ SCL	34	10	9			
RB1				I/O	TTL	Digital I/O.
AN10				I	Analog	Analog input 10.
INT1				I	ST	External interrupt 1.
SCK				I/O	ST	Synchronous serial clock input/output for SPI mode.
SCL				I/O	ST	Synchronous serial clock input/output for I²C mode.
RB2/AN8/INT2/VMO	35	11	10			
RB2				I/O	TTL	Digital I/O.
AN8				I	Analog	Analog input 8.
INT2				I	ST	External interrupt 2.
VMO				O	—	External USB transceiver VMO output.
RB3/AN9/CCP2/VPO	36	12	11			
RB3				I/O	TTL	Digital I/O.
AN9				I	Analog	Analog input 9.
CCP2[1]				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
VPO				O	—	External USB transceiver VPO output.
RB4/AN11/KBI0/CSSPP	37	14	14			
RB4				I/O	TTL	Digital I/O.
AN11				I	Analog	Analog input 11.
KBI0				I	TTL	Interrupt-on-change pin.
CSSPP				O	—	SPP chip select control output.
RB5/KBI1/PGM	38	15	15			
RB5				I/O	TTL	Digital I/O.
KBI1				I	TTL	Interrupt-on-change pin.
PGM				I/O	ST	Low-Voltage ICSP™ Programming enable pin.
RB6/KBI2/PGC	39	16	16			
RB6				I/O	TTL	Digital I/O.
KBI2				I	TTL	Interrupt-on-change pin.
PGC				I/O	ST	In-Circuit Debugger and ICSP programming clock pin.
RB7/KBI3/PGD	40	17	17			
RB7				I/O	TTL	Digital I/O.
KBI3				I	TTL	Interrupt-on-change pin.
PGD				I/O	ST	In-Circuit Debugger and ICSP programming data pin.

Legend: TTL = TTL compatible input   CMOS = CMOS compatible input or output
ST = Schmitt Trigger input with CMOS levels   I = Input

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTC is a bidirectional I/O port.
RC0/T1OSO/T13CKI	15	34	32			
RC0				I/O	ST	Digital I/O.
T1OSO				O	—	Timer1 oscillator output.
T13CKI				I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2/ UOE	16	35	35			
RC1				I/O	ST	Digital I/O.
T1OSI				I	CMOS	Timer1 oscillator input.
CCP2[2]				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
UOE				O	—	External USB transceiver OE output.
RC2/CCP1/P1A	17	36	36			
RC2				I/O	ST	Digital I/O.
CCP1				I/O	ST	Capture 1 input/Compare 1 output/PWM 1 output.
P1A				O	TTL	Enhanced CCP1 PWM output, channel A.
RC4/D-/VM	23	42	42			
RC4				I	TTL	Digital input.
D-				I/O	—	USB differential minus line (input/output).
VM				I	TTL	External USB transceiver VM input.
RC5/D+/VP	24	43	43			
RC5				I	TTL	Digital input.
D+				I/O	—	USB differential plus line (input/output).
VP				I	TTL	External USB transceiver VP input.
RC6/TX/CK	25	44	44			
RC6				I/O	ST	Digital I/O.
TX				O	—	EUSART asynchronous transmit.
CK				I/O	ST	EUSART synchronous clock (see RX/DT).
RC7/RX/DT/SDO	26	1	1			
RC7				I/O	ST	Digital I/O.
RX				I	ST	EUSART asynchronous receive.
DT				I/O	ST	EUSART synchronous data (see TX/CK).
SDO				O	—	SPI data out.

Legend: TTL = TTL compatible input   CMOS = CMOS compatible input or output
ST = Schmitt Trigger input with CMOS levels   I = Input
O = Output   P = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.
    2: Default assignment for CCP2 when CCP2MX Configuration bit is set.
    3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the DEBUG Configuration bit is cleared.

TABLE 1-3: PIC18F4455/4550 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTD is a bidirectional I/O port or a Streaming Parallel Port (SPP). These pins have TTL input buffers when the SPP module is enabled.
RD0/SPP0	19	38	38			
RD0				I/O	ST	Digital I/O.
SPP0				I/O	TTL	Streaming Parallel Port data.
RD1/SPP1	20	39	39			
RD1				I/O	ST	Digital I/O.
SPP1				I/O	TTL	Streaming Parallel Port data.
RD2/SPP2	21	40	40			
RD2				I/O	ST	Digital I/O.
SPP2				I/O	TTL	Streaming Parallel Port data.
RD3/SPP3	22	41	41			
RD3				I/O	ST	Digital I/O.
SPP3				I/O	TTL	Streaming Parallel Port data.
RD4/SPP4	27	2	2			
RD4				I/O	ST	Digital I/O.
SPP4				I/O	TTL	Streaming Parallel Port data.
RD5/SPP5/P1B	28	3	3			
RD5				I/O	ST	Digital I/O.
SPP5				I/O	TTL	Streaming Parallel Port data.
P1B				O	—	Enhanced CCP1 PWM output, channel B.
RD6/SPP6/P1C	29	4	4			
RD6				I/O	ST	Digital I/O.
SPP6				I/O	TTL	Streaming Parallel Port data.
P1C				O	—	Enhanced CCP1 PWM output, channel C.
RD7/SPP7/P1D	30	5	5			
RD7				I/O	ST	Digital I/O.
SPP7				I/O	TTL	Streaming Parallel Port data.
P1D				O	—	Enhanced CCP1 PWM output, channel D.

Legend: TTL = TTL compatible input   CMOS = CMOS compatible input or output
         ST = Schmitt Trigger input with CMOS levels   I   = Input
         O = Output   P   = Power

Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.

      2: Default assignment for CCP2 when CCP2MX Configuration bit is set.

      3: These pins are No Connect unless the ICPRT Configuration bit is set. For NC/ICPORTS, the pin is No Connect unless ICPRT is set and the DEBUG Configuration bit is cleared.

```c
char txt[768];
char *string;
int i=0, j=0;
unsigned short ready=0;
char GPGLL[35];
char Lat[5];
char Lon[5];
int flag=0;
char AN_0=0;
char ii=0,jj=0,kk=0;
char SEVEN_A=0;
char SEVEN_B=0;
long latitude=0;
long a_1=0;
long a_2=0;
long a_3=0;
long a_4=0;
long a_5=0;
long longitude=0;
long M_latitude=87472;
long M_longitude=18053;
float Distance=0;
long F_Distance=0;
float D1=0;
float D2=0;
float D3=0;
float D4=0;
char char_Distance[12];
void interrupt ( ) {
if (RCIF_bit == 1) {
txt[i] = UART1_Read ( );
i++;
if (i == 768) {
i = 0;
ready = 1;
}
RCIF_bit = 0; {
}
```

```c
void SEVENA ( )
{
RC1_bit=1;RC0_bit=0;
if(SEVEN_A==0)PORTB=20;
else if(SEVEN_A==1)PORTB=126;
else if(SEVEN_A==2)PORTB=152;
else if(SEVEN_A==4)PORTB=114;
else if(SEVEN_A==5)PORTB=81;
else if(SEVEN_A==6)PORTB=17;
else if(SEVEN_A==7)PORTB=116;
else if(SEVEN_A==8)PORTB=16;
else if(SEVEN_A==9)PORTB=80;
delay_ms(1);
}
void SEVENB ( ) {
RC0_bit=1;RC1_bit=0;
if(SEVEN_B==0)PORTB=20;
else if(SEVEN_B==1)PORTB=126;
else if(SEVEN_B==2)PORTB=152;
else if(SEVEN_B==3)PORTB=88;
else if(SEVEN_B==4)PORTB=114;
else if(SEVEN_B==5)PORTB=81;
else if(SEVEN_B==6)PORTB=17;
else if(SEVEN_B==7)PORTB=116;
else if(SEVEN_B==8)PORTB=16;
else if(SEVEN_B==9)PORTB=80;
delay_ms(1);
}
void Dir_LED(char x)
{
if(x==1)PORTD=1;
else if(x==2)PORTD=2;
else if(x==3)PORTD=4;
else if(x==4)PORTD=8;
else if(x==5)PORTD=16;
else if(x==6)PORTD=32;
else if(x==7)PORTD=64;
else if(x==8)PORTD=128;
}
void  GPGLL ( )
{
for(j=0;j<750;j++)
```

```c
{
if(txt[j]=='G'&&txt[j+1]=='P'&&txt[j+2]=='G'&&txt[j+3]=='L'&&
txt[j+4]=='L'){flag=j; break;}
}
for(j=0;j<33;j++)
{GPGLL[j]=txt[j+flag];}
flag=0;
j=0;
for(j=0;j<5;j++)
Lat[j]=GPGLL[j+11];
for(j=0;j<5;j++)
Lon[j]=GPGLL[j+25];
SEVENA( );SEVENB( );
a_1=((Lat[4]-48));
a_2=((Lat[3]-48)*10);
a_3=((Lat[2]-48)*100);
a_4=((Lat[1]-48)*1000);
a_5=((Lat[0]-48)*1000);
a_5=a_5*10;
latitude=a_5+a_4+a_3+a_2+a_1;
SEVENA( );SEVENB( );
a_1=((lon[4]-48));
a_2=((lon[3]-48)*10);
a_3=((lon[2]-48)*100);
a_4=((lon[1]-48)*1000);
a_5=((lon[0]-48)*1000);
a_5=a_5*10;
longitude=a_5+a_4+a_3+a_2+a_1;
SEVENA( );SEVENB( );
D1= M_latitude-latitude;
D2= M_longitude-longitude;
D4=atan2(D1,D2) * 180/3.14;
D4=D4+180;
if(D4>0&&D4<=22)Dir_LED(3);
else if(D4>22&&D4<=67)Dir_LED(4);
else if(D4>67&&D4<=112)Dir_LED(5);
else if(D4>112&&D4<=157)Dir_LED(6);
else if(D4>157&&D4<=202)Dir_LED(7);
else if(D4>202&&D4<=247)Dir_LED(8);
else if(D4>247&&D4<=292)Dir_LED(1);
else if(D4>292&&D4<=337)Dir_LED(2);
else if(D4>337&&D4<=360)Dir_LED(3);
```

```c
D1=D1*D1;
D2=D2*D2;
D3=D1+D2;
SEVENA( );SEVENB( );
Distance=sqrt(D3);
Distance=Distance*0.0006;
F_Distance=Distance*30.9;
SEVENA( );SEVENB( );
FloatToStr(D4, char_Distance);
SEVENA( );SEVENB( );
SEVEN_B=F_Distance/10;
SEVEN_A=F_Distance%10;
}
void main ( ) {
OSCCON=0x72;
TRISA=3;
PORTA=0;
PIE1.RCIE = 1;
INTCON.PEIE = 1;
INTCON.GIE  = 1;
UART1_Init(9600);
TRISB=0;
TRISC=128;
TRISE=0;
TRISD=0;
PORTC=255;
PORTB=255;
PORTD=0;
PORTE=0;
TRISA=2;
PORTA=0;
LATD=0;
ADCON0=3;
ADCON1=14;
LATE=0;
DELAY_MS(500);
PORTE.F2=1;
DELAY_MS(500);
PORTE.F1=1;
DELAY_MS(500);
PORTE.F0=1;
DELAY_MS(500);
```

```
PORTE=0;
Delay_ms(100);
while(1) {
SEVENA( );SEVENB( );
if( ready == 1 ){
GPGLL_( );
SEVENA( );SEVENB( );
uart1_write_text("Lat =");
for(j=0;j<5;j++)
uart1_write(Lat[j];
SEVENA( );SEVENB( );
for(j=0;j<5;j++)
uart1_write(Lon[j]);
uart1_write_text(char_Distance );
SEVENA( );SEVENB( );
ready = 0;
}
SEVENA( );SEVENB( );
AN_0=ADC_Read(0)/11;
if(AN_0<55){PORTE.F2=0;PORTE.F1=0;PORTE.F0=1};
else if(AN_0<70){PORTE.F2=0;;PORTE.F0=0;PORTE.F1=1};
else if(AN_0<100){PORTE.F1=0;PORTE.F0=0;PORTE.F2=1};
SEVENA( );SEVENB( );
if (Button(&PORTA, 1, 1, 0));
{
SEVENA( );SEVENB( );
M_latitude=latitude;
M_longitude=longitude;
PORTE.F1=1;
DELAY_MS(500);
PORTE.F1=0;
PORTE=0;
}
}
}
```