



**PPU** College of  
Engineering and Technology

The Home of Competent Engineers and Researchers

**Electrical and Communication Engineering Department**  
**Communication and Electronic Engineering**

**Bachelor Thesis**

**Graduation Project**

**Smart Rescuing System Using Zigbee Technology**

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# إهداء

إلى ينبوع العطاء الذي زرع في نفسي الطموح والمثابرة.... والدي العزيز

إلى نبع الحنان الذي لا ينضب... أمي الغالية

إلى من يحملون في عيونهم ذكريات طفولتي وشبابي..... إخوتي  
وأخواتي

إلى من ضاقت السطور من ذكرهم فوسعهم قلبي..... أصدقائي

إلى من ضحوا بحريتهم من أجل حرية غيرهم..... الأسرى والمعتقلين

إلى من هم أكرم منا مكانة..... شهداء فلسطين

إلى كل محبي العلم والمعرفة

إلى الأساتذة الأفاضل .....

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

إلى زملائي وزميلاتي في جامعة بوليتكنك فلسطين

إلى كل من ساهم في إنجاح هذا العمل

**Palestine Polytechnic University**

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By the guidance of our supervisor, and by the acceptance of all members in the testing committee , this project is delivered to department of electrical engineering In the college of engineering and technology , to be as partial fulfillment of the requirement of the department for the degree of B.sc.

**Supervisor signature**

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**The head of department signature**

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جامعة بوليتكنك فلسطين

الخليل - فلسطين

كلية الهندسة

دائرة الهندسة الكهربائية

## Smart Rescuing System Using Zigbee Technology

### Abstract

فريق المشروع

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بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة المناقشة، تم تقديم هذا العمل إلى دائرة الهندسة الكهربائية وذلك للوفاء بمتطلبات درجة البكالوريوس في هندسة الاتصالات

توقيع المشرف

.....

توقيع اللجنة المناقشة

.....

توقيع رئيس اللجنة

.....

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# Abstract

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Our project is concerned with designing and implementing of a ship that will automatically rescue people wearing the sensor which responsible to measure the percentage of oxygen in blood and react according to the priority of the percentage. The system consists of transmitter at the swimmer , and receiver with ship. The transmitter consists of a GPS and pulse oximeter , PIC plus Xbee –Tx , while the receiver consists of a GPS and Xbee-Rx device , motors ,PIC. So when the percentage of oxygen is too little; the system will determine the coordination by GPS of the person who has a leakage then the ship will travel directly where the meant person is .the wireless communication technique between the ship and the person is Zig-bee .

Note that the implementation of the project is just from one node to another .

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GNSS	Global Navigation Satellite System
SCOUT	Surface Craft for Oceanographic and Undersea Testing
FSK	Frequency Shift Keying
USART	Universal Synchronous Asynchronous Receiver Transmitter
RSSI	received signal strength indicator
FTDI	Future Technology Devices International
UDA	Global Positioning System File Data
RMC	Recommended Minimum Specific GNSS Data
GPS	Satellite in view
GSA	DOP and Active Satellites
NMEA	National Marine Electronics Association
DC	Direct Current
PC	Personal computer
TX	Transmitter
RX	Receiver
GPS	Global positioning system
EMF	Electromotive force
EMI	Electromagnetic Interference
LED	Light Emitting Diode
PAN	Personal Area Network
PD	photo diode
SO <sub>2</sub>	The saturation of oxygen in blood
COHb	Carboxyhemoglobin
Hb	deoxygenated hemoglobin
PCB	Printed circuit

## List Of Abbreviation

SPO2	Saturation of Peripheral Oxygen
WHO	world health organization
IPMC	ionic polymer-metal composite
HABs	Harmful Algal Blooms
IRL	Indian River Lagoon
AMB	Autonomous Mobile Buoy
OASIS	Ocean-Atmosphere Sensor Integration System
SCOUT	Surface Craft for Oceanographic and Undersea Testing
PWM	Pulse Width Modulation
USART	Universal Synchronous Asynchronous Receiver Transmitter
RSSI	received signal strength indicator
FTDI	Future technology devices international.
GGA	Global Positioning System Fix Data
RMC	Recommended Minimum Specific GNSS Data
GSV	Satellites in view
GSA	DOP and Active Satellites
NMEA	National Marine Electronics Association
BDC	Brush DC motors
P.C	Personal computer
TX	Transmitter
RX	Receiver
GPS	Global positioning system
EMF	Electromotive Force
EMI	Electromagnetic Interference
LED	Light Emitting Diode
PAN	Personal Area Network
PD	photo diode
SO2	The saturation of oxygen in blood
COHb	Carboxyhemoglobin
Hb	deoxygenated hemoglobin
PC	Printed circuit

## List Of Abbreviation

1

SPO2	Saturation of Peripheral Oxygen
WHO	World Health Organization
IPMC	Ionic Polymer-Metal Composite
HABs	Harmful Algal Blooms
IRL	Indian River Lagoon
AMB	Autonomous Mobile Boat
OASIS	Ocean-Atmosphere Interfacial System
SCOUT	Small Coastal Oceanic Undersea
PWM	Pulse Width Modulation
USART	Universal Serial Bus
RSSI	Received Signal Strength Indicator
FTDI	Future Technology Devices International
GGA	Overview
RMC	Project Objectives
GSV	
GSA	Motivation
NMEA	
BDC	Requirements
P.C	
TX	Challenges
RX	Related Works
GPS	
EMF	Project Plan
EMI	
1.8	Estimated Cost and Budget
1.9	Report Content

# Chapter One

# 1

## Introduction :

- 1.1 Overview
- 1.2 Project Objectives
- 1.3 Motivation
- 1.4 Requirements
- 1.5 Challenges
- 1.6 Related Works
- 1.7 Project Plan
- 1.8 Estimated Cost and Budget
- 1.9 Report Content

## 1.1 Overview

Life is very important especially for parents toward their own kids by providing protection for them against various risks however the main concern to keep them safe as much as possible, so one of the risks that will be discussed is drowning which it's not only stands for kids ,it's also for all people categorizes whatever age and healthiness.

the drowning represents the third leading cause of deaths from unintentional injuries overseas , where they stand behind a 7% of the total deaths .there are about 388000 thousand cases of deaths due to drowning each year around the world Even with the swimming and safety levels availability in many countries; a large numbers of people is still drowning annually. The best available scientific evidence has notified us that 1.2 million people around the world pass away due to drowning yearly ,which means that more than two persons per minute including more than 50 percent children meet death .

Children , and individuals who often swim more than others, are more vulnerable to the risk of drowning even with the presence of safe guards on the beach , so how can we solve this problem(drowning) or reduce this phenomenon? It's found that it is not something cannot be done ,it is possible by developing a new smart system that rescue drowning statistics and take the suitable shape .

## 1.2 Project Objectives

This project aims to reduce the drowning risks , especially people with disorders along with who cannot swim through detecting percentage of oxygen in the blood of the swimmer, when this percentage decrease to a threshold that threat human life, the rescuing system will save that person's life by determining the direction and location of the person . In addition , our goal is to use wireless communication technology ( ZigBee ) combined with GPS and pulse oximeter sensor and to achieve time response reduction .

## 1.3 Motivation

Rescuing people and reduce the probability of drowning by employing a new communication techniques , through this project we will help parents to have no worries about their children's safety plus all people will feel safe while they are swimming and when the ship is around, providing good efficiency in speed , time of rescue

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

#### **1.4 Requirements**

The hardware requirements is Zig-bee , GPS , PIC Microcontroller ,Pulse Oximeter sensor plus Motors.

In concern of software we will program the microcontroller who is responsible for many tasks.

#### **1.5 Challenges**

There are many problems obstructed and change some ideas in the project. We can summarize them below :

- GPS systems do not give us the desired accuracy because Intentional jamming by occupation plus the accuracy problem .
- How to program microcontroller to achieve the goals on hardware.
- Availability of electronic chips and motors .
- Providing the suitable shape of our system.

#### **1.6 Literature Review**

We present a framework for a wireless health monitoring system using ZigBee technology. It has the capability to monitor vital signals from multiple biosensors. Biomedical signals are collected and processed using 2-tiered subsystems. The first stage is the mobile device carried on the body that runs a number of biosensors (internal subsystem). At the second stage, further processing is performed by a local base station (external subsystem) using the raw data transmitted on-request by the mobile device. The raw data is also stored at this base station. The processed data as well as the analysis results are then monitored and diagnosed through a human-machine interface. The main advantages of the proposed framework are:

- 1) the ability to detect signals wirelessly within a body sensor network.
- 2) low-power and reliable data transmission through ZigBee network nodes.
- 3) secure transmission of medical data over a body sensor network.
- 4) efficient channel allocation for medical data transmission over wireless networks.
- 5) optimized analysis of data using an adaptive hardware architecture that maximizes the utility of processing and computational capacity at each platform.

Another similar project which is “Child tracking” which is done by () supervised by Dr.Gandi Manasrah at Palestine polytechnic university this project aims to develop a Child Tracking System. The system will be based on 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.

## **1.7 Project Plan**

The project will be divided into the following categories :

### **Part 1: Preparing the project**

In this Part , 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.

### **Part 2: Analysis overview**

A deep and complete study for all options of the project will be made.

### **Part 3: Study of the principles**

In this Part, we study the GPS, ZigBee, microcontroller,SPO2 and any other technologies or information needed.

### **Part 4: Documentation and writing**

Writing and preparing the documentation of the project was start from the first Category, and will continue till the end of the project.

### **Part 5: Measurements**

Here we will do some measurements with GPS systems and pulse oximeter sensor, to determine the accuracy and Efficiency of the system , in order to choose the better option.

### **Part 6: Microcontroller programming**

The programming of project codes are started, then downloaded to microcontroller.

### **Part 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.

### **Part 8: Implementation and Testing**

Here the system will be implemented and tested to conclude the system performance (false positive and false negative )in different environment .

### **Part 9: Writing documentation**

The documentation will continue from the first Category till the end in parallel.

Table 1.1 : Summary of the Project Plan for first semester

Weeks

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Part1														
Part2														
Part3														
Part4														
Part5														

Table 1.2 : Summary of the Project Plan for second semester

Weeks

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	15
Part6														
Part7														
Part8														
Part9														

## 1.8 Estimated cost and budget

The whole estimated cost will be approximately 1200 JD (hardware and software), and the table below shows the cost of each hardware component.

Table 1.3 : Estimated cost and budget component.

Items	Quantity	Price for one item (NIS)
Xbee PRO S2	2	300
XBee Regulator	2	60
GPS	2	450
PIC18f2550	2	100
SPO2 Sensor	1	350
motor	2	900
Batteries	1	120

## 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, motivation ,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 and Block diagrams, system blocks.

### **Chapter Four: Detailed System Design**

This chapter explains how each unit connects with other units in the system in specific details.

This chapter also 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 five: Preliminary Measurements**

This chapter contains the results and analysis of GPS measurement, and zigbee power and pulse oximeter accuracy and efficiency .

### **Chapter Six: System Testing**

This section is to test the whole system work. It should be tested to conclude system performance ,reliability, speed and the effects of the environment on the system work.

### **Chapter Seven: Conclusion and Recommendation**

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

- 2.1 Theoretical Background
- 2.2 System Design
- 2.3 GPS Technology
- 2.4 Microcontroller
- 2.5 Pulse Oximeter Sensor
- 2.6 Brush motor

# Chapter Two

2

## Theoretical Background

- 2.1 Introduction
- 2.2 ZigBee Technology
- 2.3 GPS Technology
- 2.4 Microcontroller
- 2.5 Pulse Oximeter Sensor
- 2.6 Brush motor

## 2.1 Introduction

This chapter structured on focusing on all technologies and components that our project needed , such as ZigBee technology , Microcontroller , Global Positioning System (GPS) , pulse oximeter sensor and other components that used in our system .

This chapter is important to specify how to treat with all our project components and to know their characteristics and to provide ourselves by the role and ability of each component in the entire system.

## 2.2 ZigBee technology

### 2.2.1 Overview

In these days the communication between two sides , transmitter and receiver almost wireless communication .When the wireless communication used we want to achieve high speed communication and more secure system.

The ZigBee technology is a wireless technology with low cost , low power consumption and be considered as wireless mesh network and since it has low cost then this technology will be widely deployed in all wireless applications and since the zigbee technology is low power consumption this consider as advantage allow long life with smaller batteries , also since ZigBee technology considered as mesh network this provide this technology with another and important advantage which is the ZigBee will be more extensive range and high reliability .[1]



Figure 2.1: the ZigBee chip

### 2.2.2 Origin of the name ZigBee

The name " ZigBee " is coming from the zig-zagging patterns of bees use to share and exchange information , such as the location , distance, and direction of a

newly discovered food source so the engineers are trying to work in this manner , to communicate number of devices in the network as a similar as to bees network.

### 2.2.3 Motivation

The zigbee technology which we used in our system was developed to satisfy many of the important needs in wireless technologies such as low cost, secure, reliable and self healing , flexible and extendable , low power consumption , easy and inexpensive to deploy and finally integrated intelligence for network set-up and message routing.

### 2.2.4 The zigbee networks

The zigbee networks can be formed by different ways each way is suitable for some application and some type of environment , the topologies supported in zigbee networks include three topologies which are mesh configuration , star configuration , and cluster tree configuration .

During the designing the zigbee network some devices are essentially needed to build the zigbee network in a best form. These devices are :

- Coordinators
- Routers
- End devices

The following figure illustrate the zigbee network in three topologies and the needed devices :

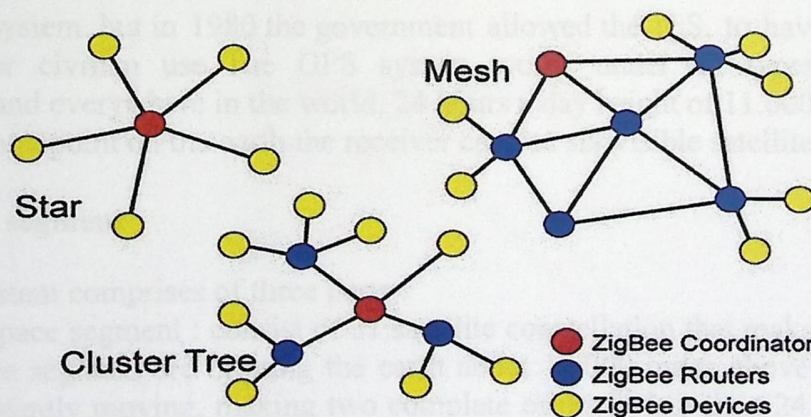


Fig 2.2 : The zigbee topologies and needed devices

The coordinator device is responsible of starting and controlling the network , in other hand the coordinator is responsible of storing the information about the network.

The router device is responsible for extending network area coverage and provide backup routes in case of network congestion or device failure , the router device can be connected to the coordinator and other routers , also routers support child devices .

And also the end devices transmit or receive a message , but can not perform any routing operations , the end devices must be connected to either the coordinator or a router , also end devices do not support child devices [2].

### 2.2.5 ZigBee Alliance

ZigBee alliance includes representative from some of the finest companies and individuals in the industry , also the zigbee alliance is group of companies work with each other to enable reliable , cost-effective , low power , wirelessly networked , and to give secure , flexible monitoring products .

The members of the zigbee alliance can be any type of companies , the zigbee technology is widely used in industrial and commercial monitoring applications . In addition the number of alliance members are increasing rapidly . [3]

## 2.3 GPS Technology

### 2.3.1 Overview of GPS

GPS stands for Global Positioning system . It is a Constellation system of 31 earth orbiting satellites that were originally designed by the US military in the 1970's as a

navigation system. 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 height of 11.000 miles above earth, from any point on the earth the receiver can see six visible satellites

### 2.3.2 GPS segment

The GPS system comprises of three parts :

- 1) Space segment : consist of 31 satellite constellation that makes up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are traveling at speeds of roughly 7,000 miles an hour [4].

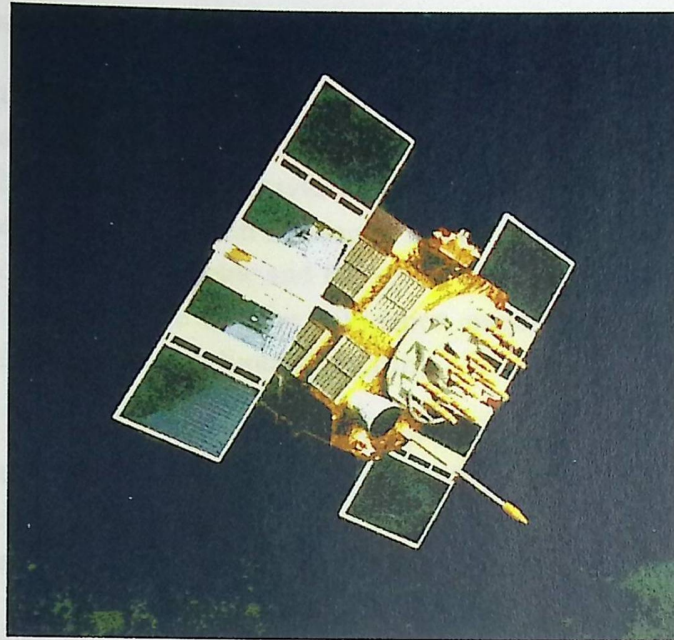


Fig 2.3 : GPS satellite

- 2) The Control Segment :consist of a worldwide network of tracking stations with a master control station located in the United states at Colorado.
- 3) User segment includes all military and civilian users .

These three segments are illustrated in the figure below.

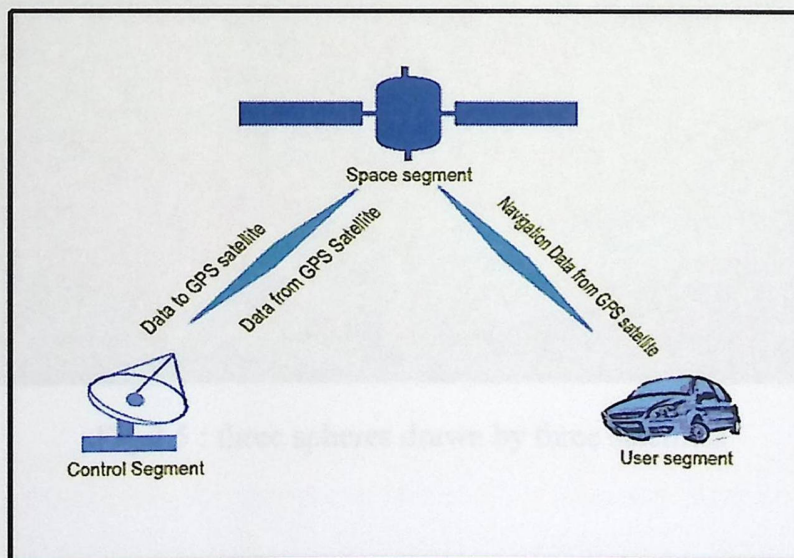


Fig 2.4 : GPS segments

### 2.3.3 GPS the basic idea

GPS satellites circle the earth twice a day in a very precise orbit .each satellite continuously transmit a microwave radio signal to the earth which have three parameters the first one two sine waves carrier frequencies , the second is digital codes and the last one is navigation message . Every receiver can receive the signal and it can use the carrier parameter and the codes to determine the distance between the user and the GPS satellite but the navigation message contains the coordinates (the location) of the satellite as a function of time.

When the receiver switch on and pick up this signal with the three parameter , it will make process to the signal by using its built-in software. The partial outcome of the signal processing consists of the distances to the GPS satellite throw the digital codes and the satellite coordinates throw the navigation message.

Theoretically only three distances to three simultaneously tracked satellites are needed. Then use the process known of resection , this process done by use the distance between each of satellites and the receiver to draw a sphere the three sphere's intersection by one point that's indicate to the receiver .the figure 2.5 illustrate the intersect-tion between the sphere's that determine the location of the receiver. [5]

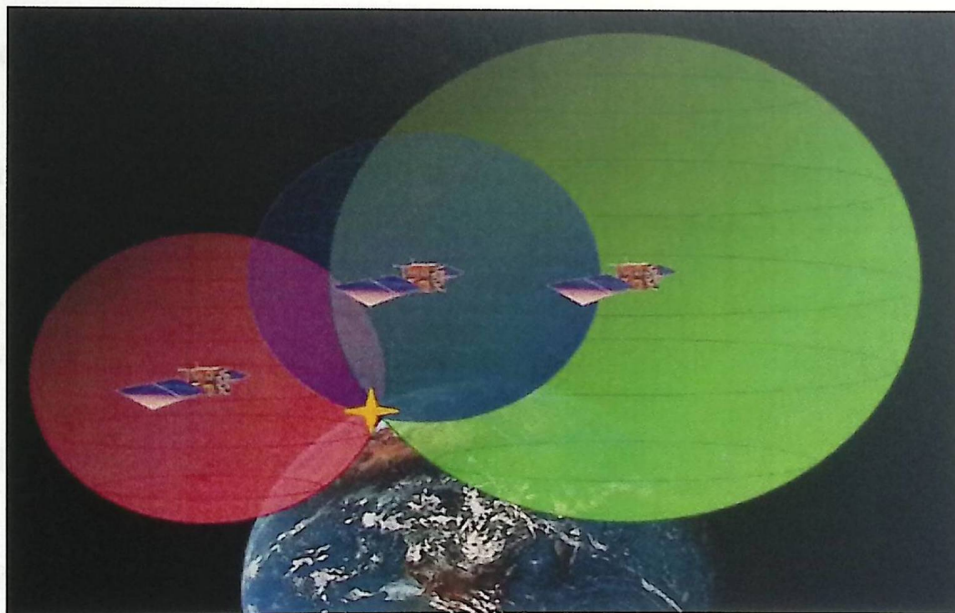


Fig 2.5 : three spheres drawn by three satellites

### 2.3.4 GPS Accuracy

GPS Position relies on precise measurements of the distance from the receiver to the satellite, and therefore suffers from numerous effects which can reduce the quality of the signal. These include atmospheric effects which delay the signals from

the satellites and reflections from nearby objects such as buildings which introduce multipath, again adding to the length of the signal ,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 timing. [6]

## **2.4 PIC microcontroller**

Basically, a microcontroller is a device which integrates a number of the components of a microprocessor system onto a single microchip and optimized to interact with the outside world through on-board interfaces i.e. it is a little gadget that houses a microprocessor, ROM (Read Only Memory), RAM (Random Access Memory), I/O (Input Output functions), and various other specialized circuits all in one package.

## **2.5 Pulse Oximeter Sensor**

### **2.5.1 Introduction**

Pulse oximeter sensor is a photoelectric device that measures oxygen saturation of the blood by recording the amount of absorbed or reflected light by deoxygenated versus oxygenated hemoglobin. We can define the pulse oximeter as the method for non-invasive measurements of two important quantities the saturation of oxygen in blood, the heart beat rate-pulse. [7]

## 2.5.2 Principle of operation

The measuring principle of pulse oximeter sensor depends on spectrophotometry, which mean measurement of the absorptivity or extinction coefficient of a given substance at particular wavelengths.

In pulse oximeter only two light sources with different wavelengths are used So only the concentration of two different solutes can be determined. A source of light originates from the probe at two wave lengths (650nm and 805nm), the light is partly absorbed by hemoglobin by amount which differ depending on whether it is saturated or de-saturated with oxygen.

The saturation of oxygen in blood,  $SO_2$ , is defined by the concentration of oxygenated hemoglobin ( $HbO_2$ ) to the ratio of the sum of oxygenated and deoxygenated (Hb) hemoglobin, which can be written as the following formula [8] :

$$SO_2 = \frac{C_{HbO_2}}{C_{HbO_2} + C_{Hb}}$$

### Where:

$SO_2$  : the saturation of oxygen in blood.

$CHbO_2$  : the concentration of oxygenated hemoglobin.

$CHb$  : the concentration of deoxygenated hemoglobin.

In a pulse oximeter device only the saturation of arterial blood is measured, and this is always indicated by the correct terminology  $S_aO_2$ .

An important point must be in consideration , that the saturation found by the previous formula takes the concentration of  $HbO_2$  to the concentration for Hb and  $HbO_2$ , which we find with a pulse oximeter but there are other types of hemoglobin in blood such as carboxyhemoglobin (COHb) and methemoglobin (Mettlb) therefore the previous equation could be taken between  $HbO_2$  and the total hemoglobin and then this called the fractional oxygen saturation.

The pulse oximeter device which we used in our system uses only two wavelengths are not able to find the concentration of Hb and  $HbO_2$  correctly, but the reading from the pulse oximeter is an estimation of the functioned arterial oxygen concentration and this should be interpreted as "arterial oxygen concentration as measured by pulse oximeter" or  $SPO_2$ . [9]

In total we have three terms denoting the functioned oxygen saturation in blood:

- $SO_2$ : Saturation of oxygen in blood.
- $SaO_2$ : Saturation of oxygen in arterial blood.
- $SpO_2$ : Saturation of oxygen in arterial blood as measured by a pulse oximeter.

There are two different concepts for a lack of oxygen for the respiratory process. The first concept is called hypoxia which means lower normal tissue oxygenation and this refers to a condition where the cells ability to absorb Oxygen is jeopardized, and this is undetectable by pulse oximeter. The second concept is hypoxemia which means lower than normal blood oxygenation and this is what a pulse oximeter is able to detect.

The two light sources with different wavelengths are absorbed by more than one substance of the finger and the following figure represent the variation of light absorbed in two cases of pulsatile and non pulsatile blood.

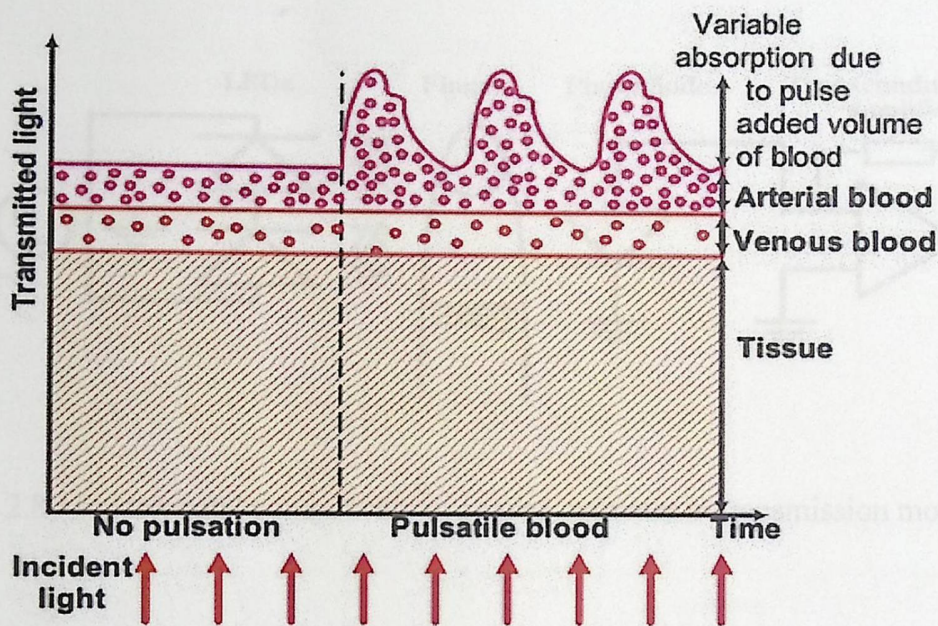


Fig 2.6 : light passing through the substances of a finger

As illustrated in the figure 2.6 there are several contributors to the absorbance : skin , tissue , bones makes a constant absorbance together with the venous blood and the non-pulsating arterial blood .

### 2.5.3 Pulse oximeter operating modes

There are two modes for pulse oximeter which can operate with, the first mode is transmission mode and the second mode is the reflectance.

In the first mode (transmission mode) the light transmitted through the medium is detected by using a photodiode (PD) opposite the light emitting diode (LED). This mode is illustrated in the following figure.

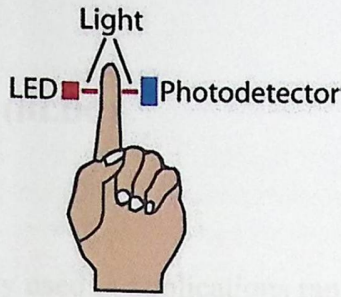


Fig 2.7 : LED and PD placement for transmission mode pulse oximeter

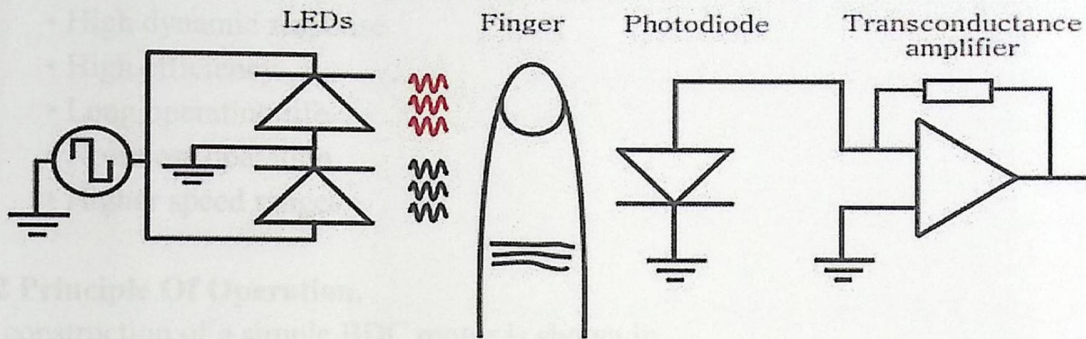


Fig 2.8 : fundamental components in a pulse oximeter in transmission mode

The second mode (Reflectance mode) the pulse oximeter consists of the same LEDs and PD as in the first mode but the photo diode is located on the same planar surface as the LEDs. This mode is illustrated in the following figure.

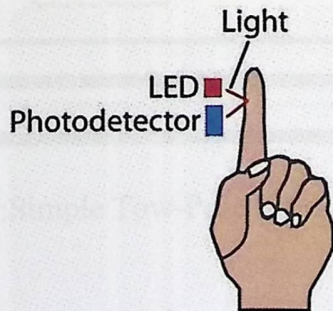


Fig 2.9 : LED and PD placement for reflectance mode pulse oximeter.

The PD is responsible to detect light that is back-scattered or reflected off of the tissue, bones, and blood vessels. [10]

## 2.6 Brushless DC Motor (BLDC)

### 2.6.1 Introduction

Brushed DC motors are widely used in applications ranging from toys to push-button adjustable car seats. Brushed DC (BDC) motors are inexpensive, easy to drive, and are readily available in all sizes and shapes. This application note will discuss how a BDC motor works, how to drive a BDC motor, and how a drive circuit can be interfaced to a PIC® microcontroller. BDC motors have many advantages, A few of these are:

- Better speed versus torque characteristics
- High dynamic response
- High efficiency
- Long operating life
- Noiseless operation
- Higher speed ranges

### 2.6.2 Principle Of Operation.

The construction of a simple BDC motor is shown in Figure 2.10 [11].

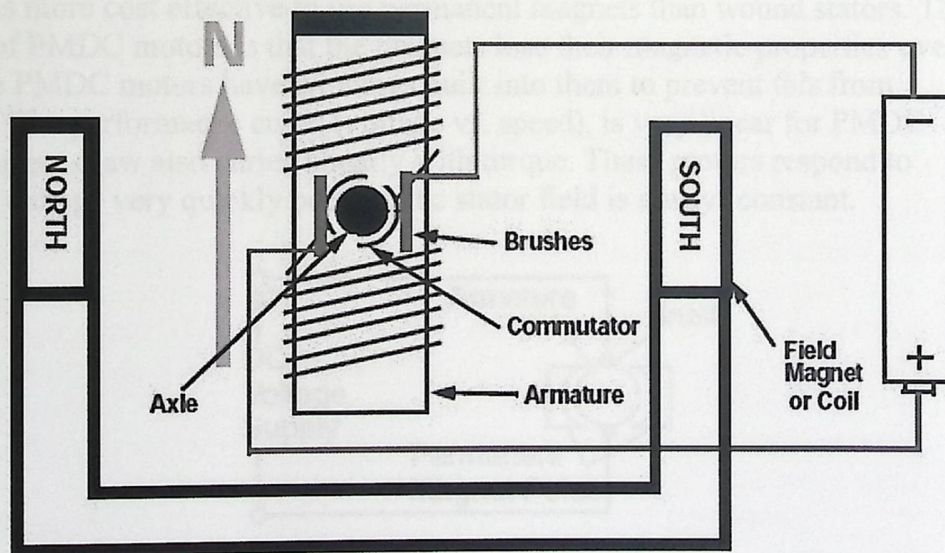


Figure 2.10 :Simple Two-Pole Brushed DC Motor

All BDC motors are made of the same basic components: a stator, rotor, brushes and a commutator.

The following paragraphs will explain each component in greater detail.

### 2.6.3 Stator

The stator generates a stationary magnetic field that surrounds the rotor. This field is generated by either permanent magnets or electromagnetic windings. The different types of BDC motors are distinguished by the construction of the stator or the way the electromagnetic windings are connected to the power source. (See Types of Stepping Motors for the different BDC motor types).

### 2.6.4 Rotor

The rotor, also called the armature, is made up of one or more windings. When these windings are energized they produce a magnetic field. The magnetic poles of this rotor field will be attracted to the opposite poles generated by the stator, causing the rotor to turn. As the motor turns, the windings are constantly being energized in a different sequence so that the magnetic poles generated by the rotor do not overrun the poles generated in the stator. This switching of the field in the rotor windings is called commutation.

### 2.6.5 Permanent Magnet

Permanent Magnet Brushed DC (PMDC) motors are the most common BDC motors found in the world. These motors use permanent magnets to produce the stator field. PMDC motors are generally used in applications involving fractional horsepower because it is more cost effective to use permanent magnets than wound stators. The drawback of PMDC motors is that the magnets lose their magnetic properties over time. Some PMDC motors have windings built into them to prevent this from happening. The performance curve (voltage vs. speed), is very linear for PMDC motors. Current draw also varies linearly with torque. These motors respond to changes in voltage very quickly because the stator field is always constant.

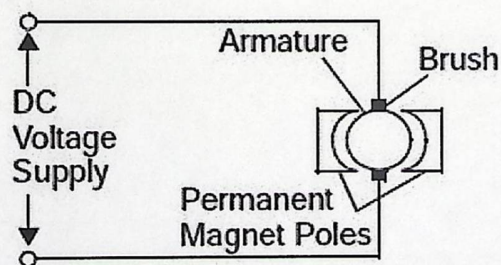


Figure 2.11 :Permanent Magnet DC Motor

### 2.6.6 Series-Wound

Series-wound Brushed DC (SWDC) motors have the field coil in series with the armature. These motors are ideally suited for high-torque applications because the current in both the stator and armature increases under load. A drawback to SWDC motors is that they do not have precise speed control like PMDC and SHWDC motors have.

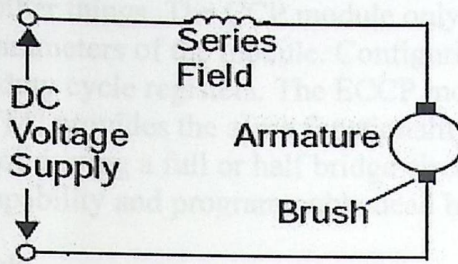


Figure 2.12 :Series-Wound DC Motors

### 2.6.7 SPEED CONTROL

The speed of a BDC motor is proportional to the voltage applied to the motor. When using digital control, a pulse-width modulated (PWM) signal is used to generate an average voltage. The motor winding acts as a low pass filter so a PWM waveform of sufficient frequency will generate a stable current in the motor winding. The relation between average voltage, the supply voltage, and duty cycle is given by: EQUATION 1:

$$V_{AVERAGE} = D \times V_{SUPPLY}$$

Speed and duty cycle are proportional to one another. For example, if a BDC motor is rated to turn at 15000 RPM at 12V, the motor will (ideally) turn at 7500 RPM when a 50% duty cycle waveform is applied across the motor. Speed and duty cycle are proportional to one another. For example, if a BDC motor is rated to turn at 15000 RPM at 12V, the motor will (ideally) turn at 7500 RPM when a 50% duty cycle waveform is applied across the motor.

The frequency of the PWM waveform is an important consideration. Too low a frequency will result in a noisy motor at low speeds and sluggish response to changes in duty cycle. Too high a frequency lessens the efficiency of the system due to switching losses in the switching devices. A good rule of thumb is to modulate the input waveform at a frequency in the range of 4 kHz to 20 kHz. This range is high enough that audible motor noise is attenuated and the switching losses present in the MOSFETs (or BJTs) are negligible. Generally, it is a good idea to experiment with the PWM frequency for a given motor to find a satisfactory frequency.

So how can a PIC microcontroller be used to generate the PWM waveform required to control the speed of a BDC motor? One way would be to toggle an output pin by writing assembly or C code dedicated to driving that pin(1). Another way is to select a PIC microcontroller with a hardware PWM module. The modules available from Microchip for this purpose are the CCP and ECCP modules. Many of the PIC microcontrollers have CCP and ECCP modules. Refer to the product selector guide to find the devices having these features. The CCP module (short for Capture Compare and PWM) is capable of outputting a 10-bit resolution PWM waveform on a single I/O pin. 10-bit resolution means that 210, or 1024, possible duty cycle values ranging from 0% to 100% are achievable by the module. The advantage to using this module

is that it automatically generates a PWM signal on an I/O pin which frees up processor time for doing other things. The CCP module only requires that the developer configure the parameters of the module. Configuring the module includes setting the frequency and duty cycle registers. The ECCP module (short for Enhanced Capture Compare and PWM) provides the same functionality as the CCP module with the added capability of driving a full or half bridge circuit. The ECCP module also has auto-shutdown capability and programmable dead band delay.

### 2.6.8 Sensored Feedback

There are a variety of sensors used for speed feedback. The most common are optical encoders and hall effect sensors. Optical encoders are made up of several components. A slotted wheel is mounted to the shaft at the non-driving end of the motor. An infrared LED provides a light source on one side of the wheel and a photo transistor detects light on the other side of the wheel (see Figure 2.13). Light passing through the slots in the wheel will turn the photo transistor on. As the shaft turns, the photo transistor turns on and off with the passing of the slots in the wheel. The frequency at which the transistor toggles is an indication of motor speed. In the case of positioning applications, an optical encoder will also provide feedback as to the position of the motor.

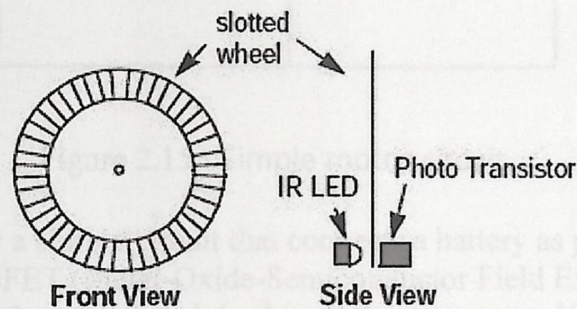


Fig. 2.13 : Optical Encoder

Hall effect sensors are also used to provide speed feedback. Like optical encoders, hall effect sensors require a rotary element attached to the motor and a stationary component. The rotary element is a wheel with one or more magnets positioned on its outer rim. A stationary sensor detects the magnet when it passes and generates a TTL pulse. Figure 10 shows the basic components of a hall effect sensor.

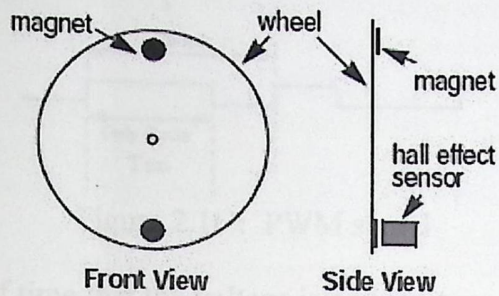


Figure 2.14 : Hall Effect sensor

### 2.6.9 Speed Control by Using PWM and Full H Bridge Motor Drive

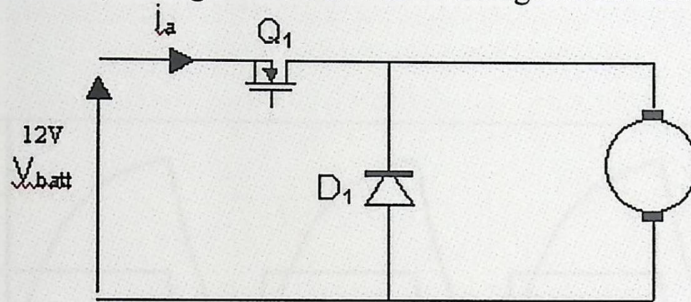


Figure 2.15 : Simple motor circuit.

Let us consider a simple circuit that connects a battery as power supply through a switch MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) as shown in Figure 2.8. When the switch is closed, the motor sees 12 Volts, and when it is open it sees 0 Volts. If the switch is open for the same amount of time as it is closed, the motor will see an average of 6 Volts, and will run more slowly accordingly.

This on-off switching is performed by power MOSFETs. A MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) is a device that can turn very large currents on and off under the control of a low signal level voltage. The average of voltage that supply to DC motor is given by, [12]

$$V_{ave} = \frac{t_{on}}{T} \times V_{in}$$

where  $V_{ave}$  = average voltage supply to DC motor

$t_{on}$  = time ON of switches

$T$  = period of PWM

$t_{on}/T = DC$ , duty cycle

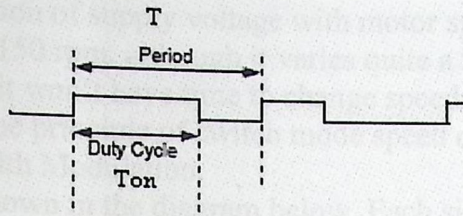


Figure 2.16 : PWM signal

As the amount of time that the voltage is on increases compared with the amount of time that it is off, the average speed of the motor increases and vice versa. The time that it takes a motor to speed up and slow down under switching conditions is depends on the inertia of the rotor (basically how heavy it is), and how much friction and load torque there is. Figure 2.10 shows the speed of a motor that is being turned on and off fairly slowly:

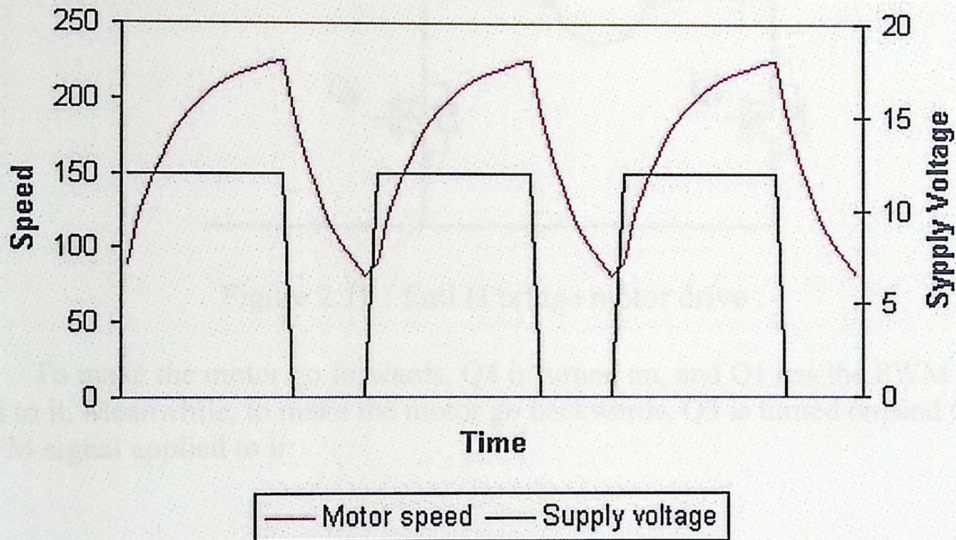


Figure 2.17 : Relation of supply voltage with motor speed

Figure 2.17 Relation of supply voltage with motor speed We can see that the average speed is around 150 rpm, although it varies quite a bit. If the supply voltage is switched fast enough, it won't have time to change speed much, and the speed will be quite steady. This is the principle of switch mode speed control. Thus the speed is set by PWM – Pulse Width Modulation.

A full bridge circuit is shown in the diagram below. Each side of the motor can be connected either to battery positive, or to battery negative. Only one MOSFET on each side of the motor must be turned on at any one time otherwise they will short out the battery and burn out.

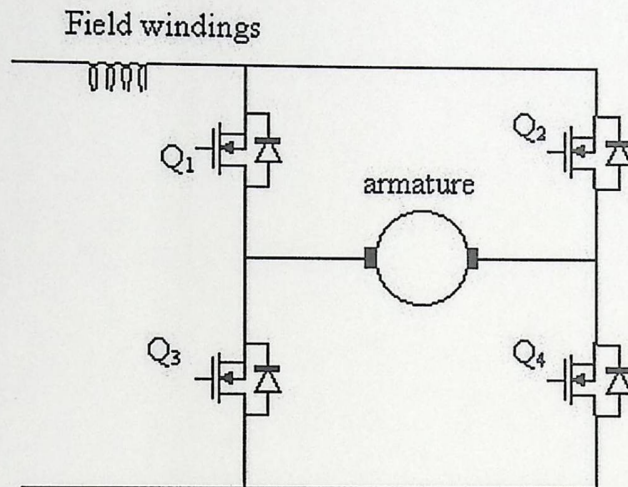


Figure 2.18 : Full H bridge motor drive .

To make the motor go forwards, Q4 is turned on, and Q1 has the PWM signal applied to it. Meanwhile, to make the motor go backwards, Q3 is turned on, and Q2 has the PWM signal applied to it:

### 2.6.10 CONCLUSION

Brushed DC motors are very simple to use and control, which makes them a short design-in item. PIC microcontrollers, especially those with CCP or ECCP modules are ideally suited for driving BDC motors.

After what we have explained in this chapter about the general concept in details of each ZigBee ,GPS ,pulse oximeter, microcontroller and required motors , the next chapter going to discuss the Conceptual Design of our project .

# Chapter three

3

## Conceptual Design

- 3.1 Introduction
- 3.2 System Functions and Block Diagram
- 3.3 How does the System work?
- 3.4 System Entities
- 3.5 Software 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.

# Chapter three

# 3

### 3.2 System Function and block diagram

The project aims to achieve the following objectives:

1) Locating the person under danger using the GPS Technology.

## Conceptual Design

### 3.1 Introduction

### 3.2 System Functions and Block Diagram

### 3.3 How does the System work?

### 3.4 System Entities

### 3.5 Software Design

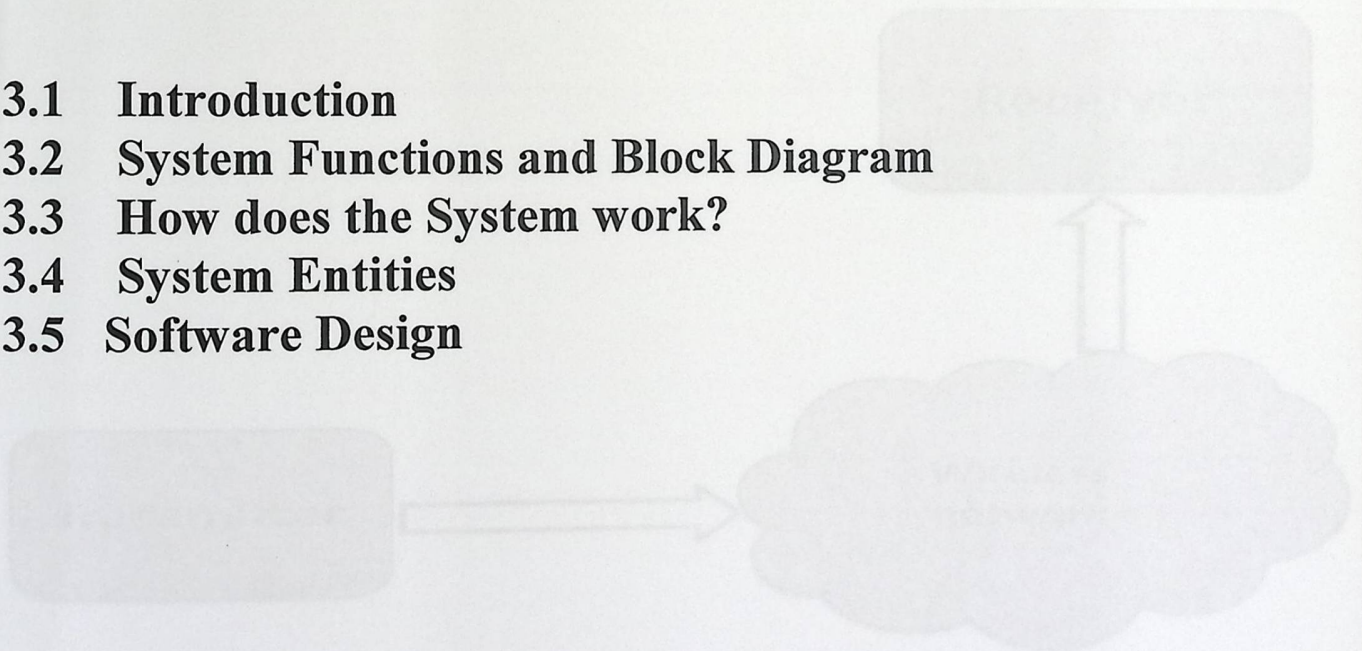


Figure 3.1: General block diagram

### 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, pulse oximeter, regulator, motors and microcontroller. Also, the explanation will include the work design methodology.

### 3.2 System Function and block diagram .

The project aims to achieve the following objectives :

- 1) locating the person under danger using the GPS Technology.
- 2) Building a system capable to sense the percentage of oxygen in the human body using pulse oximeter sensor, if it's decreased from a threshold value note that it represents the level of danger caused by the lack of oxygen which is selected in the soft ware code that notify an alarm signal plus location to the PIC controller in order to send it to the receiver side using zigbee network causing to turn the motor on which move the rescuing ship to the person .

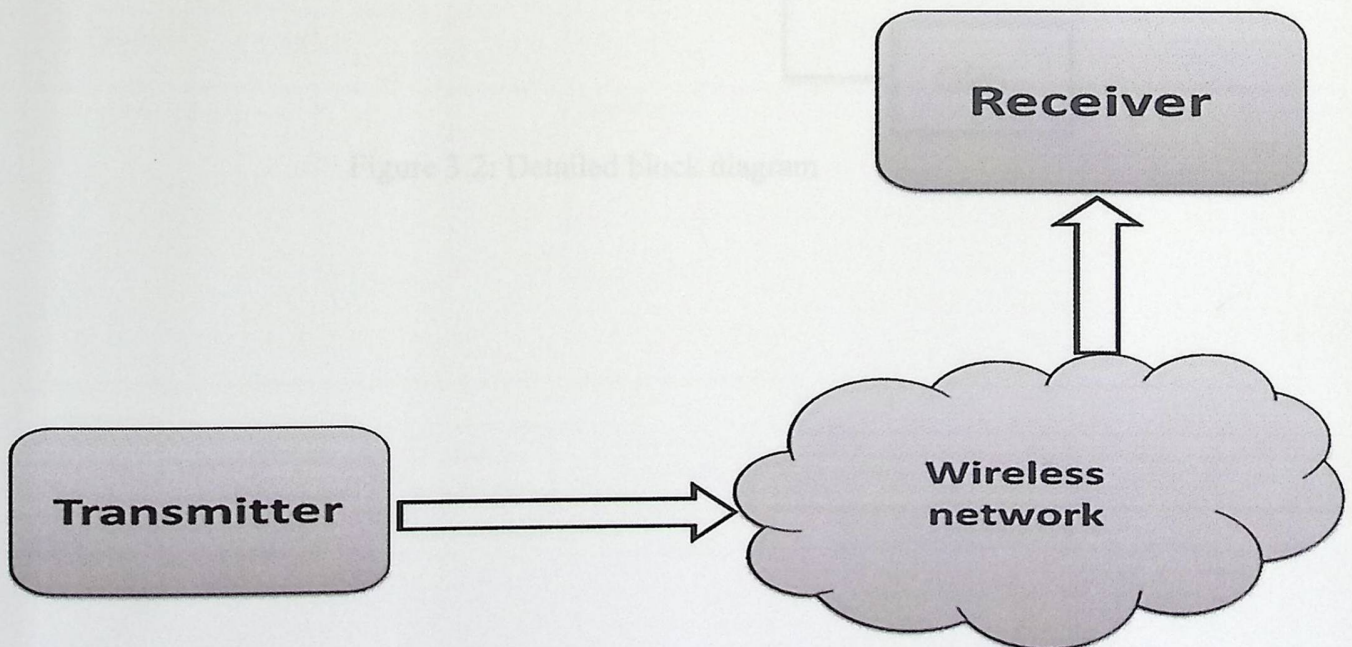


Figure 3.1: General block diagram

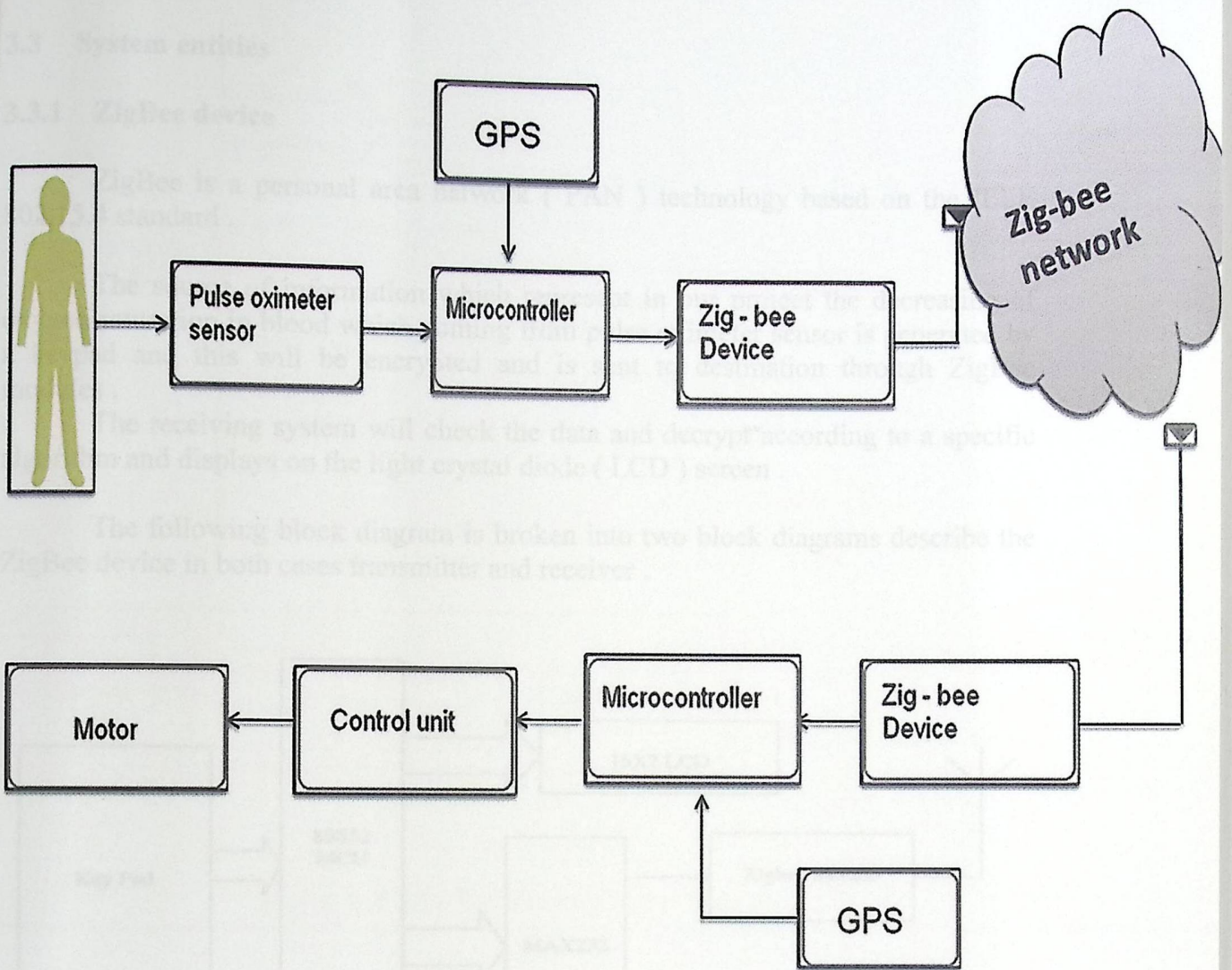


Figure 3.2: Detailed block diagram

### 3.3 System entities

#### 3.3.1 ZigBee device

ZigBee is a personal area network ( PAN ) technology based on the IEEE 802.15.4 standard .

The source of information which represent in our project the decreasing of oxygen saturation in blood which coming from pulse oximeter sensor is generated by a keypad and this will be encrypted and is sent to destination through ZigBee modules .

The receiving system will check the data and decrypt according to a specific algorithm and displays on the light crystal diode ( LCD ) screen .

The following block diagram is broken into two block diagrams describe the ZigBee device in both cases transmitter and receiver .

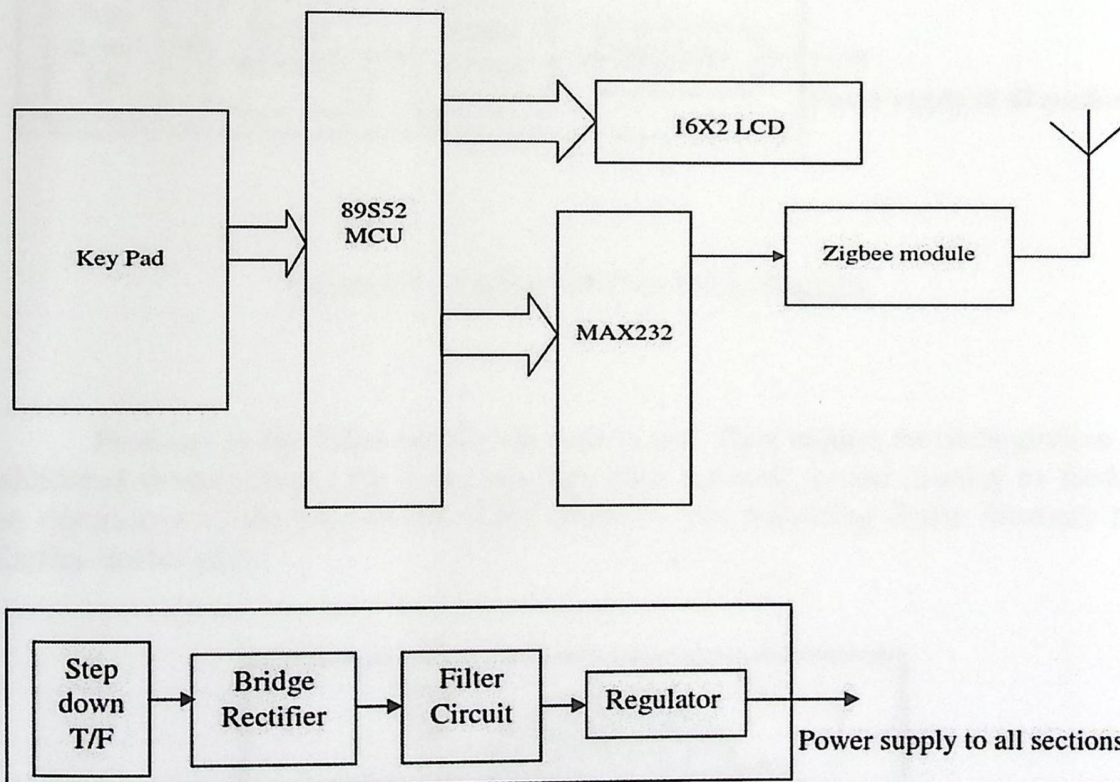


Figure 3.3 : ZigBee transmitter block diagram

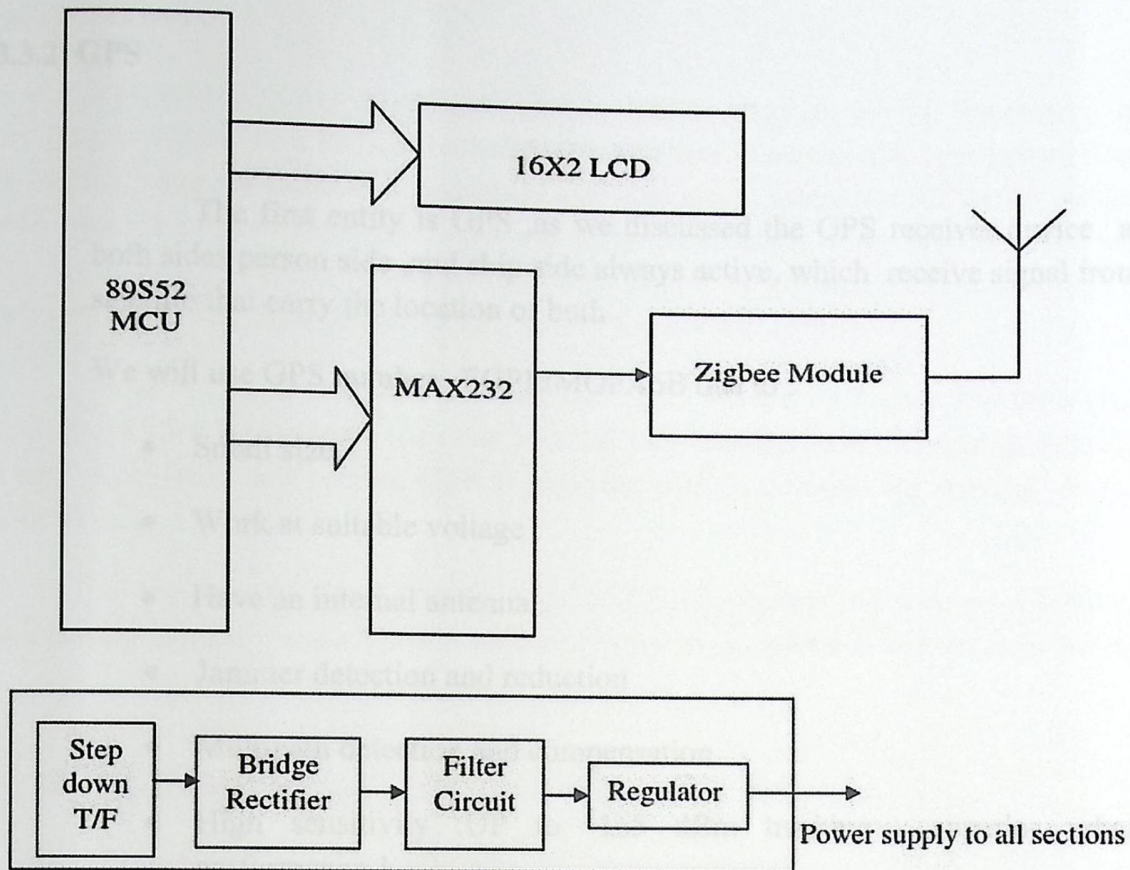


Figure 3.4 : ZigBee receiver block diagram

Products in the XBee family are easy to use. They require no configuration or additional development ; the users can have their network up and running by having an experience in the pins of the XBee device . The following figure illustrate the ZigBee device pins .

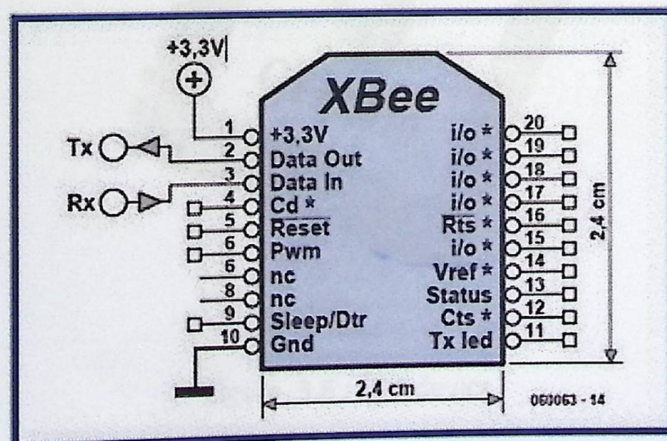


Fig. 3.5 : ZigBee device pins

### 3.3.2 GPS

The first entity is GPS ,as we discussed the GPS receiver device at both sides person side ,and ship side always active, which receive signal from satellite that carry the location of both .

We will use GPS number FGPMMPA6B due to :

- Small size.
- Work at suitable voltage .
- Have an internal antenna .
- Jammer detection and reduction
- Multipath detection and compensation
- High sensitivity :UP to -165 dBm tracking , superior urban performance 1.
- Position Accuracy:

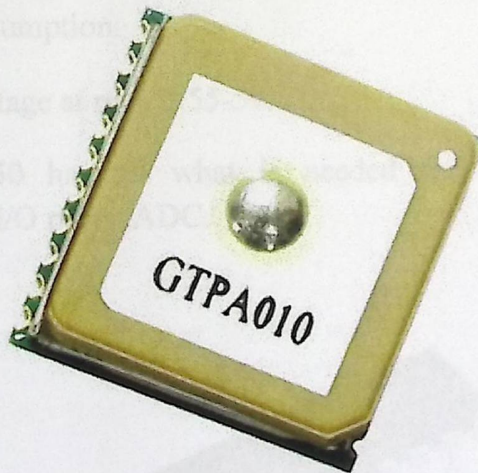


Figure 3.6 : GPS device

## Microcontroller

The second entity microcontroller is used to program overall the system, in our project we use two PICs in both side one of them in sender side (the person who swimming) and the other at the receiver side (the ship), where the PIC at the sender side receive a signal from GPS that will carry the location of the person where use this signal and do multiprocessing for then send it by Zigbee sender to the Zigbee receiver at the ship side and to the PIC at this side.

Now PIC at the receiver side use the signal arrived by Zigbee and the signal came from GPS which carry the coordinate of ship location . use tow signals to make a new processing and send another signal that carry a decision for moving to the control unit of the motor.

All of the devices in the PIC18F2455/2550 family incorporate a range of features that can significantly reduce power consumption during operation key items include:

- High computational performance at an economical price.
- Enhanced Flash program memory.
- Work at Nano-watt .
- All of the devices in the PIC18F4550 reduce power consumption during operation.
- 28-pin .
- Low power consumption.
- Work at low voltage at rang 2.55-5v.

PIC18F2455/2550 has all what is needed for implementation for our project ,enough I/O ports ,ADC.

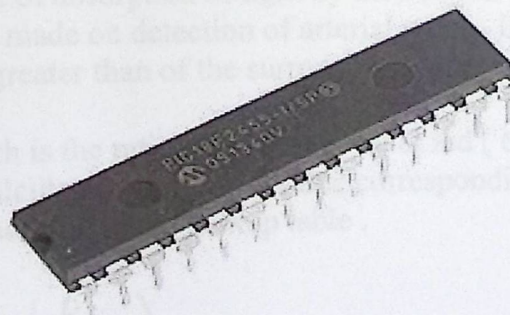


Figure 3.7 : Microcontroller Chip

### 3.3.3 Pulse Oximeter Sensor

The working principle of a pulse oximeter is based on the Beer-Lambert's law for spectral analysis . This law state that the concentration of absorbent in solution can be determined as a mathematical function of the amount of light transmitted through the solution , providing that the intensity of the incident light , the path length , and the extinction coefficient of a substance at particular wavelength are known .

Extinction coefficient : is a measure of how strongly a substance absorbs light at a particular wavelength.

The percentage of oxygen in blood measured by the pulse oximeter is the ratio of oxygenated hemoglobin to the total amount of hemoglobin capable of binding with or transporting oxygen .[13]

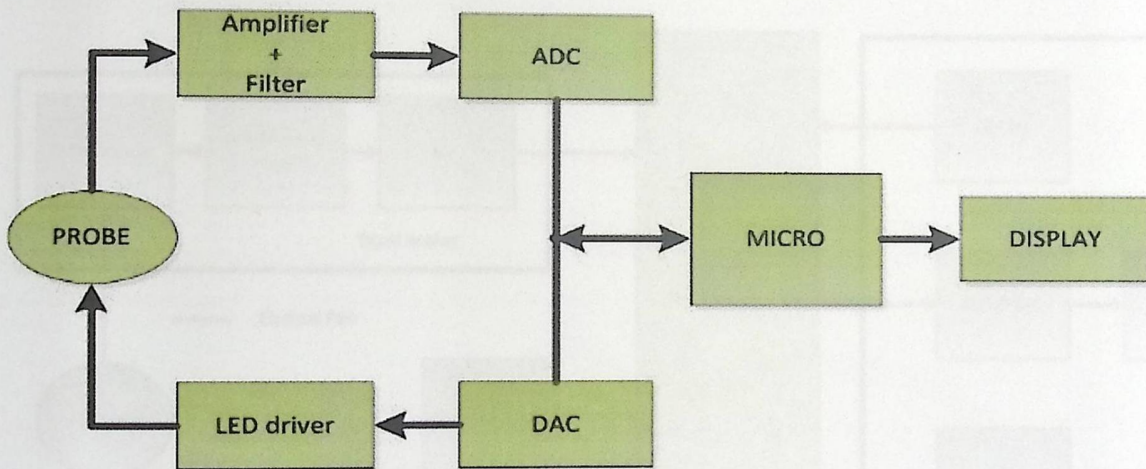


Figure 3.8 : signal flow diagram of pulse oximeter

The current produced by the photo diode is converted to equivalent voltage and filtered using low pass filter . The filtered signal is digitized and demodulated before subtracting the ambient light effect .

To reduce the effect of absorption of light by the surrounding tissue , measurements are only made on detection of arterial pulse . Blood has a light absorption coefficient greater than of the surrounding tissue .

The ratio ( R ) which is the ratio of voltage level at red ( 660nm ) to that of infrared ( 940nm ) is calculated . the SPO2 value corresponding to ratio ( R ) is computed from empirical data using lookup table .

$$R = \frac{\log(R_{rms} / R_{dc})}{\log(IR_{rms} / IR_{dc})}$$

Where :

$R_{rms}$  : absorption for arterial blood for red root mean square

$R_{dc}$  : absorption for tissue and bone for red light

$IR_{rms}$  : absorption for arterial blood for infrared root mean square

$IR_{dc}$  : absorption for tissue and bone for infrared light

Based on the  $R$  parameter both  $SPO_2$  and heart rate (  $HR$  ) can be determined by applying the following calibrated equations :

For  $SPO_2$  quantity :

$$SPO_2 = 10.0002R^3 - 52.887R^2 + 26.871R + 98.283$$

And finally , pulse oximeter sensor has the functional block diagram connected with microcontroller.

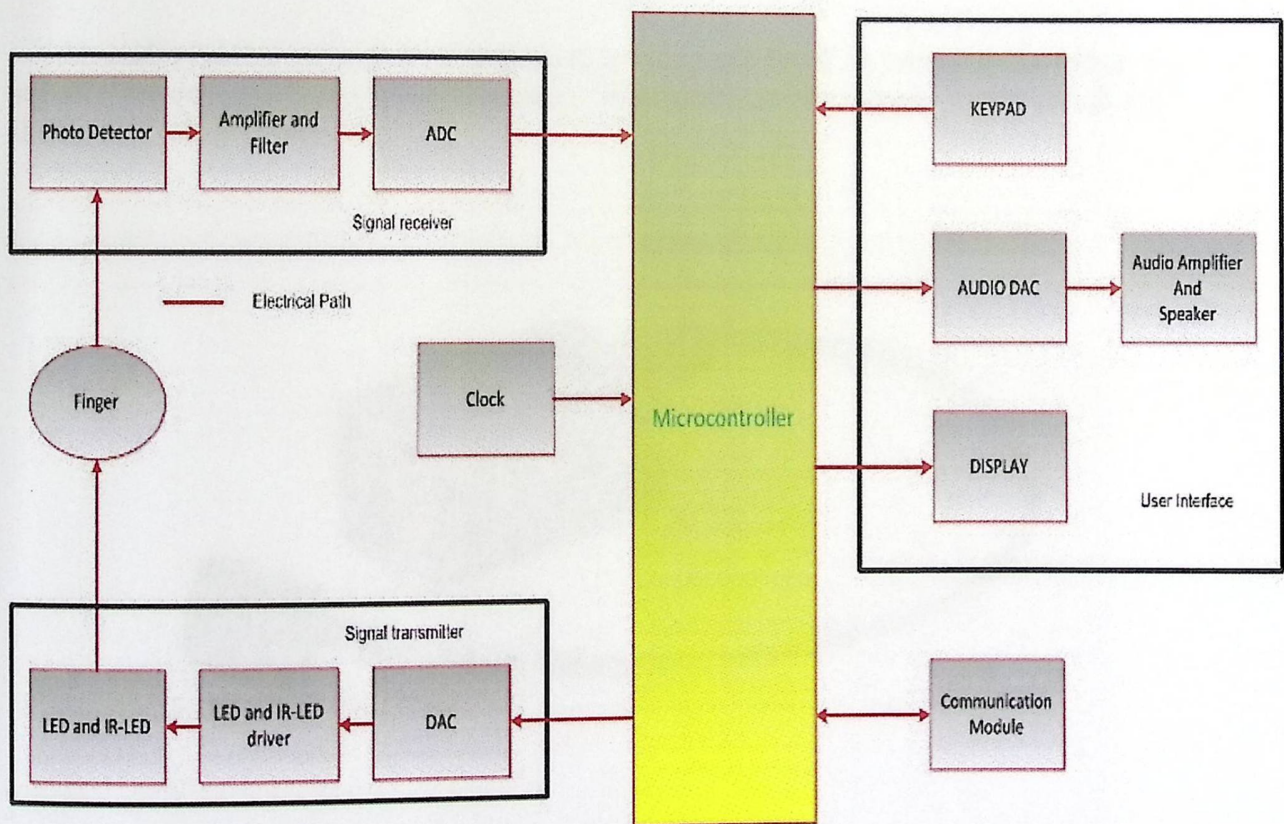


Figure 3.9 : Block diagram of pulse oximeter

From fig 3.5 the operation of pulse oximeter is passing through these blocks , a probe consisting of a red LED , an infrared LED , and a sensitive photo detector . A timing control circuit to sequence the LEDs and to synchronize with the photo detector , analog front-end electronics to amplify and process the signal before digitization. .

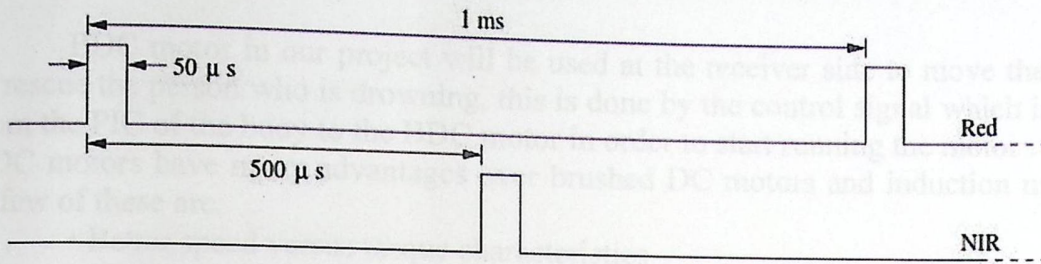


Figure 3.10 Timing signals for the LED drivers

An analog to digital converter ( ADC ) is used to digitize the signal , a processor here is microcontroller is used to compute the received red and infrared light intensity ratio and hence to derive SPO2 value from the lookup table , a LCD display and push buttons to display the values and provide user interface .

An audio buzzer to sound an alarm on low oxygen level , a connectivity block to transfer information to external computer and finally power supply to power all the electronics using battery.

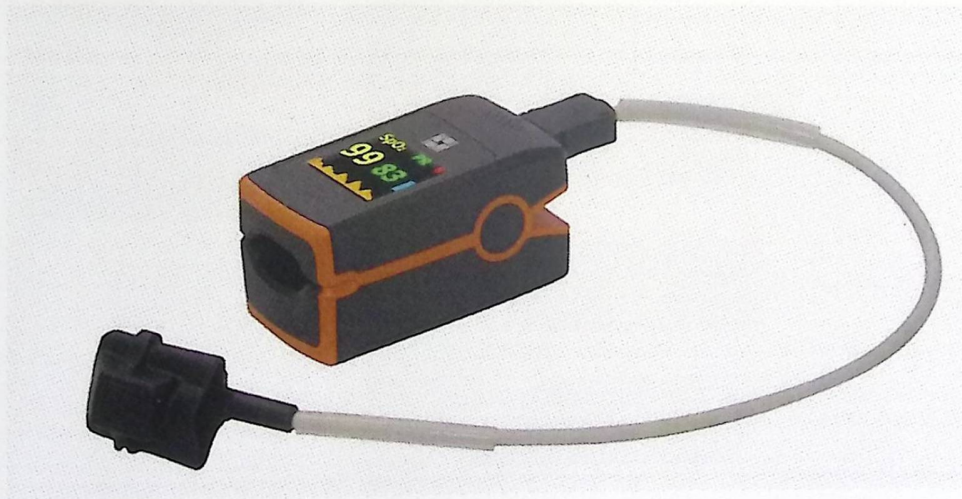


Figure 3.11 : Pulse Oximeter sensor

### 3.3.5 Software design

#### 3.3.4 brush direct current( BDC) motor

BDC motor in our project will be used at the receiver side to move the buoy to rescue the person who is drowning, this is done by the control signal which is send from the PIC of the buoy to the BDC motor in order to start running the motor . BDC motors have many advantages over brushed DC motors and induction motors, A few of these are:

- Better speed versus torque characteristics
- High dynamic response
- High efficiency
- Long operating life
- Noiseless operation
- Higher speed ranges

In addition, the ratio of torque delivered to the size of the motor is higher.

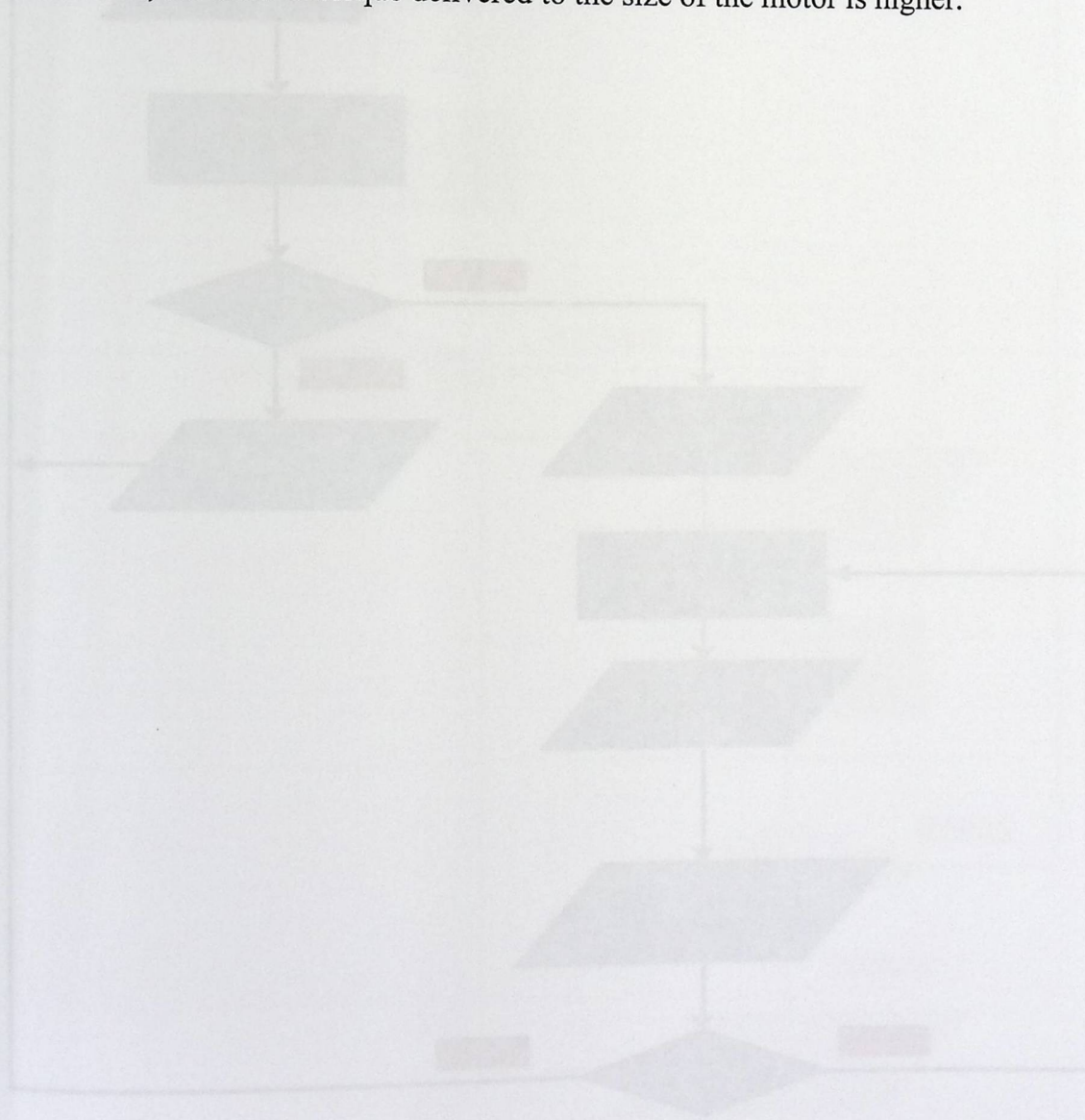


Figure 3.12 : Transmitter flowchart

### 3.3.5 Software design

This is the flow chart of the transmitter side which illustrate the complete path of signal and data of the whole system as below:

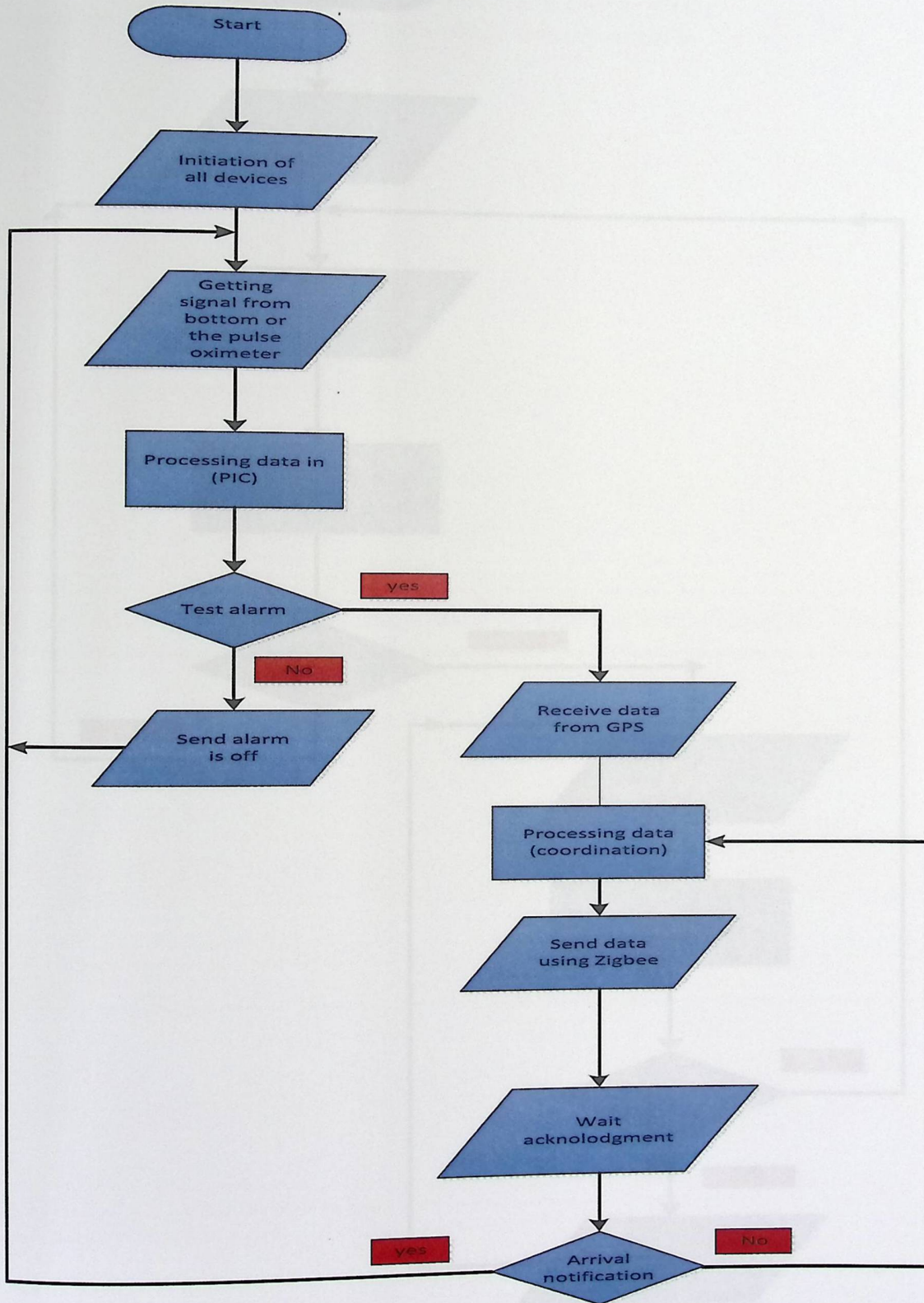


Figure 3.12 : Transmitter flowchart

The second flow chart is the receiver side which illustrate the complete path of signal and data of the whole system as below:

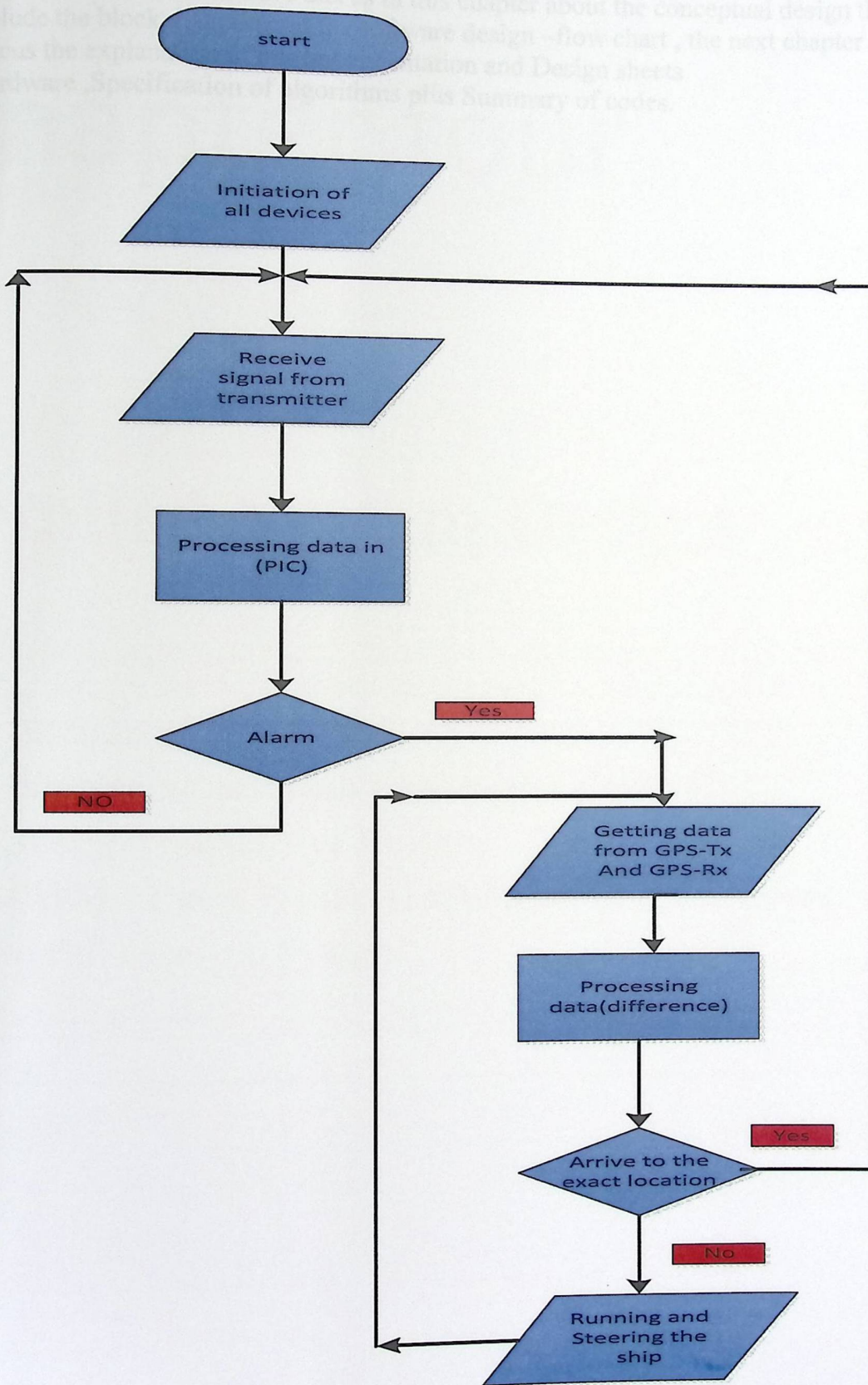
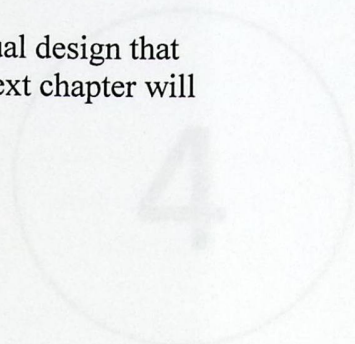


Figure 3.13: Receiver flowchart

After what we have discussed in this chapter about the conceptual design that include the block diagram and the software design –flow chart , the next chapter will discuss the explanation of our implementation and Design sheets Hardware ,Specification of algorithms plus Summary of codes.



## Detailed System Design

- 41 Introduction.
- 42 interfacing between transmitter devices .
- 43 Overall transmitter Design.
- 44 PWM : Pulse Width Modulation at the receiver.
- 45 Overall receiver Design.

# Chapter four

# 4

## Detailed System Design

- 4.1 Introduction.
- 4.2 interfacing between transmitter devices .
- 4.3 Overall transmitter Design.
- 4.4 PWM : Pulse Width Modulation at the receiver.
- 4.5 Overall receiver Design.

## 4.1 Microcontroller

### 4.1 Introduction

As shown in previous chapter, this system has mainly two sides, transmitter (person), and receiver (the tube or ship). 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 we will need it at the two sides.

### 4.2 interfacing between transmitter devices .

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



Figure 4.1 : transmitter side elements

## 4.2.1 Microcontroller

Microcontroller is a Microchip programmable IC, that controls the inputs and outputs from each device. Figure 4.1 shows the pins of PIC18F2550, more explanation for required ports will be illustrated.

28-Pin PDIP, SOIC

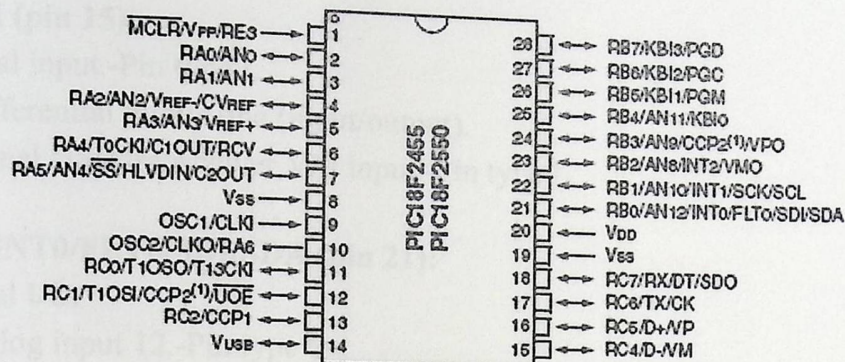


Figure 4.2: Pins out of PIC18F2550

### Pin description:

#### 1. RA0/AN0 (pin 2):

- PORTA is a bidirectional I/O port.
- RA0-Digital I/O .
- AN0- Analog input 0- pin type I.

I = Input.

O = Output .

#### 2. RC7/RX/DT/SDO (pin 18):

- RC7-Digital I/O.
- RX-EUSART asynchronous receive-Pin type I.
- DT-EUSART synchronous data (see TX/CK)-Pin type I/O.
- SDO-SPI data out-Pin type O.

Were SPI is The Serial Peripheral Interface .

#### 3. RC6/TX/CK (pin 17):

- RC6-Digital I/O.
- TX-EUSART asynchronous transmit.-Pin type O.

- CK- EUSART synchronous clock (see RX/DT)-Pin type I/O.

**4. VSS (pin 8 or 19):**

- Ground reference for logic and I/O pins)-Pin type P.

P = Power.

**5. VDD (pin 20):**

- Positive supply for logic and I/O pins)-Pin type P.

**6. RC4/D-/VM (pin 15):**

- RC4-Digital input.-Pin type I.
- D-USB differential minus line (input/output).
- VM- External USB transceiver VM input.-Pin type I.

**7. RB0/AN12/INT0/FLT0/SDI/SDA (pin 21):**

- RB0-Digital I/O.
- AN12-Analog input 12.-Pin type I.
- INT0-External interrupt 0.-Pin type I.
- FLT0-PWM Fault input (CCP1 module)-Pin type I.
- SDI-SPI data in-Pin type I.
- SDA-I2C™ data I/O.

**8. RB1/AN10/INT1/SCK/SCL (pin 22):**

- RB1-Digital I/O.
- AN10-Analog input 10.-Pin type I.
- INT1-External interrupt1.-Pin type I.
- SCK-Synchronous serial clock input/output for SPI mode.-Pin type I/O.
- SCL-Synchronous serial clock input/output for I2C mode.-Pin type I/O.

**9. RC1/T1OSI/CCP2/EOE (pin 12):**

- RC1-Digital I/O.
- TIOSI-Timer1 oscillator input.-Pin type I.
- CCP2-Capture 2 input/Compare 2 output/PWM 2 output.
- EOE-External USB transceiver OE output.

Note:- the prim is high not low .

**10. RC2/CCP1 (pin 13):**

- RC2-Digital I/O.
- CCP1-Capture 1 input/Compare 1 output/PWM 1 output.  
Output of dutycycle(PWM) to control motor speed.

**Oscillator Types:**

PIC18F2550 devices can be operated in twelve distinct oscillator modes. From these mode we use internal oscillator that have 8MHz.

**Serial port:**

PIC 18F2550 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**

$$SPBRG = 4000000 / (16 \times 9600) - 1 = 51.08$$

**For BRGH = 0**

$$SPBRG = 4000000 / (64 \times 9600) - 1 = 12.02$$

## 4.2.2 Interfacing between Microcontroller and pulse oximeter.

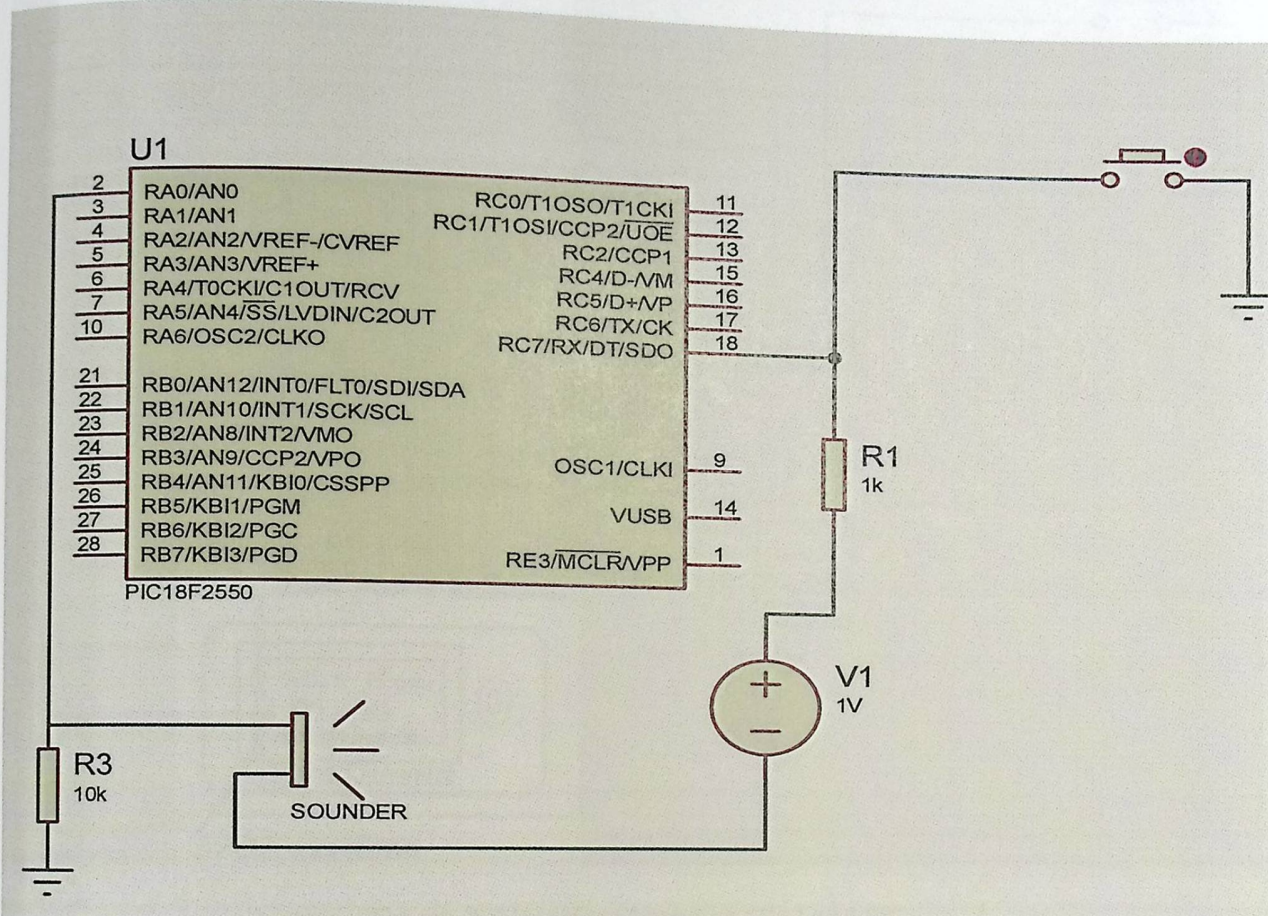


Figure 4.3 Interface between PIC and Pulse Oximeter

First of all we have the pulse oximeter that gives the alarm signal using Sounder so we need to remove the sounder to get a direct signal to the analog port of the microcontroller that detect if there is an alarm signal or there isn't, so by this connecting that aims to get the alarm signal we must do a couple of setting of the pulse oximeter to determine the SPO2 Level and depending on that level the sensor will or will not give the alarm.

While Pin RA0/AN0 is responsible about receiving analog signal which represent the alarm signal from the pulse oximeter(SPO2 level) to the PIC.

This figure shows connection between the pulse oximeter and the PIC after replacing sounder by pulse oximeter.

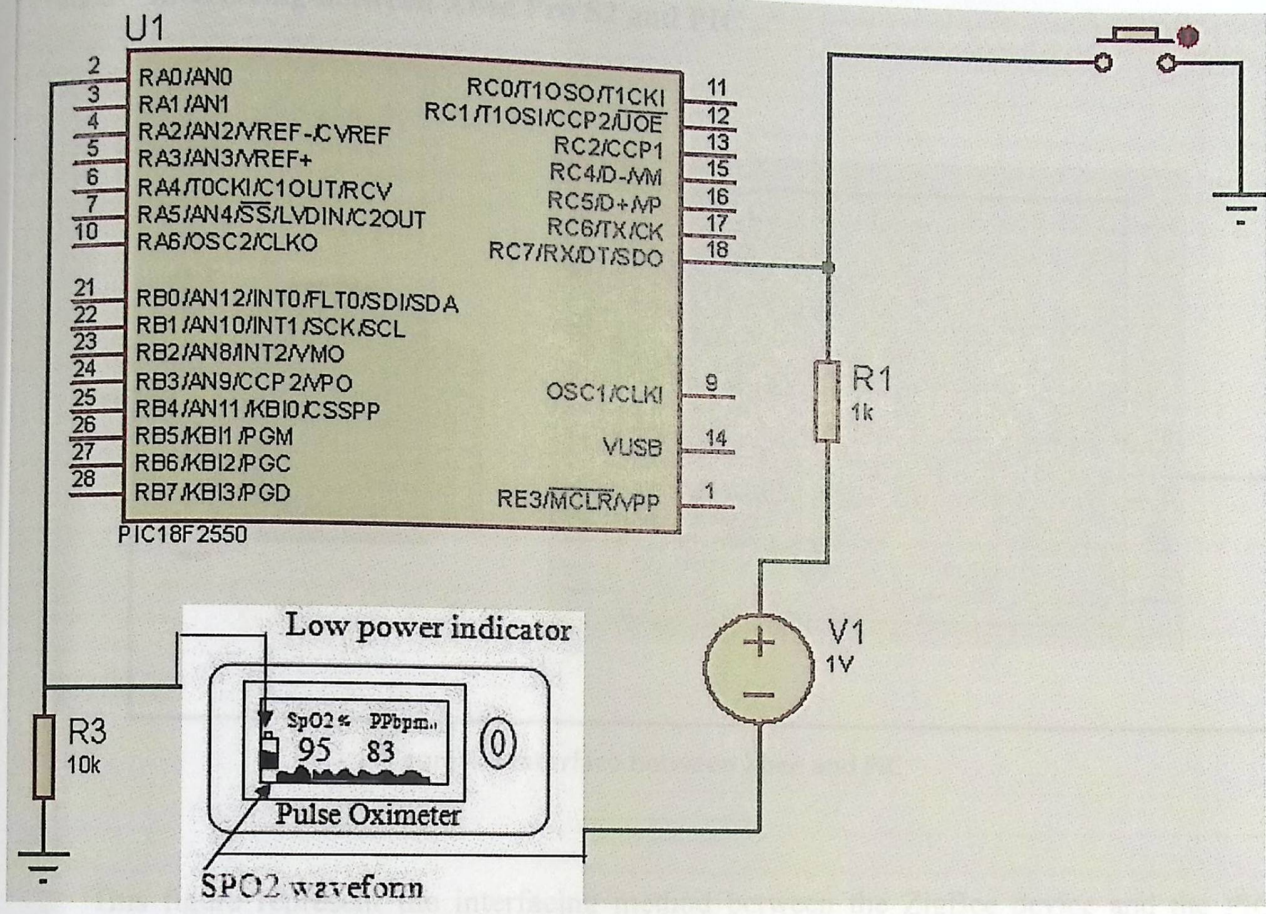


Figure 4.4 Interface between SPO2 and PIC

microcontroller, Xbee as the wireless source (Vcc = +3 Volt), pin 10 of ZigBee is going through the ground. From PIC microcontroller the signal comes from pin number 17 and enters pin number 3 on ZigBee device, this signal carry the alarm about the percentage of oxygen that goes down a threshold value.

Output power

Xbee - PRO (S2) which we used in our system has a transmit power output 50mW (+17 dBm) 10mW (+10 dBm) for international variant.

Data rate

RF data rate 250.000bps and the data throughput up to 35000bps and the receiver sensitivity -102dBm, the voltage supplied of Xbee-PRO (S2) is 3 - 3.4 Volt, and the operating current at transmitting maximum output power is 295 mA at 3.3 Volt, 170 mA at 3.3 international variant, operating current of the receiver is 45 mA at 3.3 Volt and the idle current which represent the receiver off is 15 mA.

### 4.2.3 Interfacing between Xbee Pro S2 and PIC .

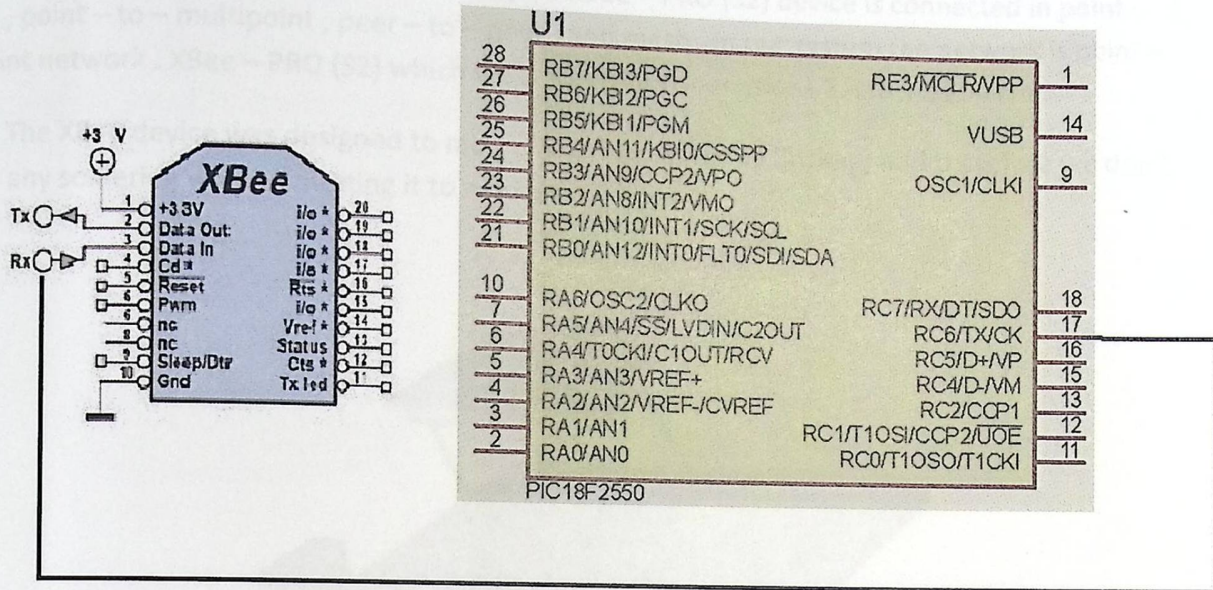


Figure 4.5 interface between Xbee and PIC

This figure represent the interfacing method between the ZigBee device and the PIC microcontroller, Xbee as shown is energized by a three DC voltage source ( $V_{cc} = +3$  Volt), pin 10 of ZigBee is going through the ground. From PIC microcontroller the signal comes from pin number 17 and enters pin number 3 on ZigBee device, this signal carry the alarm about the percentage of oxygen that goes down a threshold value .

#### Output power

Xbee – PRO (S2) which we used in our system has a transmit power output 50mW (+17 dBm) , 10mW (+10 dBm) for international variant .

#### Data rate

RF data rate 250,000bps and the data throughput up to 35000bps and the receiver sensitivity -102dBm , the voltage supplied of Xbee-PRO (S2) is 3 – 3.4 Volt , and the operating current at transmitting maximum output power is 295 mA at 3.3 Volt , 170 mA at 3.3 international variant . operating current at the receiver is 45 mA at 3.3 Volt and the Idle current which represent the receiver off is 15 mA .

XBee – PRO (S2) has a range of operating temperature which is from -40 to 85 C , the antenna is integrated whip antenna , embedded PCB antenna .

The supported network topologies may be XBee – PRO (S2) device is connected in point – to – point , point – to – multipoint , peer – to – peer , and mesh . in our system the network is point – to – point network . XBee – PRO (S2) which we are used its dimensions 2.438 x 3.294 cm .

The XBee device was designed to mount into a receptacle ( Socket ) and therefore we don't require any soldering when mounting it to a board .

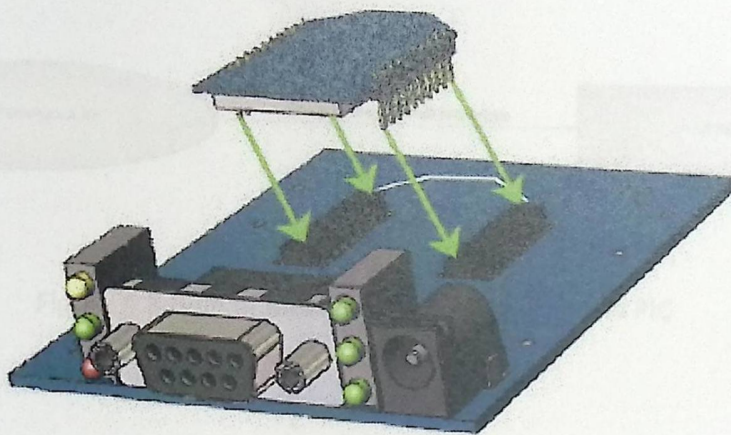


Figure 4.6

**Pins description:**

The XBee – PRO ( S2 ) device has 20 pins and the following is explanation of each pin with respect to Xbee pin figure .

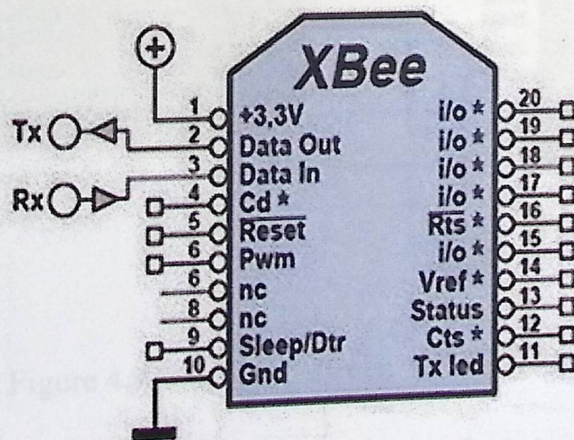


Figure 4.7 Pin description of Xbee

#### 4.2.4 Interfacing between GPS transmitter and PIC:

This part is the interface between GPS transmitter and PIC, this interface can be explained as the following :

Through this interface pin 18 at PIC (RC7) receive signal from GPS that contain coordination of the transmitter(the person) to use it later . Note that this connection will be direct without need to any interface between them.

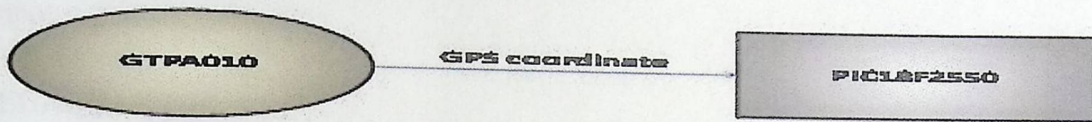


Figure 4.8 type of message transfer from GPS to PIC

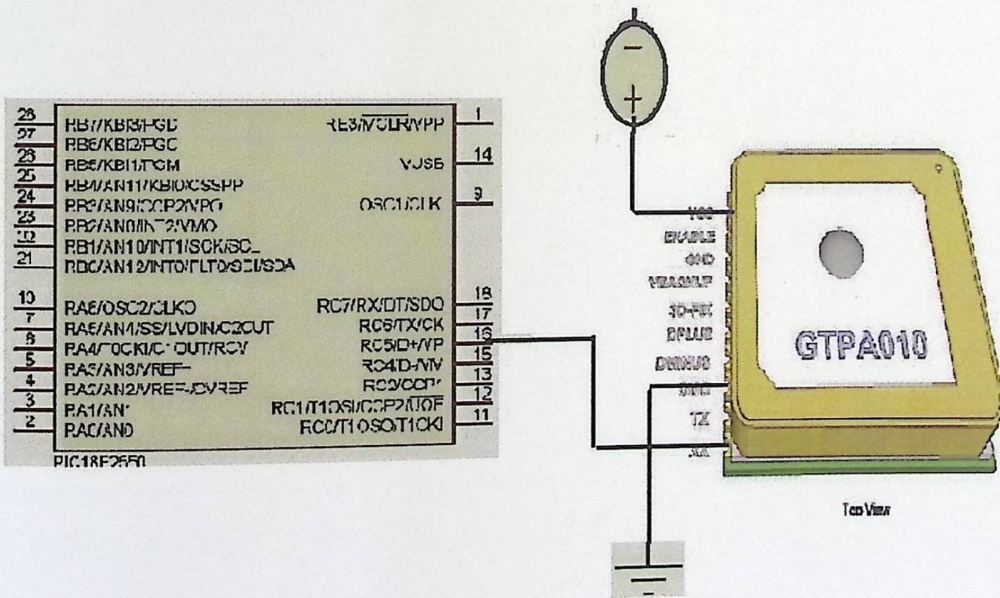
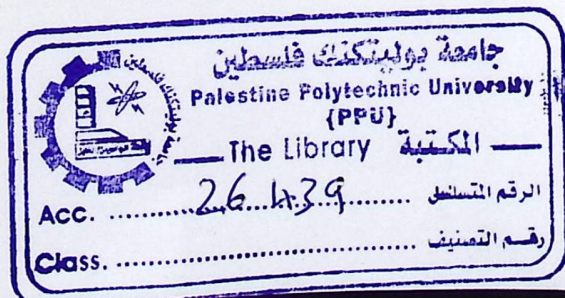


Figure 4.9 Interface between GPS and PIC

The receiver side contain a GPS device to determine the person location in the water GPS receiver will be used is 66 Channel.(for more information see appendix A)



## Overall transmitter Design

This module has the following features:

Low power consumption: 75mW @ 3.0V

• Ultra High Sensitivity:

-148dBm (Cold Start Acquisition)

-165 dBm (Navigation)

• Jammer detection and reduction

• Tiny form factor – 22mm x 22mm x 8mm

• Embedded patch antenna 18.4 x 18.4 x 4.2 mm

• NMEA protocols (default speed: 9600bps)

• One serial port (default: CMOS level, option: RS232)

• 1PPS output

• Up to 10Hz fix rate

• WAAS/EGNOS support

• Optional internal backup battery.

• Ultra high sensitivity with MediaTek MT3329, 66-channel receiver.

### 4.3 Overall transmitter Design.

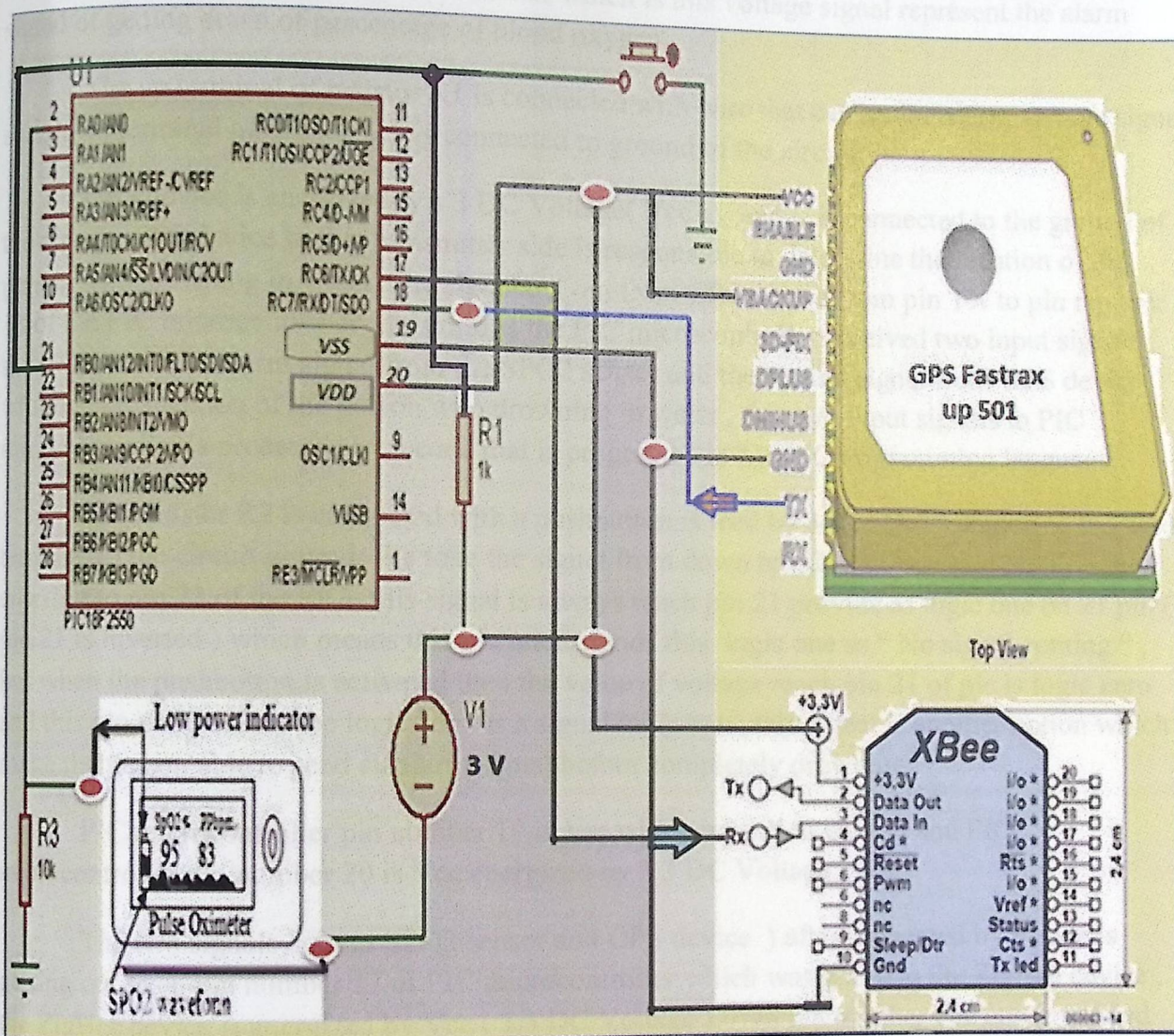


Figure 4.10 overall system

The circuit in figure 4.10 represents the transmitter side circuit, as shown from this figure the main components used to create a transmission side are PIC microcontroller, SPO2 sensor, GPS, ZigBee and finally some certain resistors and wires.

As shown the SPO2 sensor which is responsible to provide an alarm when the percentage of oxygen in blood of the person who is drowning in the water is getting down a threshold value is energized by an internal DC voltage (Battery 3.3 Volt). The threshold value we calibrated it by using the sensor options from its settings. The normal alarm get out from the sensor is a voice of a Buzzer " Buzzing ", from this Buzzer device we take the signal and connected it by a wire to a pin number 2 of PIC microcontroller and other wire from the sensor is connected to the ground.

of the circuit . The wire that entered to pin number 2 of PIC microcontroller is connected to the resistor R1 which equal to 10 Kilo Ohms which is used to guarantee the required value of voltage to enter pin 2 of PIC microcontroller which is this voltage signal represent the alarm signal of getting down of percentage of blood oxygen.

The up terminal of resistor R1 is connected with wire that carries the alarm voltage signal and down terminal of resistor R1 is connected to ground of the circuit.

GPS device is energized by a 3 DC Voltage( Vcc ) , and it is connected to the ground of the circuit. GPS device in this transmitter side is responsible to determine the location of the person who drowning in water . the signal get out from GPS device from pin TX to pin number 18 of the PIC microcontroller , this means the PIC microcontroller received two input signals , the first one is the alarm signal from the SPO2 sensor and the second signal from GPS device which is the location of the person who drowning in water , this two input signals to PIC microcontroller is processed by a code that is programed in MicroCprogramming language .

The resistor R2 is connected with a pushbutton is feed by a Vcc DC voltage and the other terminal to the circuit ground. We take the signal from down terminal of one kilo ohm resistor entering to pin 21 of the PIC , this signal is always reach pin 21 provide as logic one on 21 pin ( pin 21 is inverted ) which means this pin understands this logic one as “ No signal coming “ , but when the pushbutton is activated then the value of voltage reach pin 21 of pic is logic zero and this pin understands the logic zero as a signal logic one , this signal is another option which make the person able to send an alarm signal before completely drowning .

PIC microcontroller pin number 19 is Vss which is used to ground and PIC microcontroller pin number 20 is Vcc energized by 3.3 DC Voltage .

The two signals ( from SPO2 sensor and GPS device ) after processed by a code is getting out from pin number 17 of PIC microcontroller which was going to the ZigBee device , the ZigBee device is energized by Vcc ( 3.3 DC Voltage ) from pin number one and grounded from pin number ten and pin 3 of ZigBee receives these two signals to transmit it to receiver side

#### **4.4 PWM : Pulse Width Modulation at the receiver.**

Pulse Duration Modulation or Pulse Width Modulation is a powerful technique used to control analog circuits using digital outputs. Nowadays PWM has a wide variety of applications such as to create analog voltage level, waveform generation, motor speed control, power control and conversion, measurements and communication etc.

PWM uses a rectangular pulse wave as shown in the figure below whose pulse width is modulated, which results in the variation in the average voltage of the waveform<sup>[14]</sup>.

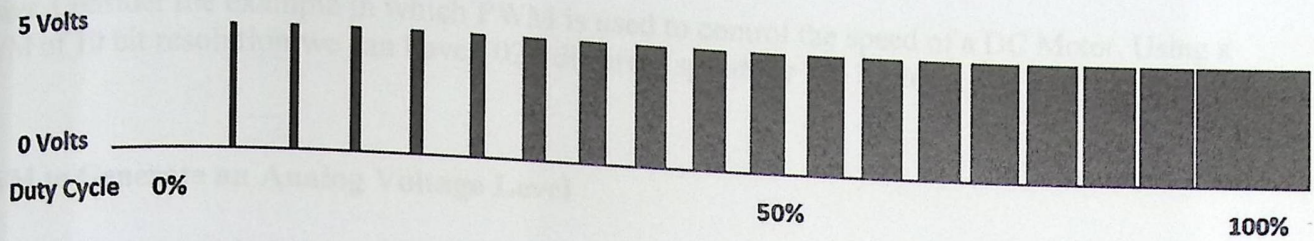


Figure 4.11 :Pulse Width Modulation

### PWM Period

The PWM Period is the time duration in which the Pulse Width Modulation takes place. In the diagram shown below PWM Period is marked as T. PWM Period should be chosen to give best results for a particular application.

## Duty Cycle

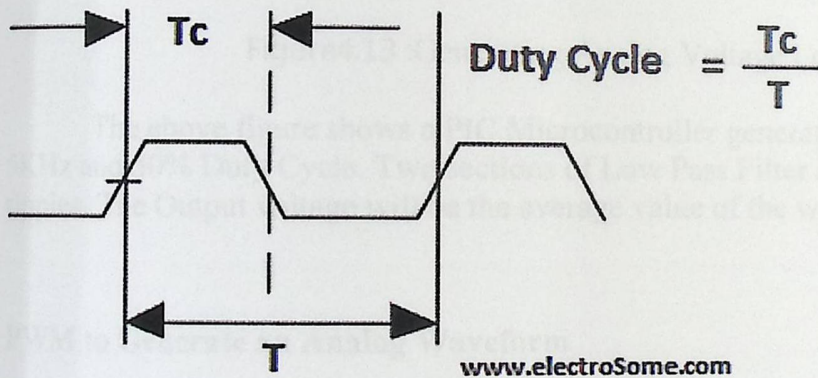


Figure 4.12: Duty Cycle

The duty cycle is the ratio of the time  $T_c$  during which the output is high to the total time period  $T$ .

The expression of duty cycle is determined by,

$$\%Duty\ cycle = \frac{t_{on}}{T} \times 100\%$$

### PWM Resolution

Resolution of a PWM is the number of different steps you can have from zero power to full power. That is a 10 bit resolution means that you can have 1024 steps from zero to full

power. Consider the example in which PWM is used to control the speed of a DC Motor. Using a PWM of 10 bit resolution we can have 1024 different speed for DC Motor<sup>[15]</sup>.

### PWM to Generate an Analog Voltage Level

In Switched Mode Power Supplies (SMPS) PWM is used to generate voltage levels. By changing the duty cycle of the PWM we can adjust the average voltage of the waveform. The PWM resolution should be selected to be greater than or equal to the required resolution of the Power Supply.

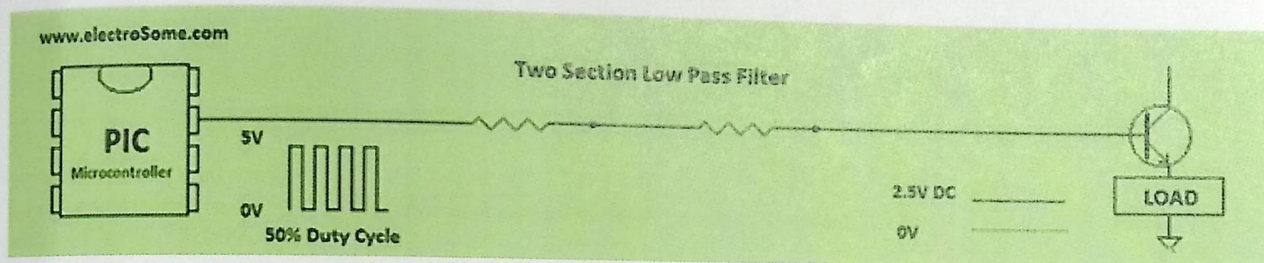


Figure4.13 :Generating Analog Voltage Level using PWM

The above figure shows a PIC Microcontroller generating PWM wave at a frequency of 5KHz and 50% Duty Cycle. Two sections of Low Pass Filter are provided to filter out the ripples. The Output voltage will be the average value of the waveform.

### PWM to Generate an Analog Waveform

Any Analog Waveform can be generated by simply outputting a sequence of PWM waves to create analog voltage levels corresponding to different points in the waveform. When we use more points we can represent faster wave forms with greater accuracy but it requires greater resolution PWM and heavier filtering.

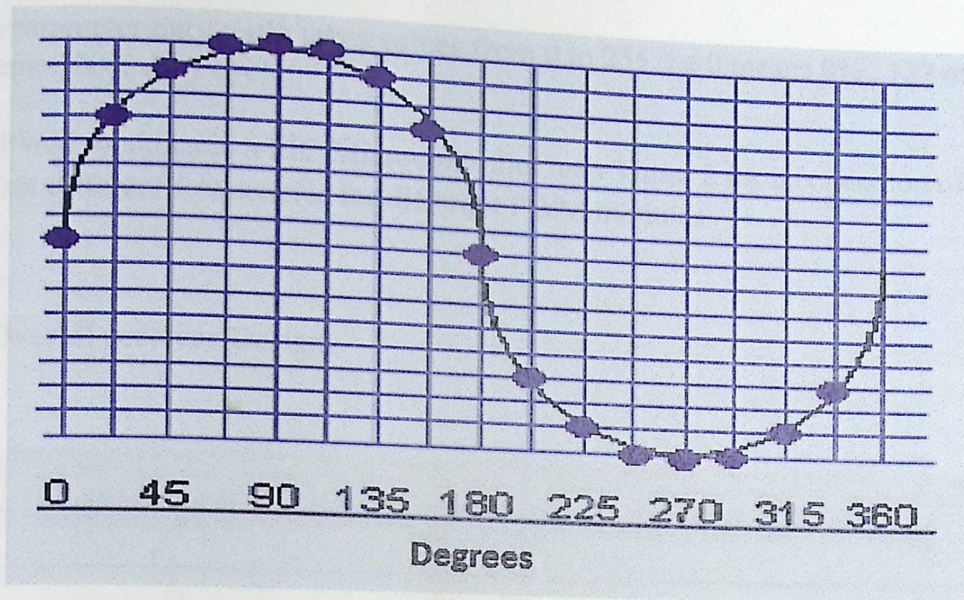


Figure4.14 : Selecting Points on a Sine Wave

#### PWM Duty Cycle can be of two types :

In concern of motor , We can't drive a DC Motor (depends) directly with a Microcontroller, as DC Motors requires high current and high voltage than a Microcontroller can handle. Microcontrollers usually operates at +5 or +3.3V supply and it I/O pin can provide only up to 25mA current. Commonly used DC Motors requires 9V supply and 300mA current, moreover interfacing DC Motors directly with Microcontrollers may affect the working of Microcontroller due to the Back EMF of the DC Motor. Thus it is clear that, it not a good idea to interface DC Motor directly with Microcontrollers.

The solution to above problems is to use transistor with resistor circuit at pulse rate of change 5kHz ,so the higher speed of change per second means smoother connect and break of the motor

The average of voltage that supply to DC motor is given by

$$V_{ave} = \frac{t_{on}}{T} \times V_{in}$$

DC Motor is interfaced with PIC Microcontroller using transistor , Here we are using 9 V DC Motor and average DC value delivered to motor can be varied by varying the duty ratio of the PWM. The average DC Voltage of 0% duty cycle is 0V, 25% duty cycle is 2.25V, 50% duty cycle is 4.5 V, 75% duty cycle is 6.75V and for 100% duty cycle 9V.

The parameter `duty_ratio` takes values from 0 to 255, i.e 0 means 0% , 127 means 50% and 255 means 100% duty cycle.

Note : All PWM modules in a PIC Microcontroller uses Timer 2 for its operation of 5kHz, so you cannot set different frequencies for different PWM modules.

#### 4.5 Overall receiver Design.

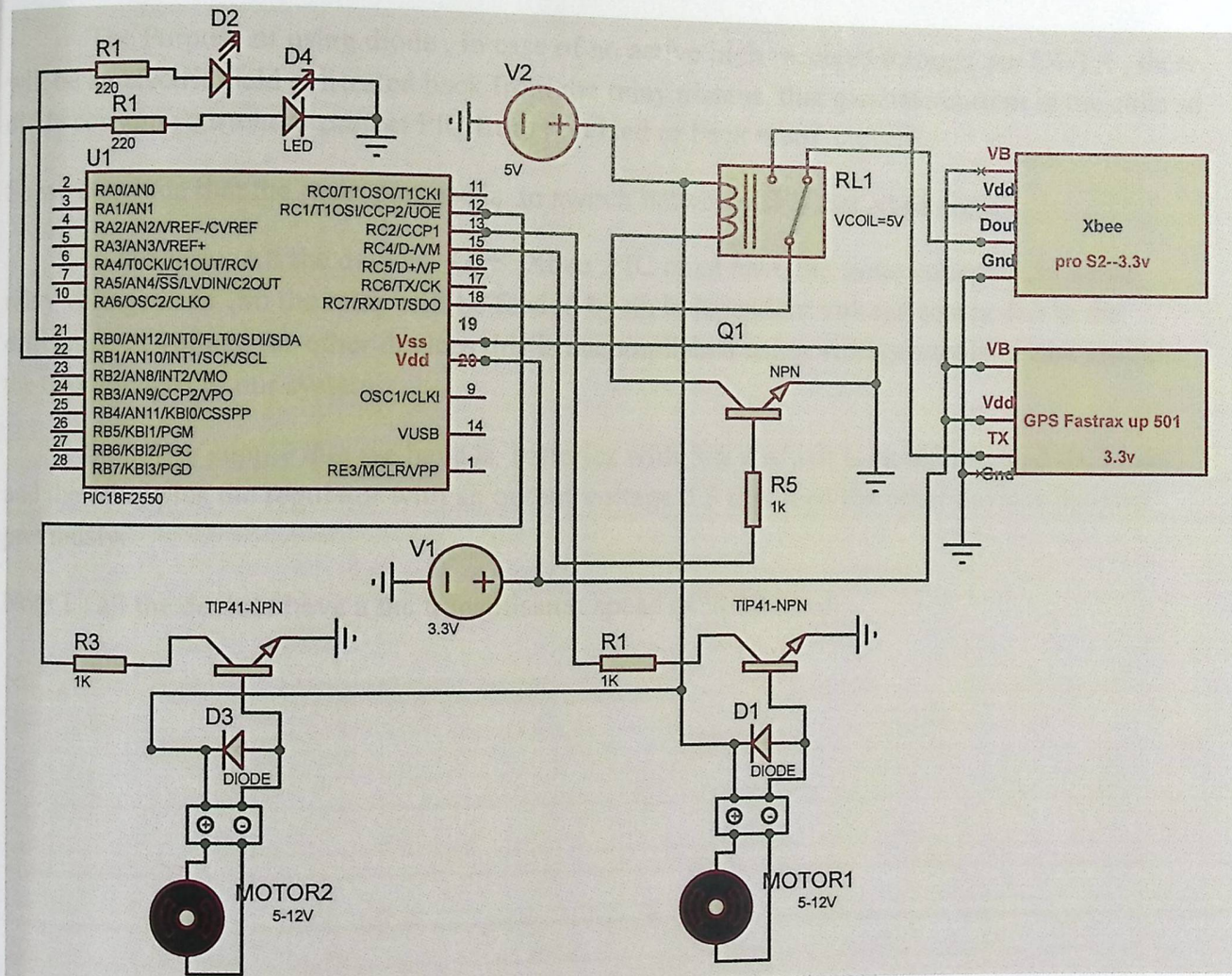


Figure4.15: Overall receiver

At the receiver side of the project ,Xbee receiver receives signal from Xbee transmitter at pin Dout ,this signal arrives at the PIC, in addition transparency done by connecting a relay between them at the normally close (N.C) platen ,and we connect GPS at the normally open (N.O) platen, noting GPS and Xbee connected at the RX pin .

When the Xbee signal arrive at the receiving pin C7-RX through N.C position at relay , and by programming pin C7- RX the PIC will send an active high signal through the serial I/O Pin C4-TX in order the signal flow to the switching system that consist of the 1 k resistance and NPN transistor .

When we receive active high signal at pin C4-TX that is connected at the base of the transistor the resistance will limit the voltage at the same time the transistor will switch connection between Emitter And collector so that we get a voltage difference in order to pass current to relay coils that generate Electric field to change the relay platen from N.C to N.O ,By this change we get the GPS signal .

The Purpose of using diode , in case of no active high received through pin C4-TX , there will be an electric field generated back from the relay platens that generate current in the coils so diode consume current to protect PIC from reversed or back word current .

So we conclude that the main purpose is to switch between GPS and Xbee signal.

In concern , All the devices GPS, Xbee ,PIC must have the same voltage 3.3v while relay voltage is 5v ,So the relay will be feeded by an independent voltage source due to the difference of voltage for other devices this is accomplished using voltage regulator that provide the two voltages to our system.

So power supply that we have is batteries with 5-6 v which is enough to feed the motor and the relay plus the regulator with an output voltage 3.3 that feed the other devices denoted previously.

Note 1 : all the devices have a the transmission speed of 9600 baud.

# Chapter Five

# 5

## Testing and Results

5.1 Introduction.

5.2 Hardware programs

5.3 Testing .

5.4 Results.

## **5.1 Introduction**

This chapter discusses the main signals properties in our system, the testing processes are very important to insure that the system work successfully. Measurements introduced in this chapter are very important and useful part of the project to achieve the most accurate results.

On the other hand to determine the distance between the drowned person and the received ship will not be enough to depend on the GPS device, so the strength of the alarm signal which is received from drowned person side (RSSI) can be employed to achieve more accurate result.

## **5.2 Hardware programs**

Program that we will use in testing and getting the result form it .

### **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.

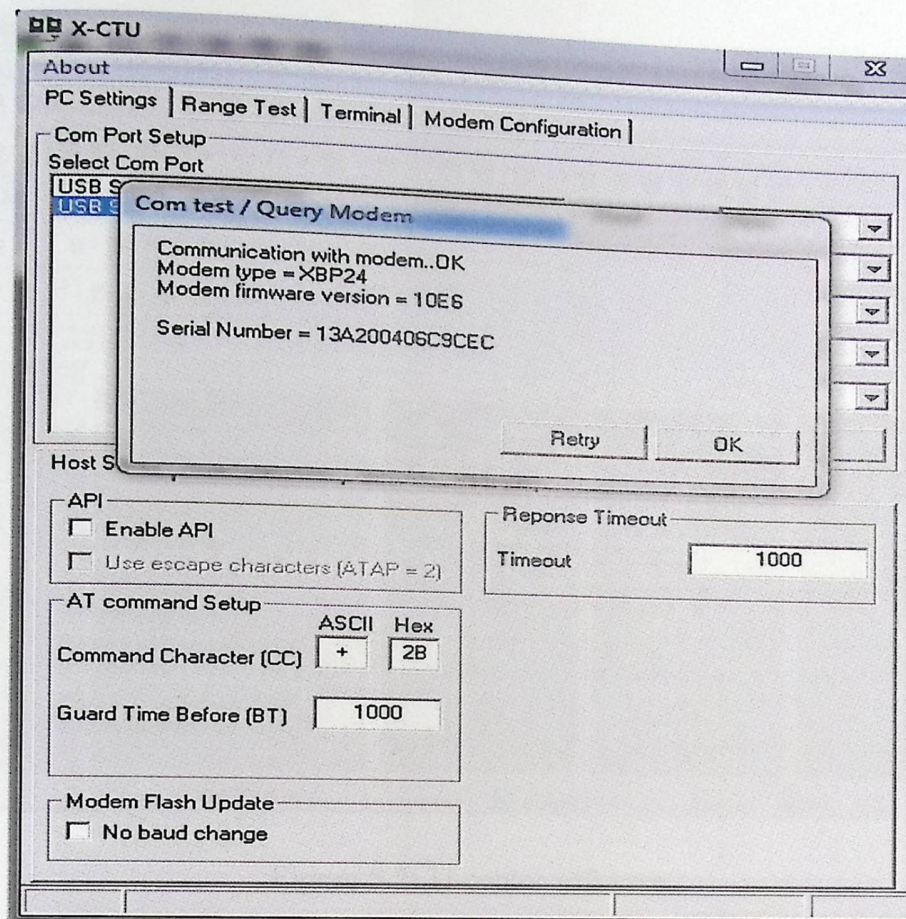


Figure 5.1X-CTU program

## 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.

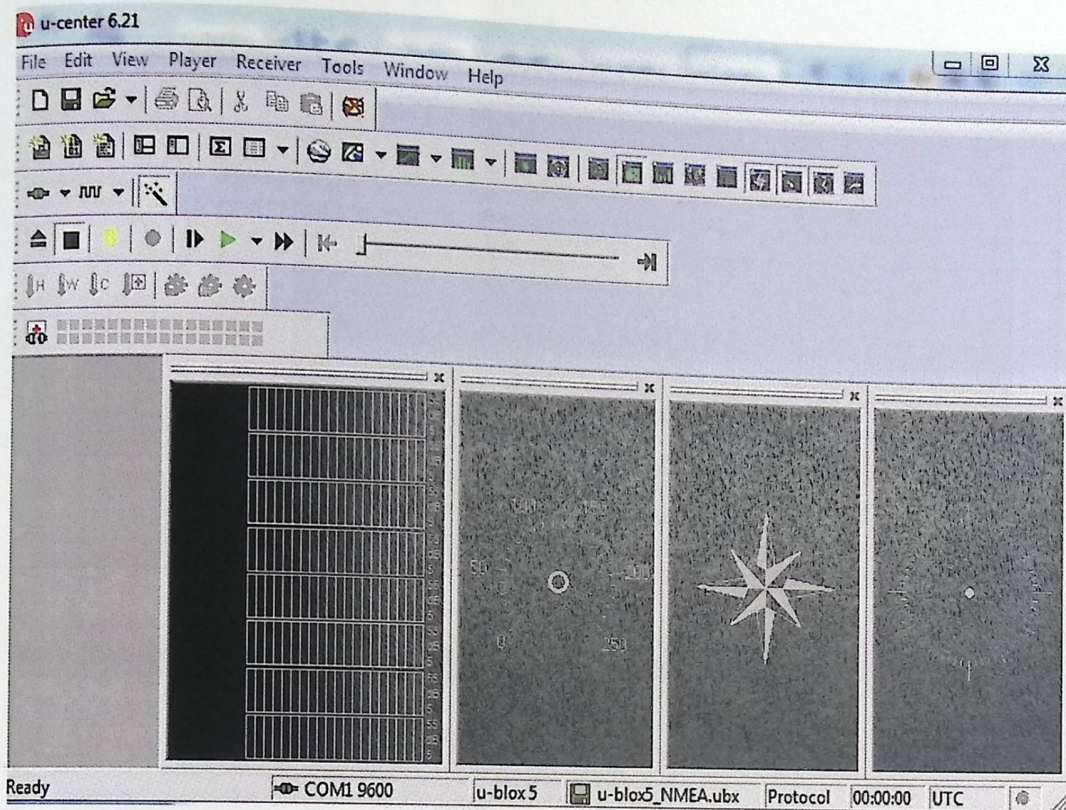


Figure 5.2: U-center software

### 5.2.3 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.



## 5.3 Testing

Testing process is very important to achieve more accurate results the most important signals we are concerned with are the XBee signal strength and the GPS signal strength so we tested each one without other to get more accurate measurements.

### 5.3.1 Testing at the transmitter

At the moment we push the button or get an alarm from pulse oximeter ,we will get GPS coordination simultaneously and as long the alarm is exist , this alarm signal pulse coordination appear on the X-CTU program using interface between PC and the Xbee-TX, This interface called UART TTL to USB.



Figure5.5:Transmitter side .

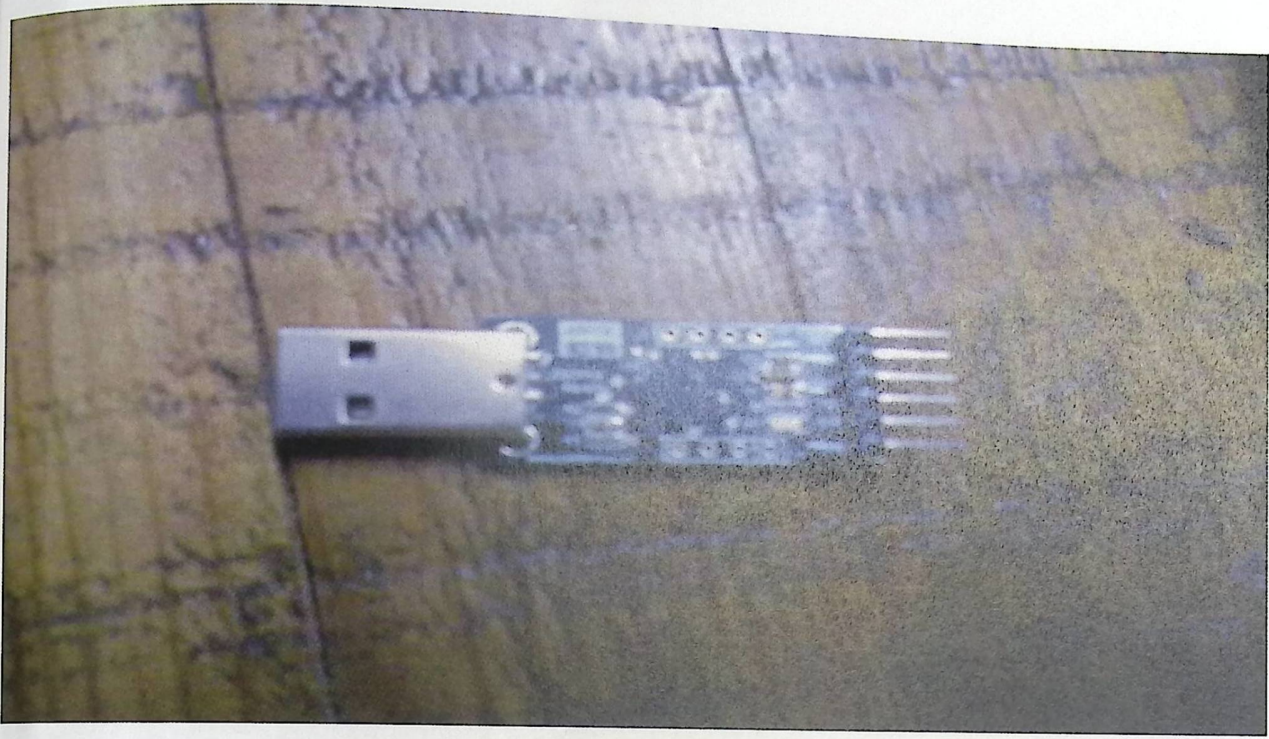


Figure 5.6:UART TTL to USB.

### 5.3.2 Testing receiver side

At the receiver side we get the transmitter longitude and latitude and the alarm signal pulse the receiver longitude and latitude by that we can calculate the angle and the distance .

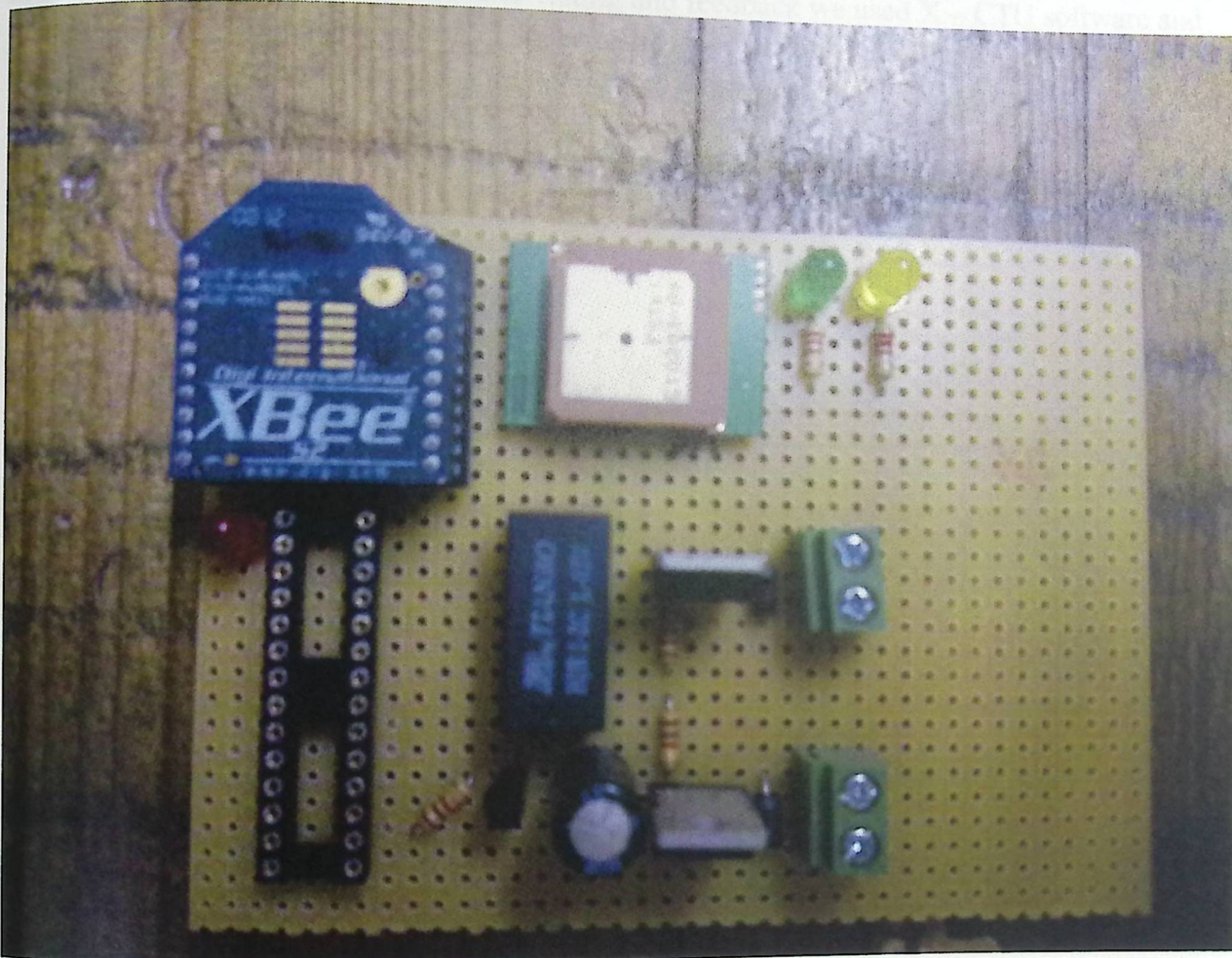


Figure5.7: Receiver Side Element

### 5.3.3 XBee testing

We tested RSSI of XBee device indoor, the communication between the PC and XBee is an integral part of our system . For XBee testing and feedback we used X – CTU software and parallax’s XBee USB adapter board. In XBee testing we used international X – CTU software for communications, signal strength monitoring and configuration of XBee.

In testing of XBee signal strength we connected the XBee USB adapter(Base node) and another remote node XBee with a certain power and a loopback connection.

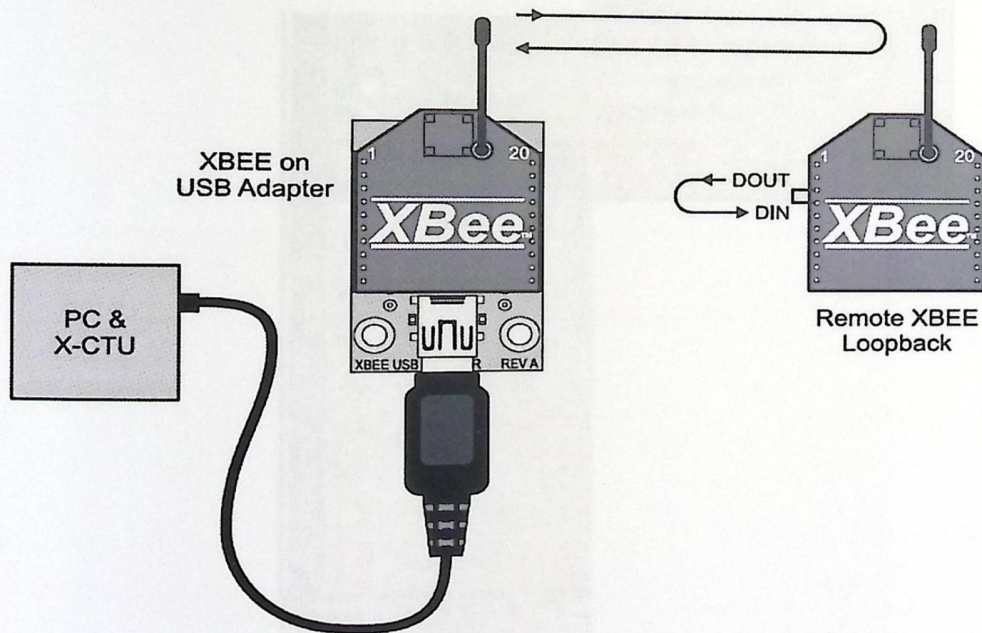


Figure 5.8: XBee loop back testing .

The loopback connection is made by connecting the DOUT pin to DIN pin which this connection will force any received data to be transmitted back to the base node and PC.

To test the range of the XBee device we downloaded the X – CTU software for windows from the website [www.digi.com](http://www.digi.com) also we could get it from parallax's page, X – CTU software is designed to operate with all windows , X – CTU can either downloaded from digi's web site or an installation CD.

When properly X – CTU installed it can be lunched by clicking on the icon on the PC desktop orselecting from start menu as shown.

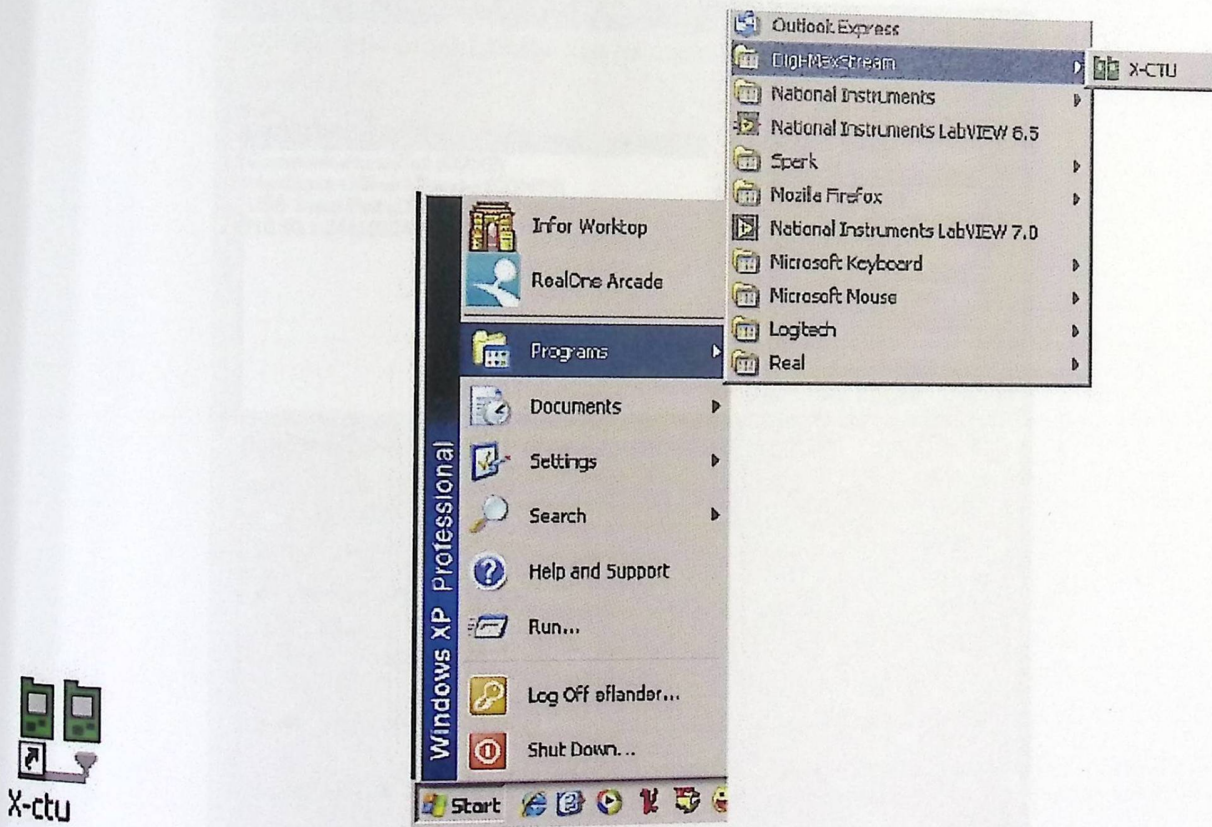


Figure 5.9:Interface between X-ctu and P.C

Also we downloaded the FTDI drivers for windows and this is vey important to be downloaded before connecting an XBee USB adapter board to the computer.

We connected the XBee USB adapter board to the PC by using an appropriate USB cable and connected Vcc and loopback connection. Now we became ready to test the XBee range with X-CTU software. Firstly we ensured that the remote node XBee with loopback connection is powered and then open the X-CTU software.

When the program was lunched we saw four tabs across the top of the program PC Settings , Range test, Terminal, Modem Configuration , each one has a different function , the default tab selected is the “ PC Settings “ tab as shown.

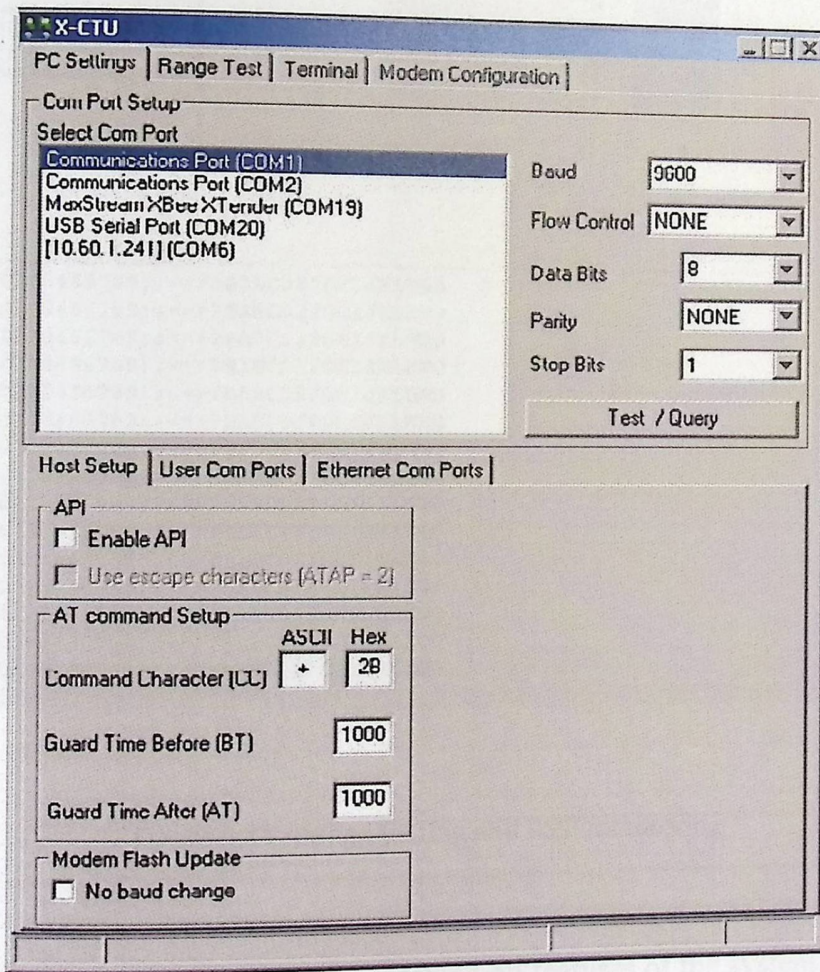


Figure 5.10: main taps on the top of X-CTU

To test the XBee range we clicked the “ Range test “ tab on the soft ware , and then under the vertical RSSI lettering we checked the checkbox to monitor signal strength , then by clicking on start the software will repeatedly send packets and display the signal strength . After complete the range test we stopped this process by clicking on stop.

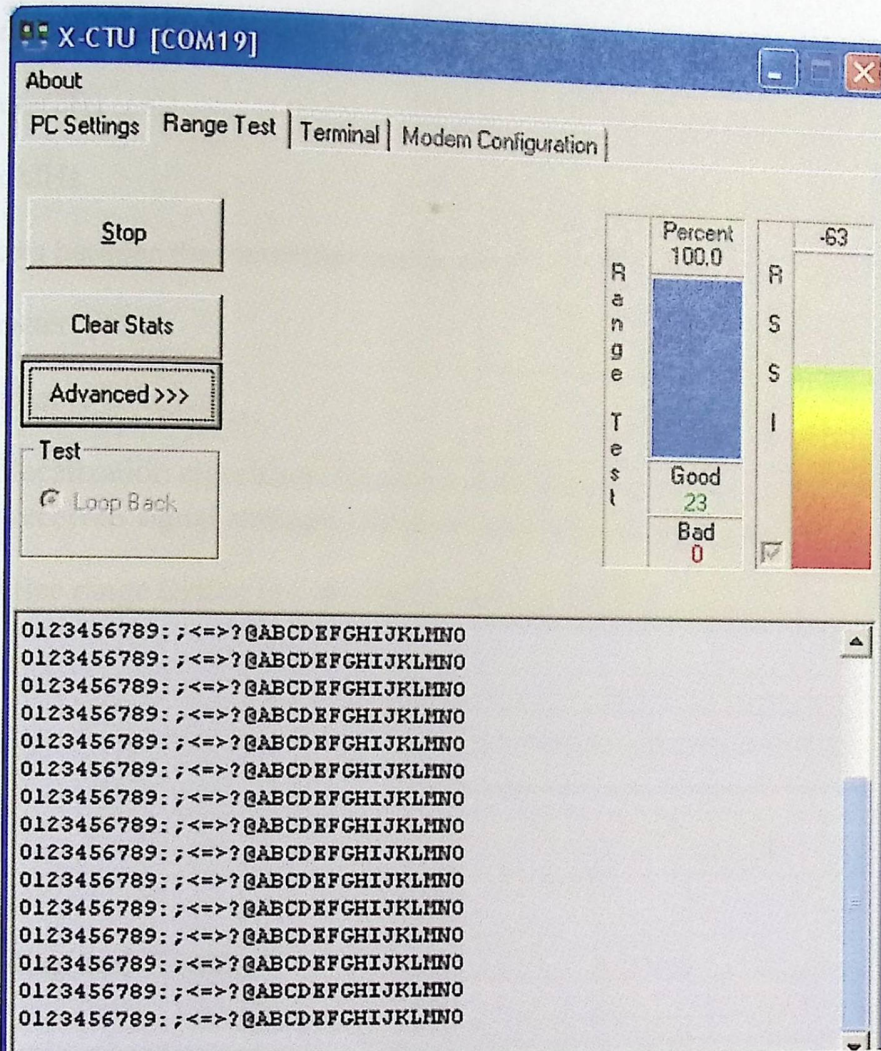


Figure 5.11 :Range testing and RSSI monitoring

The analysis of RSSI values is needed to understand all features of the system. The characteristics of RSSI ,received signal strength indicator will decreases with increased distance as the equation below shows :

$$Pr = Pt - L$$

$$Pr = Pt - 20 \log(f) - 10n \log(d) + 28_{[16]}$$

Where:

$P_r$  : received power .

$P_t$  : transmit power .

$L$  : total path loss(dB)

$f$  : frequency in MHz.

$n$  : Number of floors between the transmitter and receiver.

$d$  : distance in meter (m) .

Note: the logarithm to base ten.

Most of localization algorithms require a distance to estimate the position of unknown devices and the received signal strength which we measured is one possibility algorithm.

The results of XBee range testing are inserted in testing section .

#### 5.3.4 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:

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

To calculate the measured distance (between the person and ship ), 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.

These experiments were done to examine the formulas. Then select the best which

has less percentage of error.

Reading has a (latitude ddmm.mmm & longitude dddmm.mmmm).  
Where : d is degree.  
m is minuet.

### 1- Haversine Formula

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

$$D = R * C \quad \text{Eq.3}$$

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

$$\Delta \text{lat} = \text{lat } 2 - \text{lat } 1$$

$$\Delta \text{lon} = \text{lon } 2 - \text{lon } 1$$

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

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

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

So to calculate the percentage of error we take two reading of longitude and latitude at the person and at the ship, after that we find distance (D) then find the average by this results we can find the percentage of error using this formula:

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

### 2- Pythagoras Theorem:

$$D = \sqrt{x^2 + y^2} \quad \text{Eq.4}$$

Where:

$D$  = distance

$$x = 69.1 * (lat\ 2 - lat\ 1)$$

$$y = 53.0 * (lon\ 2 - lon\ 1)$$

We use the same previous formula to find the percentage of error

### 5.3.5 PulseOximeter Calibration

We used pulse oximeter sensor to give an alarm signal when the percentage of oxygen in blood get below a threshold value. we referred to medical references about this threshold value we found that<sup>[17]</sup> :

Threshold value of oxygen saturation 99-100% Normal, <90% hyoxia, 40% level of death.



Figure 5.12: Transmitter side

## 5.4 Results.

### 5.4.1 Results from transmitter .

We get longitude and latitude at the transmitter the first value represent latitude Second value represent longitude .

First value =3130 , second =8750

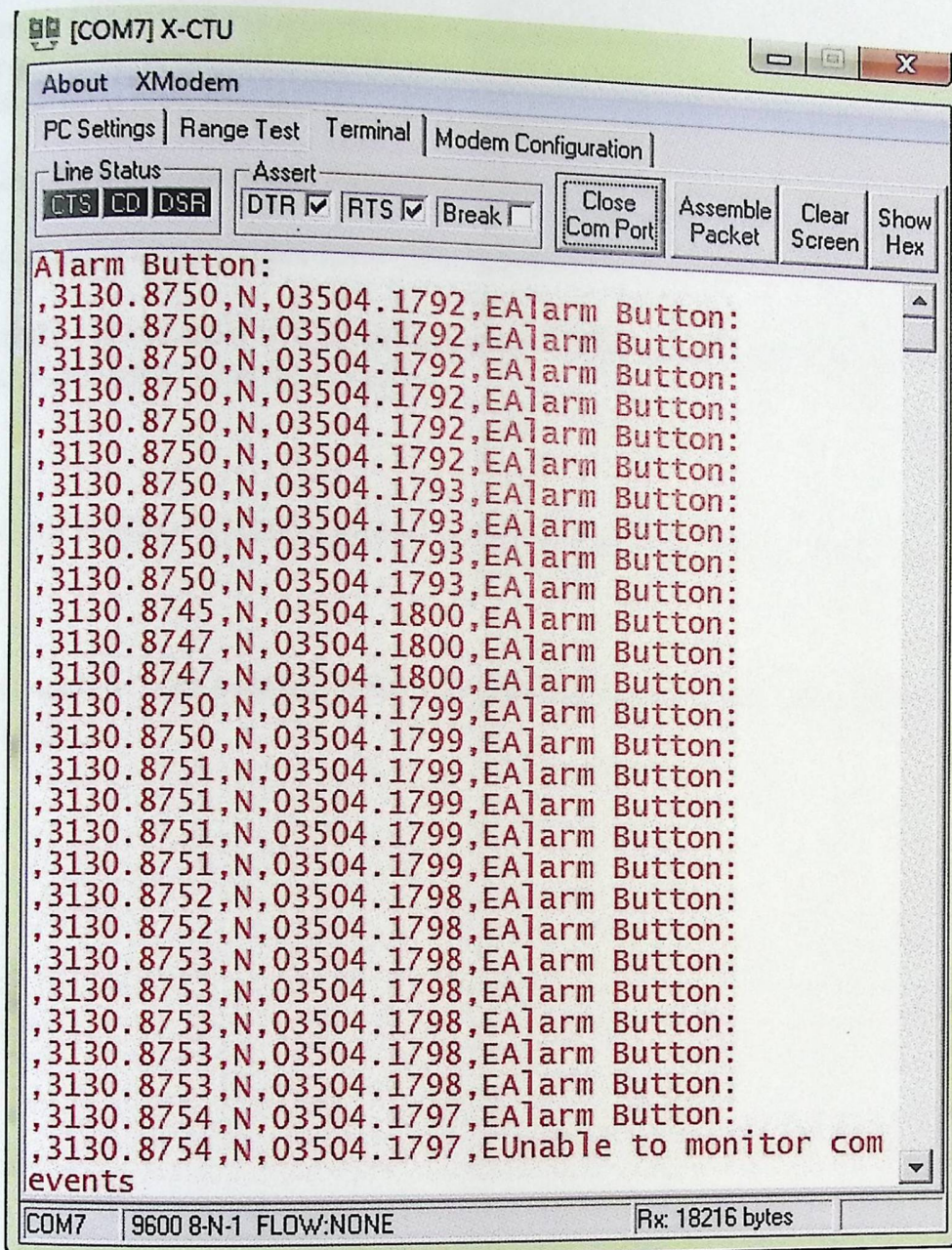


Figure 5.13: X-CTU interface

#### 5.4.2 Results from receiver .

GPS commands :

- 1- NMEA OUTPUT

Standard NMEA0183 messages that are supported by IT500 series receivers  
In default configuration outputted messages are GGA, RMC, GSV and GSA messages. Receiver  
can be configured to have user defined set of output messages by command PMTK314

## 2- GGA - Global Positioning System Fix Data

Time, position and fix related data for a GPS receiver.

According to the table that inserted below we analysis the signal receive from the GPS,  
and there's an example illustrate the idea:

### Example:

```
$GPGGA,114353.000,6016.3245,N,02458.3270,E,1,10,0.81,35.2,M,19.5,M,,*50
```

### Format:

```
$GPGGA,hhmmss.dd,xxmm.dddd,<N|S>,yyymm.dddd,<E|W>,v,ss,d.d,h.h,M,g.g,M,a.a,xxxx*h  
h<CR><LF>[18]
```

hhmmss.dd	UTC time of the fix. hh = hours mm = minutes ss = seconds dd = decimal part of seconds
xxmm.dddd	Latitude coordinate. xx = degrees mm = minutes dddd = decimal part of minutes
<N/S>	Character denoting either N = North or S =South.
yyymm.dddd	Longitude coordinate. yyy = degrees mm = minutes dddd = decimal part of minutes
<E/W>	Character denoting either E = East or W = West.
v	Fix valid indicator 1 = GPS fix (SPS) 2 = DGPS fix 3 = PPS fix 4 = Real Time Kinematic 5 = Float RTK 6 = estimated (dead reckoning) (2.3 feature) 7 = Manual input mode 8 = Simulation mode
ss	Number of satellites used in position fix, 00-12. Notice: Fixed length field of two letters.
d.d	HDOP - Horizontal Dilution Of Precision.
h.h	Altitude (mean-sea-level, geoid)
M	Letter M.
g.g	Difference between the WGS-84 reference ellipsoid surface and the mean-sea-level altitude.
M	Letter M.

Figure 5.14 X-CUT interface of GPS signal

Here we get the longitude and latitude of each transmitter and receiver. By the combination comes from GPS R.X and Zigbee signal we using Pythagoras Theorem



To measure the distance as example :

Point x	point y
Lon1=1759	lon2=1756
Lat1=8700	lat2=1756

$$X=(lon2-lon1)^2=(8709-8700)^2=81$$

$$Y=(lat2-lat1)^2=(1756-1759)^2=9$$

$$D=\sqrt{(81)+(9)}$$
  
$$=9.48683298050m$$

$$9.486*0.185=1.75m$$

The value 0.185 referred to this calculation

Every 10000 dddd equal 1 min

60 min = 1 degree

1 degree = 111 Km

60 min \_\_\_\_\_ 111 Km

1 min \_\_\_\_\_ ???

$$111 \text{ Km} / 60 \text{ min} = 1.85 \text{ Km/min}$$

To evaluate 1.85 by meter multiply

$$1.85*1000=1850$$

To evaluate

$$1850/10000 = 0.185 \text{ part from meter}$$

Angle calculation

$D1 = \text{Lat1} - \text{Lat2};$

$D2 = \text{Lon1} - \text{Lon2};$

$D4 = \text{atan2}(D1, D2) * 180 / 3.14 ;$

$D4 = D4 + 180;$

$\text{angle} = D4;$

### 5.4.3 Xbee results

Table 1.4 indoor measurement of RSSI power and distance of Xbee.

Distance (m)	P1(dBm)	P2 (dBm)	P3 (dBm)	P4 (dBm)	Avg Power (dBm)
1	-47	-50	-48	-46	-47.75
3	-56	-62	-60	-56	-58.5
5	-70	-64	-73	-70	-69.25
7	-72	-70	-78	-74	-73.5
9	-74	-77	-76	-68	-73.75
11	-82	-79	-77	-77	-78.75
12	-71	-81	-73	-80	-76.25
15	-83	-78	-79	-81	-80.25
17	-87	-88	-82	-75	-81.75

Note: As the distance increase the power will decrease.

## Conclusions and future suggestions

6.1 Conclusions.

6.2 Challenges.

6.3 Future suggestions.

# Chapter Six



## Conclusions and future suggestions

6.1 Conclusions.

6.2 Challenges.

6.3 Future suggestions.

## 6.1 Conclusions

After building the circuits of our system in both side transmitter and receiver as proposed in previous chapters we can conclude many points, the most important one that many practical experiences were added to work team in this project by working with electronic devices such as PIC microcontroller, XBee devices, pulse oximetersensor and all other used devices .

Also we learned how to write a code on PIC and how to download it in PIC microchip , we are able to distinguish between different wireless communication technologies and also we have a good Acknowledgement of technical work and very important theoretical information about device that used in project circuit implementation.

We also learned how to search of needed information in many references and thesis and how to document the project in an acceptable form.

## 6.2 Challenges

There are many problems obstructed and change some ideas in the project. We can summarize them below :

- GPS systems do not give us the desired accuracy because Intentional jamming by occupation plus the accuracy problem and at the first time we feed the GPS it will not give us the data immediately it takes time 15min approximately
- We have in PIC one receiver so we can't receive two signal at the same time at the same pin so we use relay .
- We must isolate the circuit from the water .
- How to program microcontroller to achieve the goals on hardware.
- Availability of electronic chips and motors .
- Providing the suitable shape of our system.

Decrease the data transmit from GPS to obtain the Latitude and Longitude. voltage regulation needed since zigbee needed only 3.3 volt but other devices needed 5 volt.

How to control the speed of a DC Motor using Pulse Width Modulation (PWM). By using PWM we can easily control the average power delivered to a load and by thus we can easily control the speed of the DC Motor.

You may think that a variable resistor in series with a DC Motor can control its speed. There are three reasons for "Resistor is not a good choice for controlling the speed of a DC Motor".

- The main problem is that the motor is a varying electrical load so a resistor can't do this task. It needs more power during start up than in running state. It draws more current also when a mechanical load is Applied to motor shaft.
- The resistor drops excess energy as heat. Thus it is not good for a battery powered device.
- We all know that motor requires more current, so resistors with higher power rating are required to drop excess energy.

### 6.3 Future suggestions

After complete our project we can suggest some important ideas that make the project more useful and more important by some improvement or adding a new circuits which make the project able to do more tasks and improve the system performance.

#### 6.3.1 First Suggested idea.

In this Suggested idea we try to make our system able to give an alarm signal not only when the percentage of oxygen in blood of the drowned person in water but also when the person exceed the allowable distance from the beach then the system transmit an alarm signal to emergency side to take all suitable considerations, this idea can be implemented by additional circuits and changing in the microcontroller programming.

### 6.3.2 Second Suggested idea .

In this suggested idea , if the person drowned in water then the alarm signal will be sent to the receiver side but if this receiver was busy with another person then it will be sent to the another idle receiver , this means that the alarm signal must search the idle receiver.

## APPENDIXES

### 6.3.3 Third Suggested idea.

In this suggested idea ,if there are any objects between the drowned person and the receiver ship ,We will need a sensor i.e. ultra sound sensor that discover the path ,so if there is an obstacle it will change the path in order to arrive destination successfully .

### 6.3.4 Fourth Suggested idea.

In this suggested idea we aim to make the safety space larger by using multi ships connected with each other by monitoring room .that determine the priority . of the nearest ship to the person.

# APPENDIXES

## APPENDIX

## A

XBee®/XBee PRO® ZB RF Modules

### Key Features

#### High Performance, Low Cost

##### XBee

- Indoor/Urban: up to 133' (40 m)
- Outdoor line of sight: up to 100' (120 m)
- Transmit Power: 2 mW (3 dBm)
- Receiver Sensitivity: -96 dBm

##### XBee-PRO (S2)

- Indoor/Urban: up to 300' (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 2 miles (3200 m), 5000' (1500 m) for International variant
- Transmit Power: 50mW (17dBm), 10mW (10dBm) for International variant
- Receiver Sensitivity: -102 dBm

##### XBee-PRO (S2B)

- Indoor/Urban: up to 300' (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 2 miles (3200 m), 5000' (1500 m) for International variant
- Transmit Power: 63mW (18dBm), 10mW (10dBm) for International variant
- Receiver Sensitivity: -102 dBm

#### Advanced Networking & Security

Retries and Acknowledgements

DSSS (Direct Sequence Spread Spectrum)

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

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

Self-routing, self-healing and fault-tolerant mesh networking

#### Low Power

##### XBee

- TX Peak Current: 40 mA (@3.3 V)
- RX Current: 10 mA (@3.3 V)
- Power-down Current: < 1  $\mu$ A

##### XBee-PRO (S2)

- TX Peak Current: 295mA (170mA for international variant)
- RX Current: 45 mA (@3.3 V)
- Power-down Current: 3.5  $\mu$ A typical @ 25 degrees C

##### XBee-PRO (S2B)

- TX Peak Current: 205mA (117mA for international variant)
- RX Current: 47 mA (@3.3 V)
- Power-down Current: 3.5  $\mu$ A typical @ 25 degrees C

#### Easy-to-Use

No configuration necessary for out-of box RF communications

AT and API Command Modes for configuring module parameters

Small form factor

Extensive command set

Free X-CTU Software (Testing and configuration software)

Free & Unlimited Technical Support

# Specifications

Specifications of the XBee®/XBee-PRO® ZB RF Module

Specification	XBee	XBee-PRO (S2)	XBee-PRO (S2B)
<b>Performance</b>			
Indoor/Urban Range	up to 133 ft. (40 m)	Up to 300 ft. (90 m), up to 200 ft. (60 m) international variant	Up to 300 ft. (90 m), up to 200 ft. (60 m) international variant
Outdoor RF line-of-sight Range	up to 400 ft. (120 m)	Up to 2 miles (3200 m), up to 5000 ft (1500 m) international variant	Up to 2 miles (3200 m), up to 5000 ft (1500 m) international variant
Transmit Power Output	2mW (+3dBm), boost mode enabled 1.25mW (+1dBm), boost mode disabled	50mW (+17 dBm) 10mW (+10 dBm) for International variant	63mW (+18 dBm) 10mW (+10 dBm) for International variant
RF Data Rate	250,000 bps	250,000 bps	250,000 bps
Data Throughput	up to 35000 bps (see chapter 4)	up to 35000 bps (see chapter 4)	up to 35000 bps (see chapter 4)
Serial Interface Data Rate (software selectable)	1200 bps - 1 Mbps (non-standard baud rates also supported)	1200 bps - 1 Mbps (non-standard baud rates also supported)	1200 bps - 1 Mbps (non-standard baud rates also supported)
Receiver Sensitivity	-96 dBm, boost mode enabled -95 dBm, boost mode disabled	-102 dBm	-102 dBm
<b>Power Requirements</b>			
Supply Voltage	2.1 - 3.6 V	3.0 - 3.4 V	2.7 - 3.6 V
Operating Current (Transmit, max output power)	40mA (@ 3.3 V, boost mode enabled) 35mA (@ 3.3 V, boost mode disabled)	295mA (@3.3 V) 170mA (@3.3 V) international variant	205mA, up to 220 mA with programmable variant (@3.3 V) 117mA, up to 132 mA with programmable variant (@3.3 V), International variant
Operating Current (Receive)	40mA (@ 3.3 V, boost mode enabled) 38mA (@ 3.3 V, boost mode disabled)	45 mA (@3.3 V)	47 mA, up to 62 mA with programmable variant (@3.3 V)
Idle Current (Receiver off)	15mA	15mA	15mA
Power-down Current	< 1 uA @ 25°C	3.5 uA typical @ 25°C	3.5 uA typical @ 25°C
<b>General</b>			
Operating Frequency Band	ISM 2.4 GHz	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)	0.960 x 1.297 (2.438cm x 3.294cm)
Operating Temperature	-40 to 85° C (industrial)	-40 to 85° C (industrial)	-40 to 85° C (industrial)
Antenna Options	Integrated Whip Antenna, Embedded PCB Antenna, RPSMA, or U.FL Connector	Integrated Whip Antenna, Embedded PCB Antenna, RPSMA or U.FL Connector	Integrated Whip Antenna, Embedded PCB Antenna, RPSMA or U.FL Connector
<b>Networking &amp; Security</b>			
Supported Network Topologies	Point-to-point, Point-to-multipoint, Peer-to-peer, and Mesh	Point-to-point, Point-to-multipoint, Peer-to-peer, and Mesh	Point-to-point, Point-to-multipoint, Peer-to-peer, and Mesh
Number of Channels	16 Direct Sequence Channels	14 Direct Sequence Channels	15 Direct Sequence Channels
Channels	11 to 26	11 to 24	11 to 25
Addressing Options	PAN ID and Addresses, Cluster IDs and Endpoints (optional)	PAN ID and Addresses, Cluster IDs and Endpoints (optional)	PAN ID and Addresses, Cluster IDs and Endpoints (optional)
<b>Agency Approvals</b>			
United States (FCC Part 15.247)	FCC ID: OUR-XBEE2	FCC ID: MCQ-XBEEPRO2	FCC ID: MCQ-PROS2B
Industry Canada (IC)	IC: 4214A-XBEE2	IC: 1846A-XBEEPRO2	IC: 1846A-PROS2B
Europe (CE)	ETSI	ETSI (International variant)	ETSI (10 mW max)

## Pin Signals

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

Pin #	Name	Direction	Default State	Description
1	VCC	-	-	Power supply
2	DOUT	Output	Output	UART Data Out
3	DIN / CONFIG	Input	Input	UART Data In
4	DIO12	Both	Enabled	Digital I/O 12
5	<u>RESET</u>	Both	Open-Collector with pull-up	Module Reset (reset pulse must be at least 200 ns)
6	RSSIPWM / DIO10	Both	Output	FX Signal Strength Indicator / Digital IO
7	DIO11	Both	Input	Digital I/O 11
8	[reserved]	-	Disabled	Do not connect
9	<u>DTR</u> / <u>SLEEP_RQ</u> / DIO8	Both	Input	Pin Sleep Control Line or Digital IO 8
10	GND	-	-	Ground
11	DIO4	Both	Enabled	Digital I/O 4
12	<u>CTS</u> / DIO7	Both	Output	Clear-to-Send Flow Control or Digital I/O 7. CTS, if enabled, is an output.
13	<u>ON</u> / <u>SLEEP</u>	Output	Output	Module Status Indicator or Digital I/O 9
14	VREF	Input	-	Not used for EM250. Used for programmable secondary processor. For compatibility with other XBEE modules, we recommend connecting this pin voltage reference if Analog sampling is needed. Otherwise, connect to GND.
15	Associate / DIO5	Both	Output	Associated Indicator, Digital I/O 5
16	<u>RTS</u> / DIO6	Both	Input	Request-to-Send Flow Control, Digital I/O 6. RTS, if enabled, is an input.
17	AD3 / DIO3	Both	Enabled	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Both	Enabled	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Both	Enabled	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0 / Commissioning Button	Both	Enabled	Analog Input 0, Digital IO 0, or Commissioning Button

- Signal Direction is specified with respect to the module
- See Design Notes section below for details on pin connections.

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- Outdoor line-of-sight: up to 400' (120 m)
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- Indoor/Urban: up to 300' (90 m), 200' (60 m) for International variant
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- Receiver Sensitivity: -102 dBm

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- TX Peak Current: 295mA (170mA for international variant)
- RX Current: 45 mA (@3.3 V)
- Power-down Current: 3.5  $\mu$ A typical @ 25 degrees C

**XBee-PRO (S2B)**

- TX Peak Current: 205mA (117mA for international variant)
- RX Current: 47 mA (@3.3 V)
- Power-down Current: 3.5  $\mu$ A typical @ 25 degrees C

**Easy-to-Use**

No configuration necessary for out-of box RF communications  
AT and API Command Modes for configuring module parameters  
Small form factor  
Extensive command set  
Free X-CTU Software (Testing and configuration software)  
Free & Unlimited Technical Support

Specifications of the XBee®/XBee-PRO® ZB RF Module

Specification	XBee	XBee-PRO (S2)	XBee-PRO (S2B)
<b>Performance</b>			
Indoor/Urban Range	up to 133 ft. (40 m)	Up to 300 ft. (90 m), up to 200 ft (60 m) international variant	Up to 300 ft. (90 m), up to 200 ft (60 m) international variant
Outdoor RF line-of-sight Range	up to 400 ft. (120 m)	Up to 2 miles (3200 m), up to 5000 ft (1500 m) international variant	Up to 2 miles (3200 m), up to 5000 ft (1500 m) international variant
Transmit Power Output	2mW (+3dBm), boost mode enabled 1.25mW (+1dBm), boost mode disabled	50mW (+17 dBm) 10mW (+10 dBm) for International variant	63mW (+18 dBm) 10mW (+10 dBm) for International variant
RF Data Rate	250,000 bps	250,000 bps	250,000 bps
Data Throughput	up to 35000 bps (see chapter 4)	up to 35000 bps (see chapter 4)	up to 35000 bps (see chapter 4)
Serial Interface Data Rate (software selectable)	1200 bps - 1 Mbps (non-standard baud rates also supported)	1200 bps - 1 Mbps (non-standard baud rates also supported)	1200 bps - 1 Mbps (non-standard baud rates also supported)
Receiver Sensitivity	-96 dBm, boost mode enabled -95 dBm, boost mode disabled	-102 dBm	-102 dBm
<b>Power Requirements</b>			
Supply Voltage	2.1 - 3.6 V	3.0 - 3.4 V	2.7 - 3.6 V
Operating Current (Transmit, max output power)	40mA (@ 3.3 V, boost mode enabled) 35mA (@ 3.3 V, boost mode disabled)	295mA (@3.3 V) 170mA (@3.3 V) international variant	205mA, up to 220 mA with programmable variant (@3.3 V) 117mA, up to 132 mA with programmable variant (@3.3 V), International variant
Operating Current (Receive)	40mA (@ 3.3 V, boost mode enabled) 38mA (@ 3.3 V, boost mode disabled)	45 mA (@3.3 V)	47 mA, up to 62 mA with programmable variant (@3.3 V)
Idle Current (Receiver off)	15mA	15mA	15mA
Power-down Current	< 1 $\mu$ A @ 25°C	3.5 $\mu$ A typical @ 25°C	3.5 $\mu$ A typical @ 25°C
<b>General</b>			
Operating Frequency Band	ISM 2.4 GHz	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)	0.960 x 1.297 (2.438cm x 3.294cm)
Operating Temperature	-40 to 85° C (industrial)	-40 to 85° C (industrial)	-40 to 85° C (industrial)
Antenna Options	Integrated Whip Antenna, Embedded PCB Antenna, RPSMA, or U.FL Connector	Integrated Whip Antenna, Embedded PCB Antenna, RPSMA or U.FL Connector	Integrated Whip Antenna, Embedded PCB Antenna, RPSMA or U.FL Connector
<b>Networking &amp; Security</b>			
Supported Network Topologies	Point-to-point, Point-to-multipoint, Peer-to-peer, and Mesh	Point-to-point, Point-to-multipoint, Peer-to-peer, and Mesh	Point-to-point, Point-to-multipoint, Peer-to-peer, and Mesh
Number of Channels	16 Direct Sequence Channels	14 Direct Sequence Channels	15 Direct Sequence Channels
Channels	11 to 26	11 to 24	11 to 25
Addressing Options	PAN ID and Addresses, Cluster IDs and Endpoints (optional)	PAN ID and Addresses, Cluster IDs and Endpoints (optional)	PAN ID and Addresses, Cluster IDs and Endpoints (optional)
<b>Agency Approvals</b>			
United States (FCC Part 15.247)	FCC ID: OUR-XBEE2	FCC ID: MCQ-XBEEPRO2	FCC ID: MCQ-PROS2B
Industry Canada (IC)	IC: 4214A-XBEE2	IC: 1846A-XBEEPRO2	IC: 1846A-PROS2B
Europe (CE)	ETSI	ETSI (International variant)	ETSI (10 mW max)

## Pin Signals

### Pin Assignments for the XBee/XBee-PRO Modules

(Low-asserted signals are distinguished with a horizontal line above signal name.)

Pin #	Name	Direction	Default State	Description
1	VCC			Power supply
2	DOUT	Output	Output	UART Data Out
3	DIN / CONFIG	Input	Input	UART Data In
4	DIO12	Both	Disabled	Digital I/O 12
5	RESET	Both	Open-Collector with pull-up	Module Reset; reset pulse must be at least 200 ns!
6	RSSI PWM / DIO10	Both	Output	RX Signal Strength Indicator / Digital IO
7	DIO11	Both	Input	Digital I/O 11
8	[reserved]	-	Disabled	Do not connect
9	DTR / SLEEP_REQ / DIO8	Both	Input	Pin Sleep Control Line or Digital IO 8
10	GND	-	-	Ground
11	DIO4	Both	Disabled	Digital I/O 4
12	CTS / DIO7	Both	Output	Clear-to-Send Flow Control or Digital I/O 7. CTS, if enabled, is an output.
13	ON / SLEEP	Output	Output	Module Status Indicator or Digital I/O 9
14	VREF	Input	-	Not used for EM250. Used for programmable secondary processor. For compatibility with other XBEE modules, we recommend connecting this pin voltage reference if Analog sampling is desired. Otherwise, connect to GND.
15	AssocInd / DIO5	Both	Output	Associated Indicator, Digital I/O 5
16	RTS / DIO6	Both	Input	Request-to-Send Flow Control, Digital I/O 6. RTS, if enabled, is an input.
17	AD3 / DIO3	Both	Disabled	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Both	Disabled	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Both	Disabled	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0 / Commissioning Button	Both	Disabled	Analog Input 0, Digital I/O 0, or Commissioning Button

- Signal Direction is specified with respect to the module
- See Design Notes section below for details on pin connections.

**High Performance, Low Cost**

**XBee**

- Indoor/Urban: up to 133' (40 m)
- Outdoor line-of-sight: up to 400' (120 m)
- Transmit Power: 2 mW (3 dBm)
- Receiver Sensitivity: -96 dBm

**XBee-PRO (S2)**

- Indoor/Urban: up to 300' (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 2 miles (3200 m), 5000' (1500 m) for International variant
- Transmit Power: 50mW (17dBm), 10mW (10dBm) for International variant
- Receiver Sensitivity: -102 dBm

**XBee-PRO (S2B)**

- Indoor/Urban: up to 300' (90 m), 200' (60 m) for International variant
- Outdoor line-of-sight: up to 2 miles (3200 m), 5000' (1500 m) for International variant
- Transmit Power: 63mW (18dBm), 10mW (10dBm) for International variant
- Receiver Sensitivity: -102 dBm

**Advanced Networking & Security**

Retries and Acknowledgements

DSSS (Direct Sequence Spread Spectrum)

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

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

Self-routing, self-healing and fault-tolerant mesh networking

**Low Power**

**XBee**

- TX Peak Current: 40 mA (@3.3 V)
- RX Current: 40 mA (@3.3 V)
- Power-down Current: < 1  $\mu$ A

**XBee-PRO (S2)**

- TX Peak Current: 295mA (170mA for international variant)
- RX Current: 45 mA (@3.3 V)
- Power-down Current: 3.5  $\mu$ A typical @ 25 degrees C

**XBee-PRO (S2B)**

- TX Peak Current: 205mA (117mA for international variant)
- RX Current: 47 mA (@3.3 V)
- Power-down Current: 3.5  $\mu$ A typical @ 25 degrees C

**Easy-to-Use**

No configuration necessary for out-of box RF communications

AT and API Command Modes for configuring module parameters

Small form factor

Extensive command set

Free X-CTU Software (Testing and configuration software)

Free & Unlimited Technical Support

UP501 GPS Antenna Module		
Specifications		
General:	L1 frequency, C/A code (SPS)	
	22 tracking + 66 search channels	
Update rate:	1 fix/s (user configurable, up to 10 fix/s)	
Accuracy:	Position:	1.8m (CEP95)
	Velocity:	0.1m/s
	Time:	+/-50ns (RMS)
TTFF:	Cold Start (out of the box):	34s typ.
	Warm Start	34s typ.
	Hot start:	1s typ.
Sensitivity:	Acquisition (cold):	-148dBm (1)
	Re-acquisition:	-158dBm (1)
	Navigation:	-165dBm (1)
Power Drain (3.0V):	Navigating 1 fix/s:	75mW typ.
	Backup state:	< 15uW typ.
Operating voltage:	Main Supply:	+3.0V..4.2V (2)
	Backup Supply:	+2.0V..4.2V (2)

IF Connector:	2.54mm pitch, 1x6pin grid
I/O ports:	Pin1: Serial port RX
	Pin2: Serial port TX
	Pin3: Ground
	Pin4: Main supply
	Pin5: Backup supply
	Pin6: 1PPS output
Protocol:	NMEA 0183, 9600 baud
Chip set:	MediaTek MT3329
Dimensions:	22mm x 22mm x 8mm
Weight:	9 g
Operating temperature:	-40C..+85C
Storage temperature:	-40C..+85C
Standard Options:	Dual SAW filter front end
	Internal Backup battery

## 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 MCLR Vpp RE3	1	18	18	I P I	ST  ST	Master Clear (input) or programming voltage (input). Master Clear (Reset) input. This pin is an active-low Reset to the device. Programming voltage input. Digital input.
OSC1/CLKI OSC1 CLKI	13	32	30	I I	Analog Analog	Oscillator crystal or external clock input. Oscillator crystal input or external clock source input. External clock source input. Always associated with pin function OSC1. (See OSC2/CLKO pin.)
OSC2/CLKO/RA6 OSC2 CLKO RA6	14	33	31	O O I/O	— — TTL	Oscillator crystal or clock output. Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate. 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			
RA0/AN0 RA0 AN0	2	19	19	I/O I	TTL Analog	PORTA is a bidirectional I/O port. Digital I/O. Analog input 0.
RA1/AN1 RA1 AN1	3	20	20	I/O I	TTL Analog	Digital I/O. Analog input 1.
RA2/AN2/VREF-/ CVREF RA2 AN2 VREF- CVREF	4	21	21	I/O I I O	TTL Analog Analog Analog	Digital I/O. Analog input 2. A/D reference voltage (low) input. Analog comparator reference output.
RA3/AN3/VREF+ RA3 AN3 VREF+	5	22	22	I/O I I	TTL Analog Analog	Digital I/O. Analog input 3. A/D reference voltage (high) input.
RA4/T0CKI/C1OUT/ RCV RA4 T0CKI C1OUT RCV	6	23	23	I/O I O I	ST ST — TTL	Digital I/O. Timer0 external clock input. Comparator 1 output. External USB transceiver RCV input.
RA5/AN4/ $\overline{SS}$ / HLVDIN/C2OUT RA5 AN4 $\overline{SS}$ HLVDIN C2OUT RA6	7	24	24	I/O I I I O —	TTL Analog TTL Analog — —	Digital I/O. Analog input 4. SPI slave select input. High/Low-Voltage Detect input. Comparator 2 output. See the OSC2/CLKO/RA6 pin.

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

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

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

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

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

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
RC0/T1OSO/T13CKI RC0 T1OSO T13CKI	15	34	32	I/O O I	ST — ST	PORTC is a bidirectional I/O port. Digital I/O. Timer1 oscillator output. Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2/ UOE RC1 T1OSI CCP2 <sup>(2)</sup> UOE	16	35	35	I/O I I/O O	ST CMOS ST —	Digital I/O. Timer1 oscillator input. Capture 2 input/Compare 2 output/PWM 2 output. External USB transceiver OE output.
RC2/CCP1/P1A RC2 CCP1 P1A	17	36	36	I/O I/O O	ST ST TTL	Digital I/O. Capture 1 input/Compare 1 output/PWM 1 output. Enhanced CCP1 PWM output, channel A.
RC4/D-/VM RC4 D- VM	23	42	42	I I/O I	TTL — TTL	Digital input. USB differential minus line (input/output). External USB transceiver VM input.
RC5/D+/VP RC5 D+ VP	24	43	43	I I/O I	TTL — TTL	Digital input. USB differential plus line (input/output). External USB transceiver VP input.
RC6/TX/CK RC6 TX CK	25	44	44	I/O O I/O	ST — ST	Digital I/O. EUSART asynchronous transmit. EUSART synchronous clock (see RX/DT).
RC7/RX/DT/SDO RC7 RX DT SDO	26	1	1	I/O I I/O O	ST ST ST —	Digital I/O. EUSART asynchronous receive. EUSART synchronous data (see TX/CK). 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.  
 Note 2: Default assignment for CCP2 when CCP2MX Configuration bit is set.  
 Note 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			
RD0/SPP0 RD0 SPP0	19	38	38	I/O I/O	ST TTL	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.  Digital I/O. Streaming Parallel Port data.
RD1/SPP1 RD1 SPP1	20	39	39	I/O I/O	ST TTL	
RD2/SPP2 RD2 SPP2	21	40	40	I/O I/O	ST TTL	
RD3/SPP3 RD3 SPP3	22	41	41	I/O I/O	ST TTL	
RD4/SPP4 RD4 SPP4	27	2	2	I/O I/O	ST TTL	
RD5/SPP5/P1B RD5 SPP5 P1B	28	3	3	I/O I/O O	ST TTL —	
RD6/SPP6/P1C RD6 SPP6 P1C	29	4	4	I/O I/O O	ST TTL —	
RD7/SPP7/P1D RD7 SPP7 P1D	30	5	5	I/O I/O O	ST TTL —	

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

- Note 1: Alternate assignment for CCP2 when CCP2MX Configuration bit is cleared.  
 Note 2: Default assignment for CCP2 when CCP2MX Configuration bit is set.  
 Note 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.

# APPENDIX

## D

---

```
char char_Distance[12];
char tmp;
char stat=0;
char GPGGA[100];
char GPGGAIN=0;
char GPGGA_i=0;
void interrupt() {
if (RCIF_bit == 1) { // If interrupt is generated by RCIF
tmp = UART1_Read(); // Read data and store it to txrt string

switch(stat)
{
case 0:if(tmp=='G')stat=1;else stat=0;break;
case 1:if(tmp=='P')stat=2;else stat=0;break;
case 2:if(tmp=='G')stat=3;else stat=0;break;
case 3:if(tmp=='G')stat=4;else stat=0;break;
case 4:if(tmp=='A')stat=5;else stat=0;break;
case 5:if(tmp=='*' || GPGGA_i>100){GPGGAIN=1;GPGGA_i=0;stat=0;}else
{GPGGA[GPGGA_i]=tmp;GPGGA_i++;}break;
```

```
}  
  
RCIF_bit = 0; // Set RCIF to 0  
}  
}
```

```
void main() {  
char temp;  
char i=0;  
OSCCON=0x72; //  
CMCON |= 7; // comparators off  
PIE1.RCIE = 1;  
INTCON.PEIE = 1;  
INTCON.GIE = 1;  
//ADCON1 = 0x0D; // all digital inputs  
UART1_Init(9600);  
  
TRISA=0b11111111; //  
TRISB=0b00001111;  
TRISC=0b10001111;  
ADCON1 = 0x0D; //  
while(1)  
{
```

# APPENDIXE

```
temp = ADC_Read(0)/4;
if(Button(&PORTB, 0, 200, 0))
{
    UART1_Write_Text("#");
    for(i=12;i<36;i++)
    {UART1_Write(GPGGA[i]);}
    UART1_Write_Text("%");
}

else if(temp>5)
{
    UART1_Write_Text("#");
    for(i=12;i<36;i++)
    {UART1_Write(GPGGA[i]);}
    UART1_Write_Text("%");
}

}

}
```

## APPENDIXE

---

chartmp;

char stat=0;

char GPGGA[100];

char GPGGAIN=0;

charGPGGA\_i=0;

char GPGGA1[100];

char GPGGAIN1=0;

char GPGGA\_i1=0;

char GPGGA2[100];

char GPGGAIN2=0;

char GPGGA\_i2=0;

char lat\_1[5];

char lon\_1[5];

char lat\_2[5];

char lon\_2[5];

```
long lat1=0;
long lon1=0;
long lat2=0;
long lon2=0;
```

```
long L_1,L_2,L_3,L_4;
```

```
float D1=0;
float D2=0;
float D3=0;
float D4=0;
```

```
long angle;
```

```
float Distance=0;
longF_Distance=0;
```

```
char des[11];
charang[11];
voidgozero()
```

```
{
char i=0;
for(i=0;i<100;i++)
```

```
{
GPFGA[i]='0';
```

```

GPGGA1[i]='0';
GPGGA2[i]='0';
}
for(i=0;i<5;i++)
{
lat_1[i]='0';
lat_2[i]='0';
lon_1[i]='0';
lon_2[i]='0';
}
}

void interrupt() {
if(RCIF_bit == 1) { // If interrupt is generated by RCIF
tmp=UART1_Read(); // Read data and store it to txrt string

switch(stat)
{
case 0:if(tmp=='G')stat=1;else if(tmp=='#')stat=10;else stat=0;break;
case 1:if(tmp=='P')stat=2;else stat=0;break;
case 2:if(tmp=='G')stat=3;else stat=0;break;
case 3:if(tmp=='G')stat=4;else stat=0;break;
case 4:if(tmp=='A')stat=5;else stat=0;break;
case 5:if(tmp=='*'||GPGGA_i>100){GPGGAIN=1;GPGGA_i=0;stat=0;}else
{GPGGA[GPGGA_i]=tmp;GPGGA_i++;}break;
}
}
}

```

```
case 10:if(tmp=="%"){GPGGA_i2>100}{GPGGAIN2=1;GPGGA_i2=0;stat=0;}else
{GPGGA2[GPGGA_i2]=tmp;GPGGA_i2++;}break;
}
```

```
RCIF_bit = 0;          // Set RCIF to 0
```

```
}
```

```
}
```

```
void GPGGAtoGPGGA1()
```

```
{
```

```
char i;
```

```
for(i=12;i<36;i++)
```

```
{
```

```
GPGGA1[i-12]=GPGGA[i];
```

```
}
```

```
}
```

```
void latlon()
```

```
{
```

```
char i=0;
```

```
for(i=0;i<4;i++)
```

```
lat_1[i]=GPGGA1[i+5];
```

```
for(i=0;i<4;i++)
```

```
lon_1[i]=GPGGA1[i+18];
```

```
for(i=0;i<4;i++)
```

```
lat_2[i]=GPGGA2[i+5];
```

```
for(i=0;i<4;i++)
```

```
lon_2[i]=GPGGA2[i+18];
```

```
L_1=((Lat_1[3]-48));
```

```
L_2=((Lat_1[2]-48)*10);
```

```
L_3=((Lat_1[1]-48)*100);
```

```
L_4=((Lat_1[0]-48)*1000);
```

```
lat1=L_1+L_2+L_3+L_4;
```

```
//=====
```

```
L_1=((Lon_1[3]-48));
```

```
L_2=((Lon_1[2]-48)*10);
```

```
L_3=((Lon_1[1]-48)*100);
```

```
L_4=((Lon_1[0]-48)*1000);
```

```
Lon1=L_1+L_2+L_3+L_4;
```

```
//=====
```

```
L_1=((Lat_2[3]-48));
```

```
L_2=((Lat_2[2]-48)*10);
```

```
L_3=((Lat_2[1]-48)*100);
```

```
L_4=((Lat_2[0]-48)*1000);
```

```
lat2=L_1+L_2+L_3+L_4;
```

```
//=====
```

```
L_1=((Lon_2[3]-48));
```

```
L_2=((Lon_2[2]-48)*10);  
L_3=((Lon_2[1]-48)*100);  
L_4=((Lon_2[0]-48)*1000);  
Lon2=L_1+L_2+L_3+L_4;
```

//=====

```
D1= Lat1-Lat2;  
D2= Lon1-Lon2;  
D4=atan2(D1,D2) * 180/3.14 ;  
D4=D4+180;  
angle=D4;
```

//-----

```
D1=D1*D1;  
D2=D2*D2;  
D3=D1+D2;  
Distance=sqrt(D3);  
Distance=Distance*0.0006;  
F_Distance=Distance*30.9;
```

```
LongWordToStrWithZeros(F_Distance,des);  
LongWordToStrWithZeros(angle,ang);  
}
```

```
voidgotosee()  
{
```

```
GPGGAtoGPGGA10;  
latlon();
```

```

}
void main()
{
char i=0;
PIE1.RCIE = 1;
INTCON.PEIE = 1;
INTCON.GIE = 1;
OSCCON=0x72;
CMCON |= 7; // comparators off
ADCON1 |= 0x0F; // all digital inputs

TRISA=0b11111111;
TRISB=0;
TRISC=128;
portc=0;
UART1_Init(9600);
gozero();
while(1)
{
if(GPGGAIN2==1){rb2_bit=1;GPGGAIN2=0;}

if(GPGGAIN==1)

```

```
{
rb2_bit=0;GPGGAIN=0;gotosee();

uart1_write_text("start");
uart1_write(13);

uart1_write(13);
uart1_write_text("GPGGA1=");
for(i=0;i<24;i++){uart1_write(GPGGA1[i]);}
uart1_write(13);
uart1_write_text("GPGGA2=");
for(i=0;i<24;i++){uart1_write(GPGGA2[i]);}
uart1_write(13);
uart1_write_text("Lat_1=");
for(i=0;i<4;i++){uart1_write(Lat_1[i]);}
uart1_write(13);
uart1_write_text("Lon_1=");
for(i=0;i<4;i++){uart1_write(Lon_1[i]);}
uart1_write(13);
uart1_write_text("Lat_2=");
for(i=0;i<4;i++){uart1_write(Lat_2[i]);}
uart1_write(13);
uart1_write_text("Lon_2=");
for(i=0;i<4;i++){uart1_write(Lon_2[i]);}
```

```
uart1_write(13);  
uart1_write_text("angle=");  
uart1_write_text(ang);  
uart1_write(13);  
uart1_write_text("distance=");  
uart1_write_text(des);  
uart1_write(13);  
uart1_write_text("End");  
uart1_write(13);
```

```
}
```

```
}
```

```
}
```



ذ. خالد بن مناصر



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