ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Implementation and Analysis of Wireless Data transmission using Zigbee

A Thesis/Project Submitted in Partial Fulfillment of the Requirement for the Award of Degree of Master Science and Electronics Communication Technology

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CANDIDATE'S DECLARATION

We hereby declare that the work which is presented in the project entitled **"Implementation and Analysis of wireless data transmission using zigbee"** in partial fulfillment for the award of the degree of Masters of Science in Electronics and Communication Technology Management is an authentic record of our own work carried out under the supervision of **Dr Pushparaghavan.A** and Co-advisor **Mr.Anteneh Assefa** in the Department of Electrical and Computer Engineering, Adama Science and Technology University. The matter embodied in this project has not been submitted by ours for the award of any other degree or Diploma. All relevant resources of information used in this project have been duly acknowledged.

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This is to certify that the above statement made by the candidates is correct to the best of our knowledge and belief. This has been submitted for examination with our approval.

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ABSTRACT

Based on IEEE 802.15.4, ZigBee is developed for low-power and low-data-rate wireless communication and it is building up remarkable position for wireless network. Unlike Bluetooth or wireless USB devices; Zigbee devices have large distance of coverage in data transmission, less power consumption, form mesh network. This Project overcome the limitation of Bluetooth with zigbee modules and extended for 120 meters to do the wireless data transmission with the topology of point to point. Also the project extended the implementation for point to multipoint wherever it is possible. The source information is generated by a key pad is encrypted and is sent to destination through Zigbee modules. The receiving systems check the data and decrypt according to a specific program. Finally, based on above techniques, the hard ware soft ware is implemented and analyzed.

Keywords: Zigbee, IEEE 802.15.4, PAN, Bluetooth, LR-WPAN.,

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ACRONYMS

PAN	Personal access network
MAC	Medium access control
PHY	Physical layer
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
PWM	Pulse width modulation
DTR	Data terminal ready
AT	Transparent mode
API	Application Programming Interface
PCB	Printed circuit board
FTDI	Future Technology Devices International
USB	Universal Serial Bus
RTS	Request To Send
LR-WPAN	Law rate wireless personal area network
RSSI	Received Signal Strength Indicator
UART	Universal Asynchronous Receiver Transmitter
ZG	ZigBee's gateway
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
ISM	Industrial, Scientific, and Medical
TTL	Transistor-Transistor Logic
CMOS	Complementary metal oxide semi conductor
GUI	Graphical user interface
DCU	Data Concentration Unit
RF	Radio Frequency

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Wireless networks have developed very rapidly in recent years. Many related technology are widely used in the surrounding environment for greater communication and data transfer convenience involving a variety of personal portable digital devices. Wireless technology has become a hot research topic. The future trend will allow people to use various devices to connect remotely to their home or work environment. Network technology applications will link them closely together to achieve remote wireless monitoring, communication and transmission**.** Aim of wireless communication is to gather information or perform certain task in the environment; the information will be transmitted wirelessly. In the wireless environment, the signal strength which is sent by core communication can be weakened as distance from it increases, causing communication with target nodes to become difficult and abuse of the wireless resources. Therefore, it is difficult to perform stable and reliable wireless communication with wide range nodes. It is not easy to use the wireless resources using location data because the core communication cannot search the location of node. Also, the wireless link can occur to the signal attenuation by distance and the wireless signal fading by the transferring media. For the home area network, the unit of service for home using zigbee in the smart grid which is aggressively performed and validated at this moment, its service is performed as a form to locate the coordinator in each home due to the issues caused by network organization and wireless signal attenuation. This may cause unreliable coordinator position and signal based service due to the fact that it does not organize the efficient network. In addition, it may require excessive installation costs by only supporting point to point communication between core communication and end users, and may cause greater expenses and service delays as a result of increasing the load for the data concentration unit that is in charge of checking the home as the number of core communication has been increased.

This study deals the relay node selection algorithm in accordance with the node connection condition to increase the transfer rate and reduce data delay, and the efficiency after analyzing the range of dynamic network configuration by the zigbee node signal strength and interconnection of included node numbers mathematically using

performance analysis of the suggested algorithm. Zigbee is an emerging worldwide standard for WPAN; it is best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth or Wi-Fi. Its networks are secured by 128 bit symmetric encryption keys.

The use of Zigbee technique in wireless networking technology is an established set of specifications for wireless personal area networking, catering to the specific needs of low-power, low-cost, low maintenance monitoring and control systems, long battery life, short time delay characteristics high data reliability. XBee protocol is designed to communicate data through hostile RF environments that are common in commercial and industrial applications. It is alternative to the existing Wireless home management systems in existence. XBee protocol features include: provides supports for point-to-point, point-to-multipoint and mesh networks. Its latency is 15 milliseconds, while Bluetooth's is three seconds. XBee networks can consist of over 250 devices, while Bluetooth can support only eight. With XBee batteries can run for years, while Bluetooth has to be recharged as often as every day. Admittedly, XBee boasts less bandwidth than Bluetooth, but then it doesn't need it. Ultimately, comparison between Zigbee and Bluetooth is not itself a valuable exercise. Although they share the 2.4GHz frequency band and both are wireless technologies, they have little else in common. The difference in ranges 75-120 meters for XBee, 10 for Bluetooth, is attributable to the very purposes for which they were designed. With this all advantage, it is one option for wireless network and increase the distance of coverage of networks so that it designed to replace cables in the home and office, connecting and synchronizing computers, PDAs, etc. This increases the flexibility and easily expansion of project. This project is useful for data transmission for urban and rural areas which have no internet access in offices, hospitals, industries etc.

The IEEE 802.15.4 Standard

The IEEE802.15.4 standard for wireless communication was developed by the IEEE (Institute for Electrical and Electronics Engineers,) an American technical / professional association responsible for a range of communication technologies. For example, the IEEE 802.11 standard covers communications in wireless LANs, while the IEEE 802.16 standard embraces broadband wireless Metropolitan Area Network communications. Whereas these two standards are concerned with high data rate communication, the IEEE 802.15.4 standard offers low data rate applications where simple connectivity and low

power consumption are important. It defines both the "physical layer" and the "medium access layer".

1.2 Statement of the Problem

As societal dependence up on wireless systems continues to grow, wireless technology needs to expand, however the availability of current forms of wireless is very limited if necessary to explore other alternatives to wireless communication. In the existing techniques with Bluetooth and all other USB port communication the distance is restricted up to 10m, as well as the interference and fading effect with long distance transmission also the power consumes greater. Hence to overcome the distance limitation, propagation path link loss and power consumption it can be minimize with zigbee wireless technology and also it become one opportunity of accessing PAN

1.3 Objective of the project

1.3.1General objective

The objective of this project is to implement point to point wireless data communication using Zigbee. It is designed to provide reliable data transmission of 250kbps of data up to 120m distance.

1.3.2 Specific objectives:

- use XBee module for wireless data communication
- To use visual basic for user interface.
- To achieve a data rate in a reasonably power efficient manner.

1.4 Scope of the project

The scope of project is point to point wireless data communication using Zigbee. The application of communication between two nodes is using two XBee transceiver modules and the transmission distance is up to 120meter.

1.5 Significance of the project

The project has been designed to provide the following features:

- **Short time delay**: - low latency to transfer the data.
- **Low power consumption** between wireless communication links.

- **Low cost** (device, installation, maintenance): Low cost to the users means low device cost, low installation cost and low maintenance. Zigbee devices allow batteries to last up to years using primary cells (low cost) without any chargers (low cost and easy installation). Zigbee simplicity allows for inherent configuration and redundancy of network devices provides low maintenance
- **High density of nodes per network**: MAC allows networks to handle any number of devices. This attribute is critical for massive sensor arrays and control networks. Simple protocol, global implementation
- **Reliable:** Collision avoidance is adopted, with a special time slot allocated for those communications that need fixed bandwidth so that competition and conflict are avoided when transmitting data
- **Flexible** :-Nodes must exhibits a flexibility toward changes in the operation tasks, so they should be programmable

1.6 Limitation

The factors that limit the project from being practicing are, as it is new technology to our country, the scarcity of materials required to implement for the project

1.7 Project out line

This project is entitled as "Analysis and Implementation of wireless data transmission using Zigbee" and consists the following six chapters with detail description:

The first chapters describe introduction, background, problem identification, objectives, scope of the project, significant of the project and limitation of the project.

The second chapters consist of literature reviews.

The third chapter describes hard ware and soft ware description, their flow charts, block diagrams, component specifications,

The fourth chapter describes the implementation with schematic diagrams, Software interfacing, practical testing and performance analysis.

The fifth chapter describes the result and discussion of the project.

The sixth chapter comprises the conclusion and recommendation of the project. Besides it justifies further works, modifications and suggestion.

CHAPTER TWO

LITERATURE REVIEW

Zigbee employs a suite of technologies to enable scalable, self-organizing, self-healing networks that can manage various data traffic patterns. It is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range. It has been developed to meet the growing demand for capable wireless networking between numerous low power devices. In industry Zigbee is being used for next generation automated manufacturing, with small transmitters in every device on the floor, allowing for communication between devices to a central computer. This new level of communication permits finely-tuned remote monitoring and manipulation [1].

An intelligent home control system has been proposed based on Zigbee WSN, and implemented two kinds of hardware components: a ZG and some ZR nodes. With the mesh network structure and humanized operation, user in the local place and remote place can control the home devices easily and reliably through the ZG. The implemented home control system is proved to be efficient in performing home monitoring tasks, and it is ready to be used in various home automation application switch little modification. Industrial automations which are mostly depend upon the power systems & which requires distance controlled and regulated systems [2]

Researchers were proposed that WSN system will be able to communicate each other with lower power consumption in order to deliver their real data collection. The design attempted a sensor node board systems consist of a low power microcontroller so called nano Watt technology, low power semiconductor based, Zigbee IEEE 802.15.4 wireless transceiver and solar energy source with optimal power management system [3].

Moreover, in order to monitor and improve the current manufacturing progress, a monitoring and control network for the manufacturing system that uses a network is suggested [4].

An evaluation focuses on scalability issues and the need to support several communicating devices near a patient's bed side in the clinical environment [5].

Wireless techniques for short-range data transmission as well as presented currently employed wireless applications in the hospital environment. Particularly during anesthesia and to investigate which wireless technologies are suitable for this environment. Crucial parameters (blood pressures, electrocardiography, respiration rate, heart rate and temperature) of the patient are measured. There are no viable solutions for short range data transmission from patient sensors to patient monitors, but potentially usable techniques in the future are based on the WPAN standards. These techniques include Bluetooth, ZigBee and UWB [6].

Palanisamy et al. developed a wireless monitoring system for controlling the DC motor, temperature, and lighting using a wireless ZigBee [7].

Presented a brief introduction of the IEEE 802.15.4 standard and analyzed the coexistence impact of an IEEE 802.15.4 network on the IEEE 802.11b devices. The IEEE 802.15.4 devices operate in the 2.4 GHz industrial, scientific and medical (ISM) band. The IEEE 802 wireless devices, such as IEEE 802.11b (WLAN) and IEEE 802.15.1 (Bluetooth) also used same operational band. Thus several devices coexist in the 2.4 GHz band. Therefore, it is an important issue in order to ensure that each wireless service maintains its desired performance requirements. Analytical model to provide an approach for evaluating the coexistence between IEEE 802.15.4 and IEEE 802.11b standard [8].

Thesis is directed toward Bluetooth Personal Area Networks. Driven by the boom in Internet usage, on-line trading, banking and shopping, mobile and home offices, and corporate employees with multiple offices the convergence of the wireless radio and computer are a reality. The alternative to wired connectivity is the wireless short-range connectivity offered by Bluetooth technology at 2.4 GHz [9].

They assessed various wireless communication techniques used in the automation field. They found that the WI Media had a fast communication speed. Also, both wireless ZigBee and wireless Bluetooth were suitable for short distance communication. Even though there are drawbacks (slow speed and short distance communication) for the ZigBee, because of a simpler system structure and lower electric power exhaust, the ZigBee module is widely used. The main advantages for using a wireless solution in industrial applications are greater mobility and possibility to move devices and connect to

smart phones and tablets freely without constraining cables, eliminate expensive and maintenance heavy transmission media such as flexible cables, swivels, bypassing long distances and areas where cables cannot physically fit, fast and easy installation and commissioning, high flexibility if there is a need to modify an installation, increased personnel safety by not having to be physically close to a device during configuration and maintenance, flexible human interface devices ,easy integration of devices into the network [10].

The frameworks of Zigbee operating arrangement can be classified as high-tech network. Each node can sense, compute and communicate each other. They can either receive message or transmits message (full-duplex), and can transmit messages to a gateway via self-configuration and multi-hop routing. The gateway can use many ways to communicate with remote network, such as Internet, satellite, mobile communication network and in this system we use pc interfacing. More than one gateway may be used for large-scale application. Because of its limited communication areas the node must use multi-hop routing to access the nodes out of communication areas and in this case, it will compromise two nodes. One of them will act as the central server where the Zigbee will directly connect to the personal computer [11].

Wireless sensor network is a system combination of radio frequency (RF) transceivers, microcontrollers, sensors and power supply source. Wireless sensor networks with self-configuring, self-organizing, self-diagnosing and self-healing capabilities have been developed to omit problems or to enable applications that traditional technologies could not [12].

CHAPTER THREE

HARDWARE AND SOFTWARE DESCRIPTION

3.1 Methodology

The first step in beginning the implementation of the project was to find the tools necessary to accomplish the tasks. The following is a list and brief description of hardware used and why each product was selected. There are five main components that will be needed to accomplish our project. These include a Zigbee module, MAX3232, LM317, RS232, and Visual basic 6.0 Software.

3.2 Block diagram of the project

This project work point to point data transmission application using XBee module which communicate between two nodes through wireless transmission of signals over a limited distance. Also this project work for the demonstration purpose used two transceiver nodes. The data is transmitted and received using XBee modules, the required DC power supply for proper operation of the electronic circuitry in the module is derived from 9v battery and with LM317 regulator 3.3 V is acquired. The following is a logical diagram of the project. Components used and a detailed description each block used and why each product was selected. The diagram shows the 3 major components used for the project

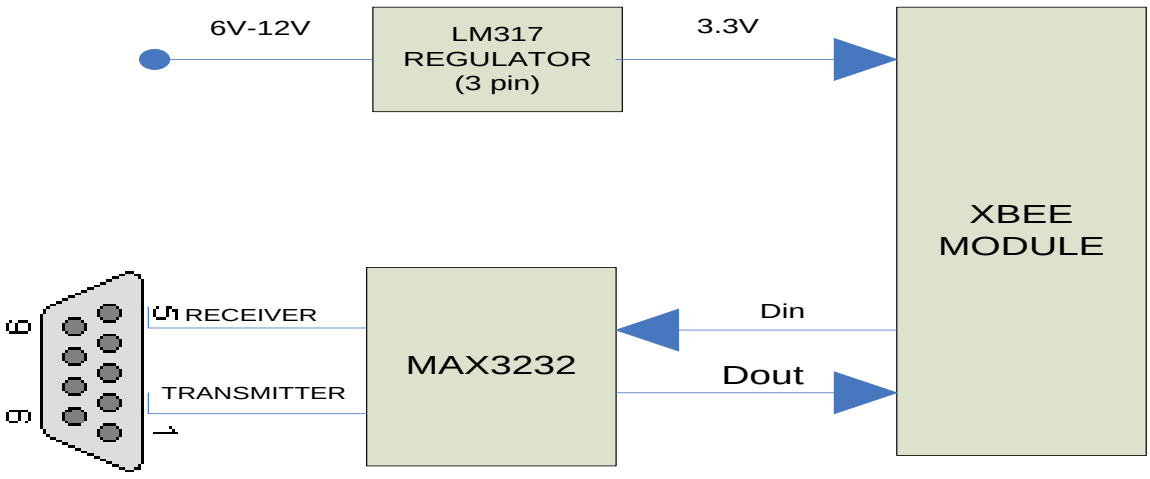

Figure 3.1 Block diagram of wireless data transmission using zigbee technology

3.2.1 XBee module transceiver

The XBee RF Modem from Digi International is a wireless transceiver. It uses a fully implemented protocol for data communications that provides features needed for robust network communications in a wireless network. Features such as addressing, acknowledgements and retries help ensure safe delivery of data to the intended node and also has additional features beyond data communications for use in monitoring and control of remote devices. The protocol helps ensure data arrives at the correct destination without errors as discussed. The protocol greatly reduces the work of the programmer in ensuring data delivery. Some key features of protocols in ensuring data delivery and integrity include:

- Media Access: A means to ensure two network nodes do not transmit at the same time causing data collisions and errors in transmission.
- Addressing: A means to ensure only the intended node uses the received data, allowing data to be sent from one point to another point. Or, point to multi-point by sending a broadcast meant for all nodes on the network.
- Error Detection: A means to verify data received at the node correctly.
- Acknowledgements & Retries: A means to inform the transmitting node that the data was delivered successfully. Lacking this, several retries may be performed in an effort to deliver the data

The XBee, using the IEEE 802.15.4 protocol, incorporates the following for communications and control on the wireless network.

- Clear Channel Assessment: Before transmitting, an XBee node listens to see if the selected frequency channel is busy.
- Addressing: The XBee has two addressing options: a fixed 64-bit serial number (MAC address) which cannot be changed, and a 16-bit assignable address (which we will use) that allows over 64,000 addresses on a network.
- Error Checking and Acknowledgements: The XBee uses a checksum to help ensure received data contains no errors. Acknowledgements are sent to the transmitting node to indicate proper reception. Up to 3 retries are performed by default if acknowledgements are not received.

3.2.1.1 XBee transceiver version

The XBee module comes in several versions but all have similar pin outs as shown in Figure 3.2 Differences between XBee versions include the power output, antenna style, operating frequency and networking abilities. The XBee is a 20-pin module with pin spacing of 2 mm (0.079 in) as opposed to typical pin spacing of 2.54 mm (0.1 in).

In this project used the series 2 wired antenna XBee transceiver module; this is the XBee XB24-Z7WIT-004 module from Digi. These transceiver modules allow a very reliable and simple communication between microcontrollers, computers, systems, really anything with a serial port Point to point and multi-point networks are supported.

Features:

- 3.3V @ 40mA
- 250kbps Max data rate
- 2mW output
- 120m range
- Built-in antenna
- Fully FCC certified
- 8 digital I/O pins
- 128-bit encryption
- Local or over-air configuration
- AT or API command set

Figure 3.2 XBee transceiver modules

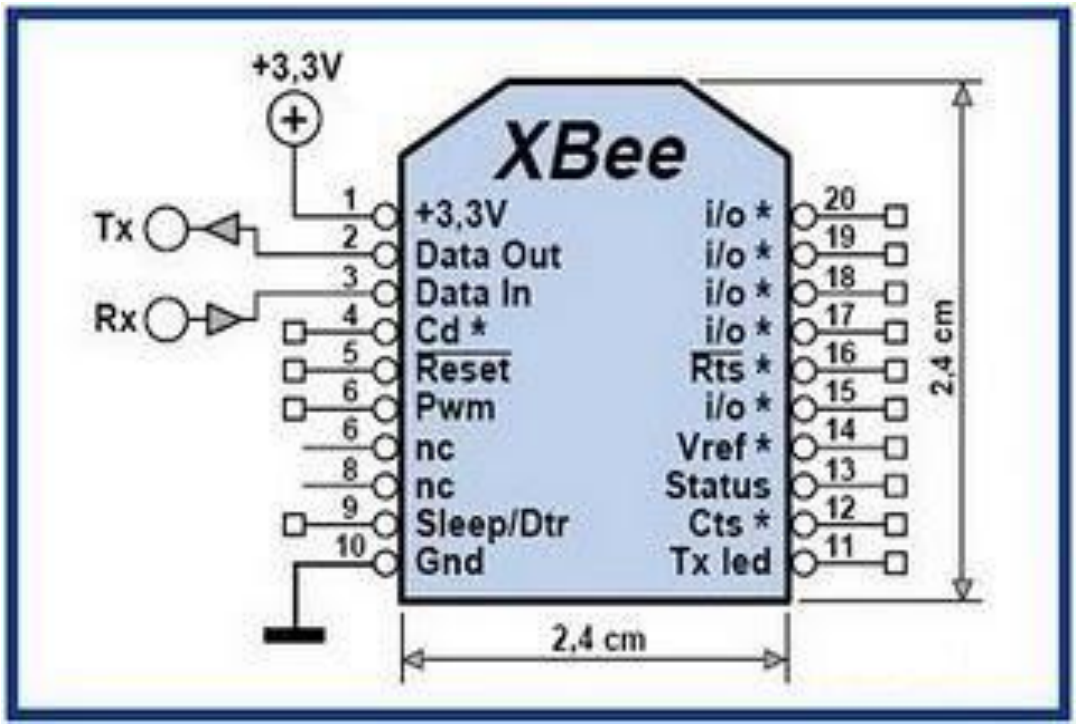

Figure 3.3 XBee module pin diagram

The figure 3.3 describes pin detail as follows:-

- **DOUT and DIN:** These are the pins through which serial data is received by our controller or PC
- **PC (DOUT)** and sent to the XBee (Din). This data may be either for transmission between XBee modules or for setting and reading configuration information of the XBee. The default data rate is 9600 baud (bps) using asynchronous serial communications.
- **RESET**: A momentary low on this pin will reset the XBee to the saved configuration settings.
- **CTS/RTS/DTR**: These are used for handshaking between the XBee and your controller or the PC. The XBee will not send data out through the DOUT line to your controller unless the RTS line is held low. This allows the controller to signal to the XBee that it is ready to receive more data. DTR is typically used by the XBee when downloading new firmware, and therefore firm ware updates can only be done using XBee adapter boards such as the Parallax USB Adapter Board that implement this connection. When transmitting, the XBee can signal to the controller through the

CTS line that it is ready to send more data. CTS is seldom needed because the Xbee sends data out by radio much more quickly than it accepts data from the controller.

- **DIO0–DIO7/D08**: These are used as standard 3.3 V digital inputs and outputs. The XBee can be controlled to set the state of the pins. They can also be used in "line passing" so that the state of a pin on one XBee (high or low) is reflected on the corresponding pin of another XBee
- **AD0 to AD6**: These are 10-bit Analog to Digital Converter (ADC) inputs to the XBee. While we cannot directly read these values, some can also be used in "line passing" so that the amount of voltage on a pin on one XBee is reflected by the amount of voltage (pulse width modulation) on the corresponding pin of another XBee.
- **RSSI**: The XBee can report the strength of the received RF signal as PWM output on this pin. This value can also be retrieved using AT commands or as part of a packet in API Mode.
- **PWM0/1**: These pins can be set for 10-bit pulse width modulated output, which can be used directly or filtered for analog output. They can also be controlled using "line passing" by the analog input on another XBee.
- **ASSOC**: When configured, the XBee can be set to join an existing network and assigned certain parameters. In this tutorial we will manually configure the XBee in the network instead of joining networks

3.2.1.2 Mode of operation

The RF module can operate in the Transmit Mode, Receive Mode, Sleep Mode and Command Mode. The module always remains in idle mode when not transmitting or receiving any data during this state, RF module constantly check for valid RF data.

Idle mode

In Idle Mode, the mode shifts into other modes of operation when serial data is received in the ID buffer then changes to transmit mode. When valid RF data is received through the antenna, it switches to receive mode. It changes to sleep mode based on sleep register conditions. When a command mode sequence is issued, then it changes to command mode

Transmit and receive modes

In Transmit Mode, the module packetizes the data and ensures the 16-bit address is n in order to establish a route to the destination. When the module cannot find the destination address, it runs the network address discovery. If the module with the destination address is not known, then the packet will be discarded. Route discovery will take place in order to establish a route to the destination and retransmit the packet. If route discovery fails to establish a route, then the packet will be discarded. In Receive Mode, If a valid RF packet is received, the data is transferred to the serial transmit buffer.

Command Mode

Command mode is a state when receiving serial characters are interpreted as commands and to be able to read RF module parameters or modify RF data; it must go into command mode

Sleep Mode

XBee modules, like many other communication or microcontroller devices can put themselves into sleep mode to save the power which is mainly consumed in sensor node by the transceiver. But the most important trade-off is that during sleep no activities can be handled and the device is nearly turned off until it wakes up. Zigbee mesh networking is specifically designed to handle communication in the network where many nodes might be in such a type of very low-power state .When an end device is asleep; one of the parents stores the data and forwards it when the end device wakes up. Zigbee network gets this feature without any additional components or code required to manage the process

3.2.2. MAX 3232 transceiver

The MAX3232 device consists of two line drivers, two line receivers, and a dual charge-pump. It is compatible with RS232 standard. Two drivers interface standard logic level to RS232 levels. Both DIN inputs must be valid high or low. Two receivers interface RS232 levels to standard logic levels. An open input will result in a high output on ROUT. Each RIN input includes an internal standard RS232 load. The MAX3232 is characterized for operation from -40ºC to+80ºC for all packages. MAX3232 is purposed for application in high-performance information processing systems and control devices of wide application. The device meets the requirements of RS-232 level and provides the electrical interface between an asynchronous communication controller and serial-port connector.

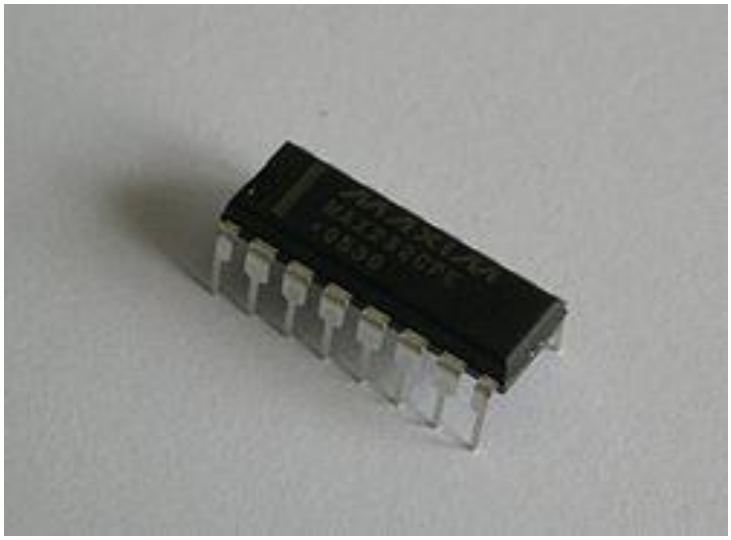

Figure 3.4 max3232 IC

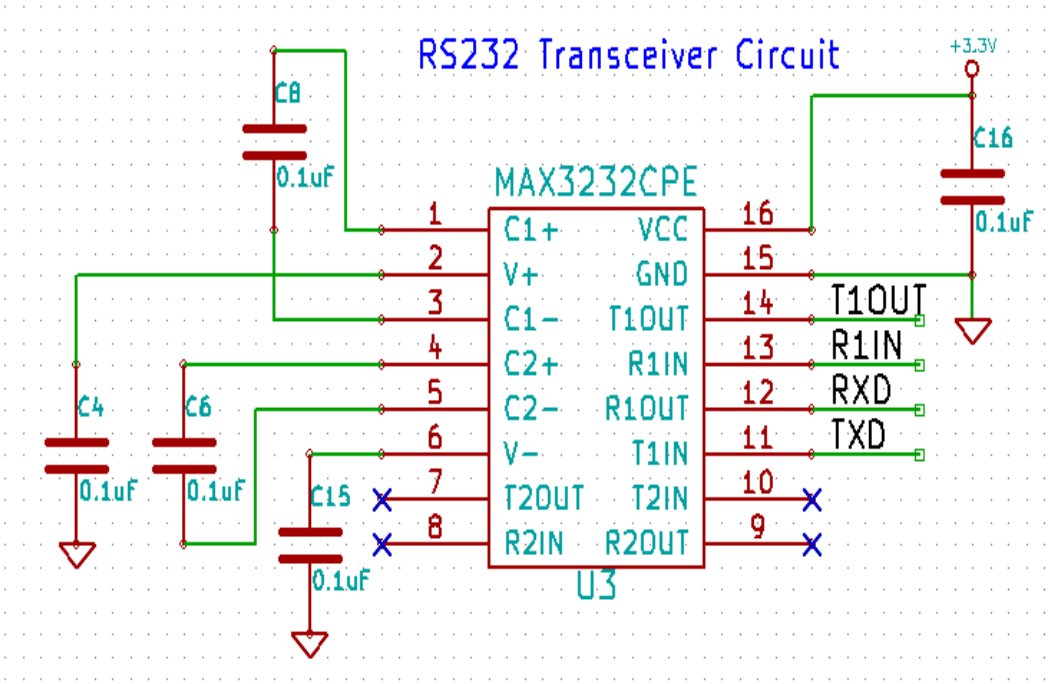

Figure 3.5 max3232 IC configurations

Features

- Input voltage levels are compatible with standard CMOS levels.
- Output voltage levels are compatible with RS-232 levels.
- Accepts 5-V Logic Input with 3.3-V Supply
- Low input current: 0.1μA at TA=25ºC
- Output current 24mA
- Operates up to 250 Kbit/s

3.2.3. LM 317 voltage regulator

The LM317 is an adjustable 3−terminal positive voltage regulator capable of supplying in excess of 1.5A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow−out proof. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317 can be used as a precision current regulator.

Features

- Output Current in Excess of 1.5 A
- Output Adjustable between 1.2 V and 37 V
- Operation ambient temperature 0 - 125ºC
- Floating Operation for High Voltage Applications
- Output Transistor Safe−Area Compensation

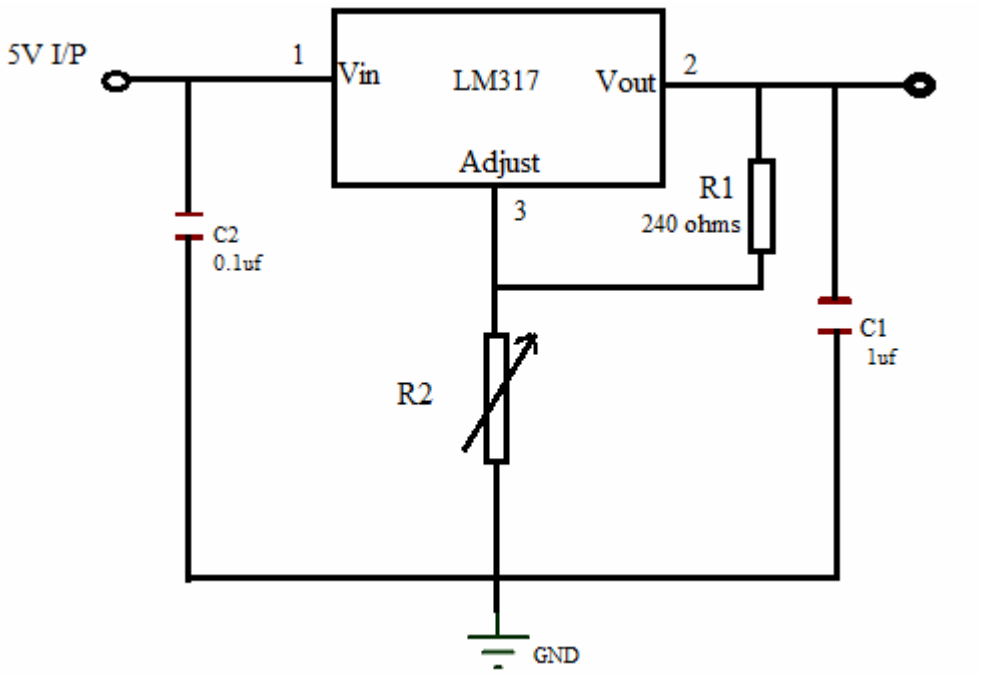

Figure 3.7 Pin diagram of LM317

The output voltage is selected using two resistors. Normally R1 is chosen to be around 220 Ω or 240 Ω .The formulas for calculating the value of R2 is

$V=1.25(1+ (R_2/R_1))$ or,

$R_2=R_1 ((V/1.25)-1)$

R_2 may be replaced by a pot to give an adjustable output voltage range.

The power supply required by the Zigbee module is attained from this 3pin regulator by adjusting the pot.

$(R_1/ R_1+ R_2)VIN=3.3V$

$R_1=240\ \Omega$

$R_2=390\ \Omega$

$V_o = R_1I_L$

$V_o = 3.3V$

$R_1 = 240\Omega$

$I_L = \frac{3.3V}{240\Omega} = 0.01375A$

$C_1 = \frac{I_L}{2fac\ X\ V_{p.p}}$

f = 50HZ

I_L = 0.01375A

$V_{p.p}$ = 1.65V

$C_1 = \frac{0.01374A}{2\ X\ 50\ X\ 1.65V}$

C_1 = 0.00000832727f

$C_2 = \frac{V}{2facR_2}$

$C_2 = \frac{5V}{2\ X\ 50X\ 390\Omega}$ $C_2 =$ 0.000001282051f

Table3.1. 9 pin Description RS-232 serial PORT

Pin	Signal
1	Data carrier detect
2	Received data
3	Transmitted data
4	Data terminal ready
5	signal ground
6	Data set ready
7	Request to send
8	Clear to send
9	Ring indicator

3.2.4 USB-RS232 Cable

The USB_RS232 cables are a family of USB to RS232 levels serial UART converter cables incorporating FTDI's .FT232RQ USB to serial UART interface IC device which handles all the USB signaling and protocols. The cables provide a fast, simple way to connect devices with a RS232 level serial UART interface to USB. Each USB-RS232 cable contains a small internal electronic circuit board, utilizing the FT232R, which is encapsulated into the USB connector end of the cable. The other end of the cable is bare, tinned wire ended connections by default, but can be customized using different connectors to support various applications. This quality USB to RS-232 converter transparently connects serial devices to PC applications via a USB port. It is perfect for the user needing to connect to a serial port-based peripheral from a laptop PC with an available USB port but no serial port. The adapter driver creates a virtual serial port. Applications connect to the virtual COM port as if it were a standard serial port

Figure 3.8 USB-RS232 Cable

3.2.5 Indicator LEDS

LEDs on the board indicate the following:

- Green: Power. Indicates 3.3 V power is available
- Red: USB Transmit
- Yellow: USB Receive

In this project it needs a 3.3volt for XBee involved in the project. Voltage regulator, and filter circuit for generation of 3.3 DC power, it use 9V battery to power up the board. For the XBee 40mA, current is specified respectively and for the indicator LEDs current (peak) of 5mA is specified respectively. Also the MAX3232 current is specified as 24mA.The resistance in voltage divider fashion will typically draw a minimal amount

current so a current of 5mA is specified. The current demand can be estimated by specifying likely current demands from the ratings of the components used:

3.3 Interface design

A popular way to transfer commands and data between a personal computer and XBee module is the use of standard interface, like the one described by protocols RS-232 or USB. The devoted to communication conforming to RS-232 protocol, the hardware for such interface is provided on board. A case in point will be presented showing the processing of commands received through RS-232 interface, and sending of a string of numbers using the same interface. One graphical user interfaces were developed, PC to PC data transmission application. The user interface was developed to allow the applications to be run on several common computer platforms. The Visual Basic 6.0 Designer software was used to create simple yet intuitive user interfaces. The interface was first developed to produce a more user friendly product.

1. Functional Requirements

The goal was to develop a robust application which would allow a user to work PC to PC data transmission application using zigbee enables the communication between two nodes using two XBee modules through wireless transmission of signals over a limited distance. The application required both user input and feedback which takes user input and sends a signal to the module. The module then performs the desired action and returns a response to the application. The applications also needed to be memory and processor conscious as both these factors are often limited on PC devices. Also, the interface is stored in a client/server architecture where the code for the interface is on the module and is downloaded to the PC device when user connects. Creating an interface that is too large results in increased download time and this needed to be avoided. With these factors in mind, the initial prototype of the application was produced.

2. Non-Functional Requirements

The interfaces needed to be simple so that it could still be used by customers that were not technically savvy. The end user may be someone very familiar with Computer applications or it may be an elderly person who is new to the technology. The goal was

to produce a product that would be easy to use for all users while still maintaining an atheistically pleasing interface which was similar to the common look and feel of other computer applications.

These flow charts explain the logic of the code and how each component interacts with the others.

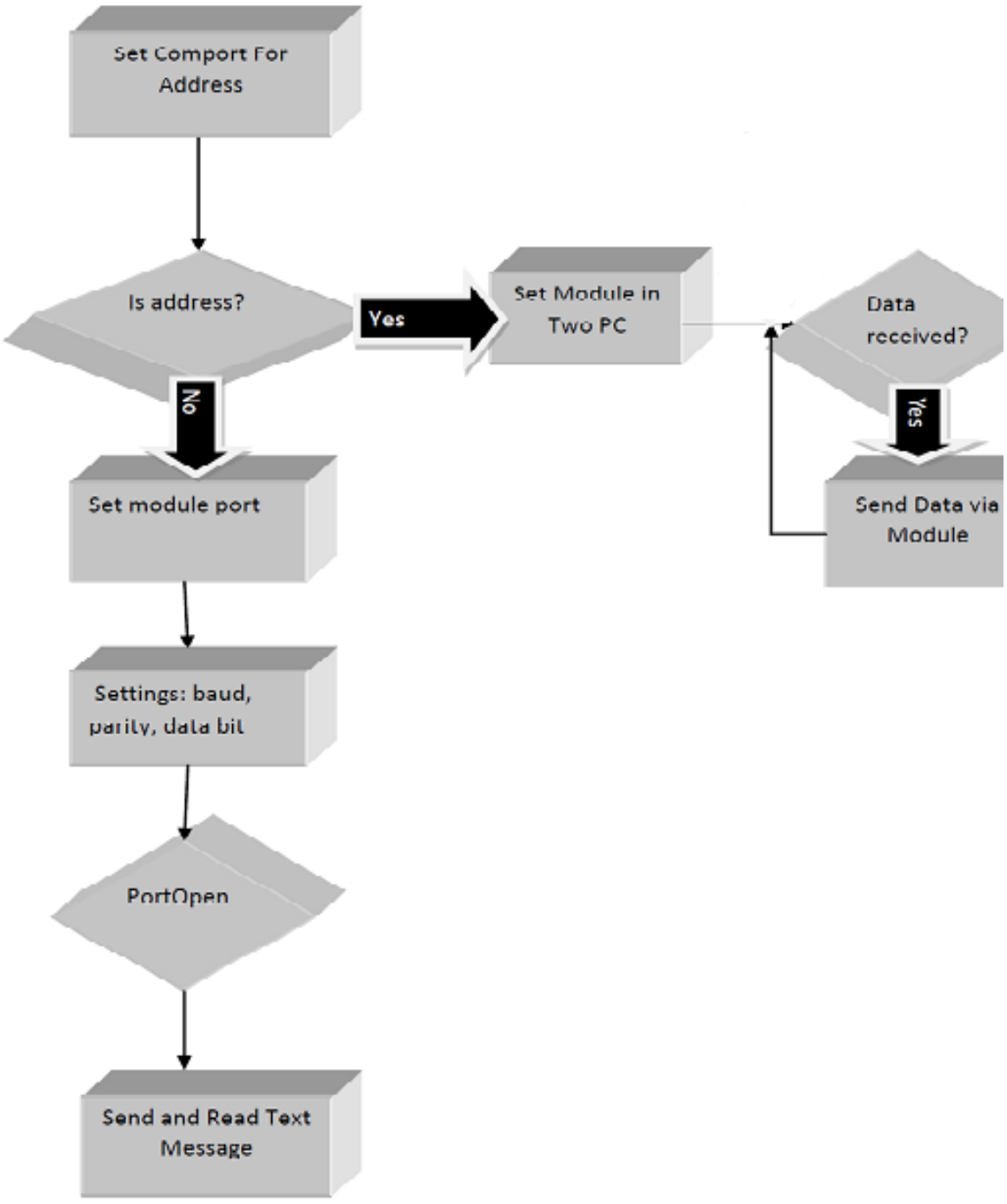

Figure 3.11: Detailed flowchart for design of the program running on the XBee modules

CHAPTER FOUR

IMPLIMENTATION AND PERFORMANCE ANALYSIS

4.1Hardware circuit

The next step was the development of the electronic components for our products. The schematic enlightenment described in detail below.

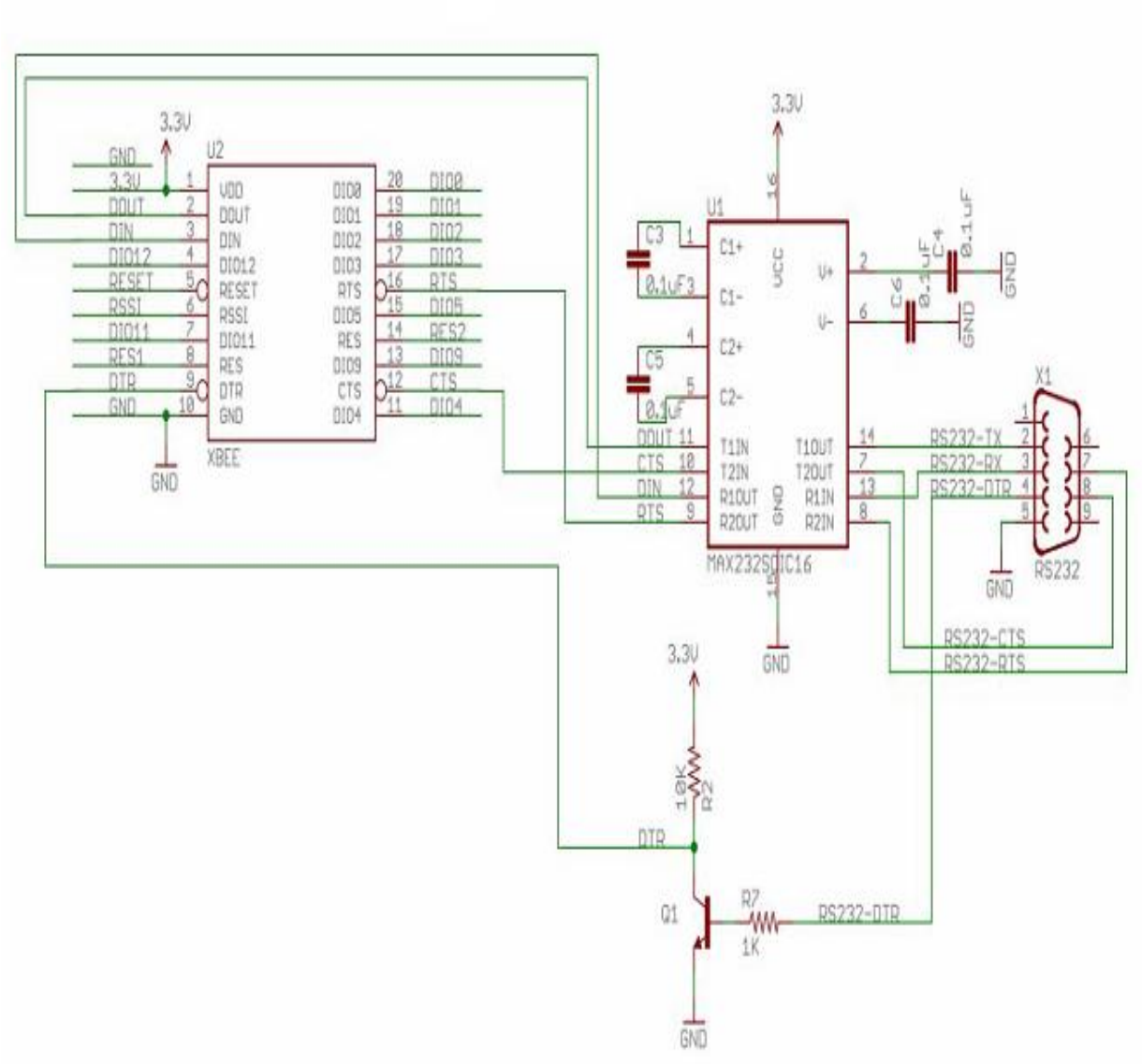

Figure 4.1 Circuit diagram of data transmission using Zigbee

XBee is not 5V tolerant; that is5V shouldn't be given to XBee. So, the first step in making the circuit will be a voltage translator. We need to convert the 5V logic signals to 3.3V signals so that XBee works. This is done by using the LM317 voltage regulator. The output pin of this voltage regulator is connected to the VCC pin of XBee. The Din and Dout pins are connected to the T1out1and Din1 pins of MAX3232 which provides

the electrical interface between an asynchronous communication controller and serial-port connector. The Dout1 and Rin1 of MAX3232 are connected to 9 pin serial port connector. The protocol RS232 defines the signals used in communication, and the hardware to transfer signals between devices. The time diagram of the typical signal used to transfer character A (ASCII: 6510 or 0x41) from device A to device B is given in Figure, and would appear on the upper line TX -> RX between devices.

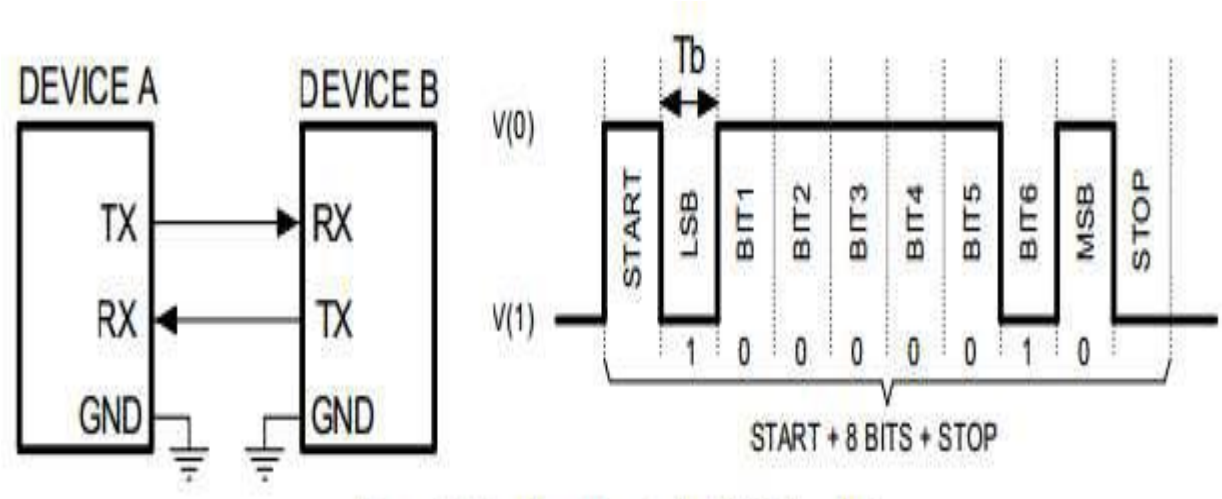

Figure 4.2: A signal conforming to RS232 standard

The RS-232 standard defines the voltage levels that correspond to logical one and logical zero levels. Valid signals are plus or minus 3 to 25 volts. The range near zero volts is not a valid RS-232 level; logic one is defined as a negative voltage, the signal condition is called marking and has the functional significance of OFF. Logic zero is positive; the signal condition is spacing, and has the function ON. So a Logic Zero represented as +3V to +25V and Logic One represented as -3V to -25V. The voltage of Logic "1" (Mark) is between -3VDC to -15VDC, while the Logic "0" (Space) is between +3VDC to +15VDC.

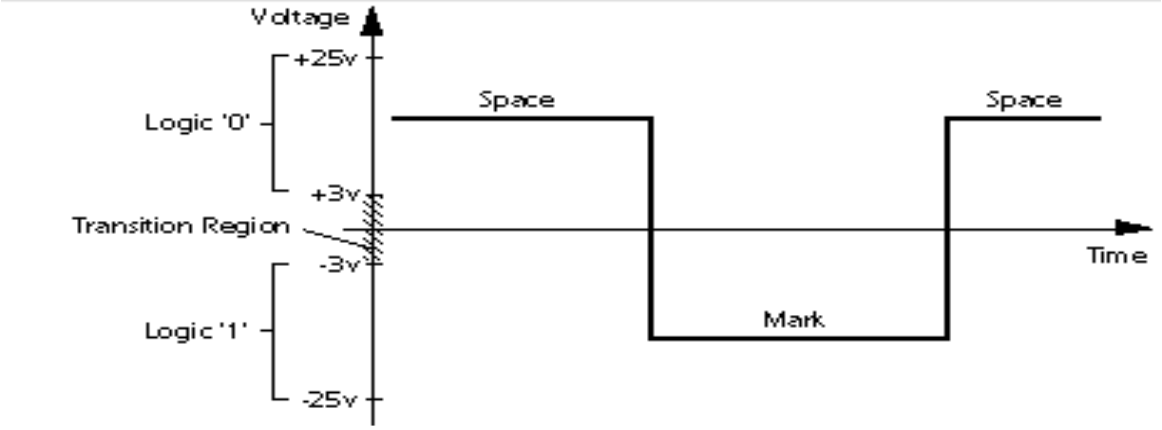

Figure 4.3 The RS-232 standard voltage level

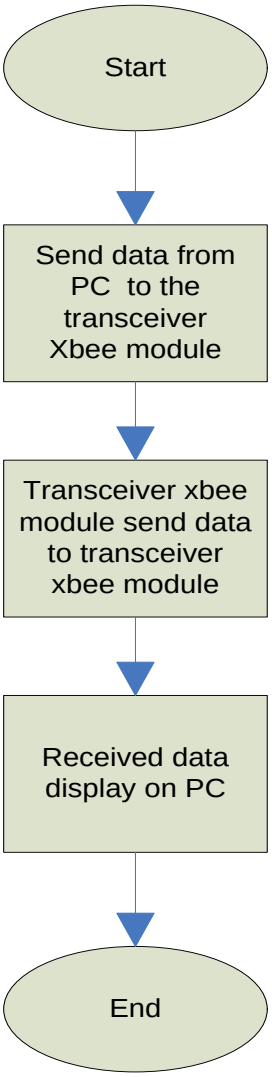

Figure 4.4 flow chart of the optimal circuit

4.2. Configuring the XBee Module

Communications between the PC and XBee can be an integral part of system this system uses the following software: X-CTU, Visual Basic. The X-CTU software configures the XBee module. The X-CTU software provided by Digi-International is recommended for the testing and configuration of the XBee module. X-CTU software was used to configured, update/upload the firmware for XBee module used in this experiment. Figure 4.5 shows the X-CTU configuration screen. The tab name modem includes all the available firmware for different types of XBee module. The "function set" was used to configure the function, the XBee module work; as a coordinator, router or end device as the case may be. For this experiment, the firmware XB24Z7WIT was selected and configured to work in API mode. the first step in the configuration is to select the com port used

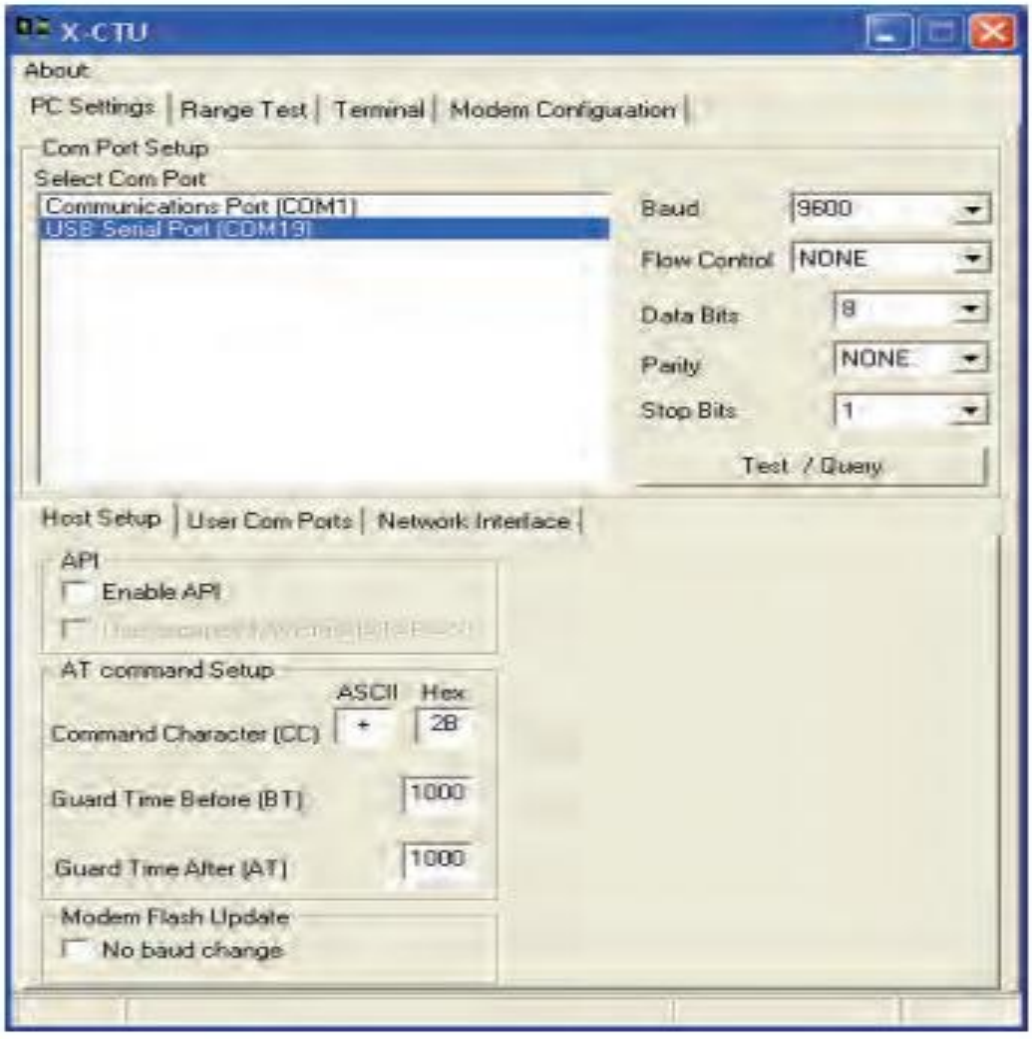

Figure 4.5. X-CTU COM Port Selection

The interface of the modem and PC is tested; the proper selection will show a response similar to Figure 4.5. The message box shows the type of XBee and the firmware version.

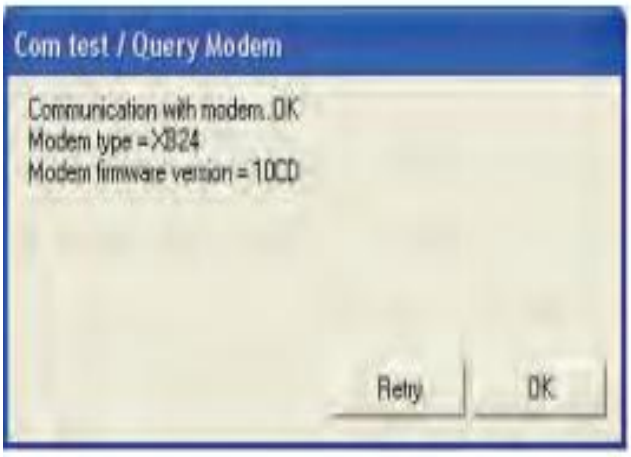

Figure 4.6. X-CTU Test/Query Response

The X-CTU program has 4 core responsibilities which are to browse current configurations, send raw text commands or data to the XBee, and perform a range test with another XBee or to setup how your local PC should communicate with the XBee Module. The XBee components also offer a quick and easy solution for wireless needs and it even uses a standardized protocol to make sure your information reaches its destination. Figure 4.7 shows the methods to configure XBee as Zigbee coordinators. Roughly fixed „function set as ZIGBEE COORDINATOR AT. Then press „read pin and XCTU will show „serial number high and „serial number low at addressing part. Both serial numbers were saved because it will be a copy of the serial numbers of others XBee components to set as the router nodes (end nodes).

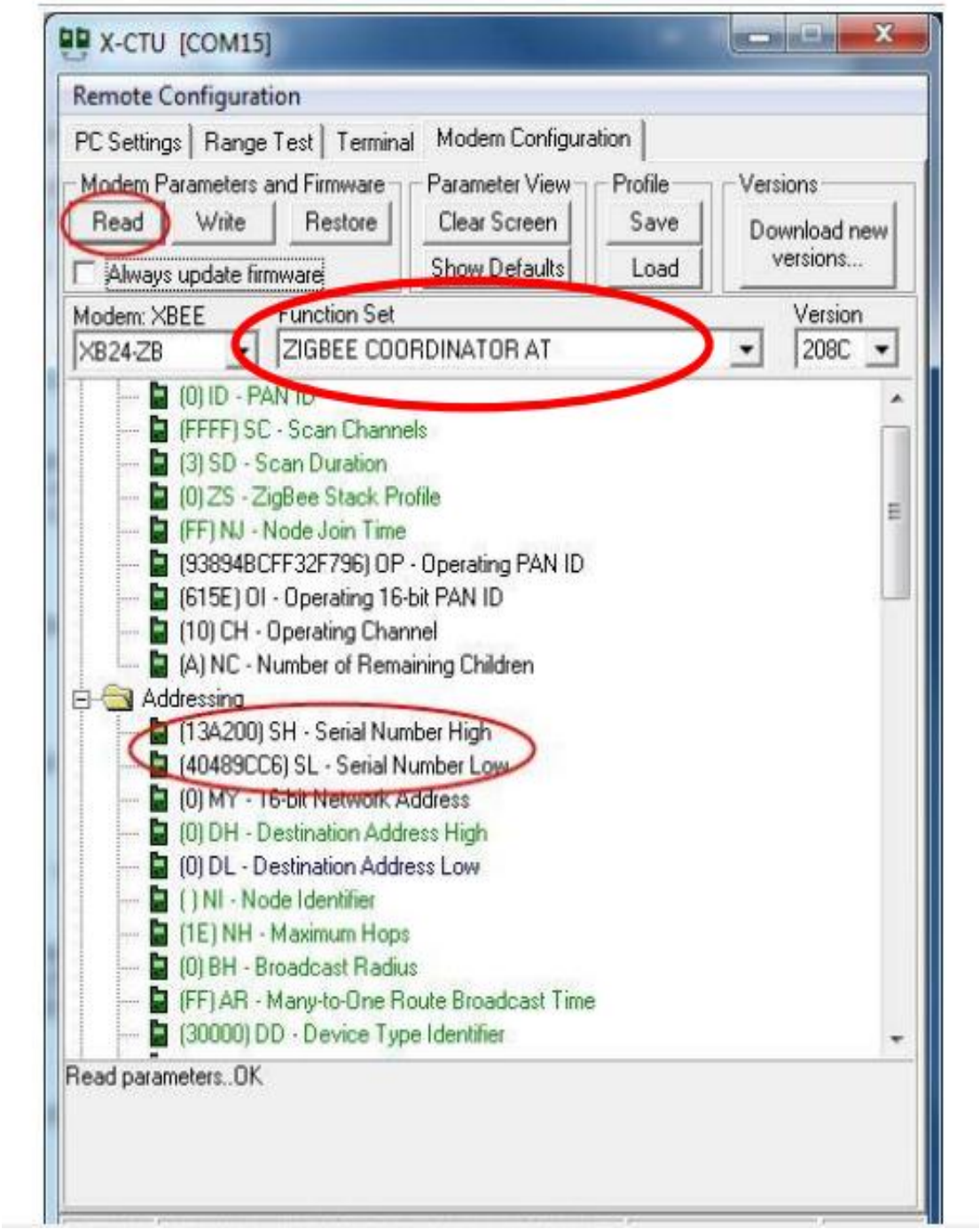

Figure 4.7 Zigbee Coordinator

Figure 4.8 shows the method to configure XBee as Zigbee routers. Fixed „function set as ZIGBEE ROUTER AT. Copy the both serial numbers and put on the „serial number high and „serial number low at addressing part as normal. Then press „write pin and it will be set up as Zigbee routers. After doing setup XBee as coordinator and the others as router nodes, so it will be automatically operated based on multi hop communication

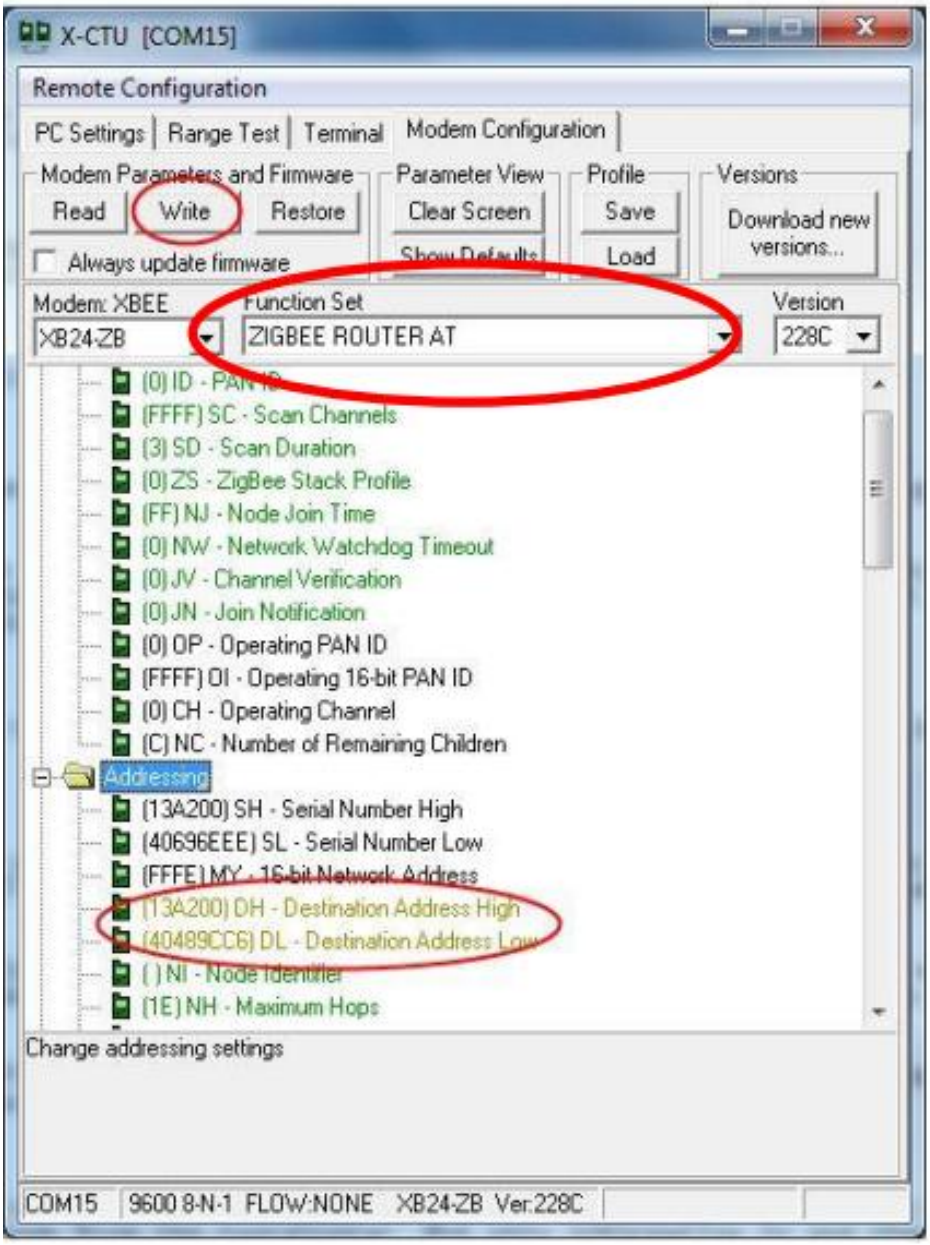

Figure: 4.8 Zigbee route result

4.3 Interface

For the Windows PC client, once you connect the computer to the module, the user interface is displayed as shown. Since a Windows PC can provide more processing power, a more advanced user interface was created and shown below.

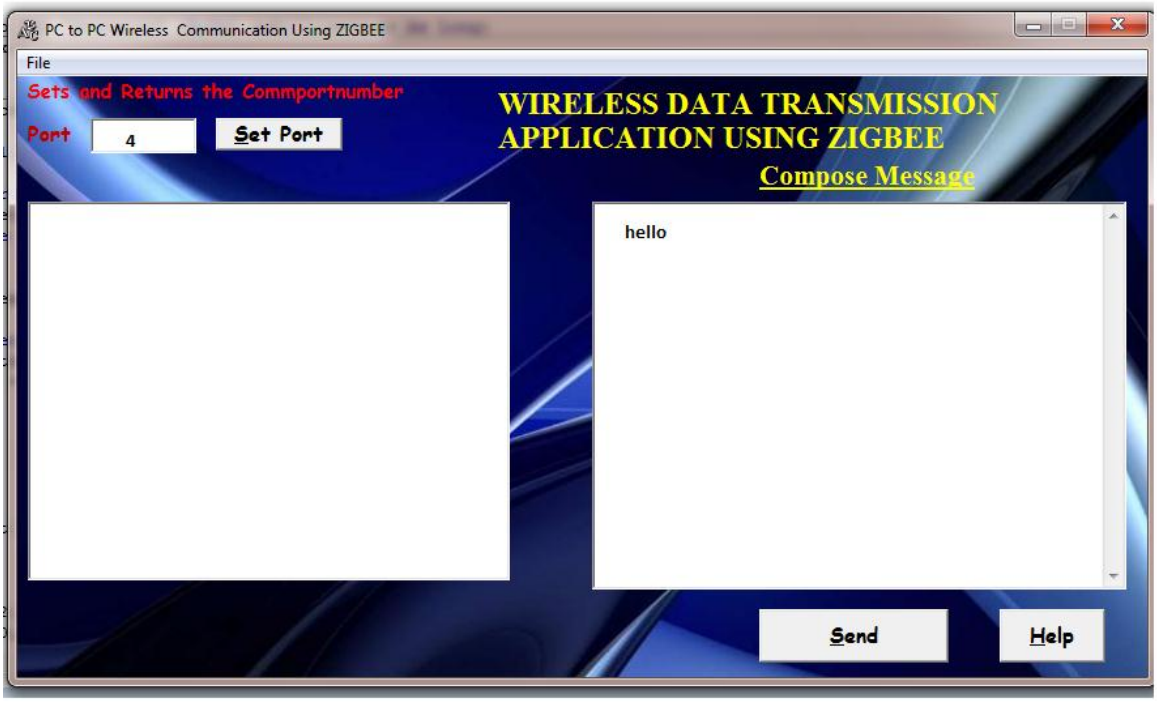

Figure 4.9: PC to PC Wireless Data transmission CPU User Interface

To open a serial port, use the CommPort, Port Open, and Settings properties.

```
On Error Resume Next
 MSComm1.CommPort = Text1.Text
 MSComm1.PortOpen = True
 If MSComm1.PortOpen = True Then
 MsgBox "Port Has Been Set Successfully..", vbExclamation, "Succes"
 MSComm1.PortOpen = False
 Text1.Enabled = False
Command2.Enabled = False
Text2.Text = Val(Text1.Text)
```

Once the port which is to be opened and the information about how data communication is to be handled is specified; it establish the connection. It is a Boolean value, True or False. If, however, the port is not functional, if the CommPort property is set incorrectly, or if the device does not support the settings you've specified, an error will be generated or the external device may not work correctly. Setting the value of the Port Open property to False closes the port. When a port is opened, receive and transmit buffers are created. Receive and transmit buffers are used to store incoming data and to transmit outgoing data. To manage these buffers, the Communications control provides you with a number of properties that can be set at design time using the control's Property Pages.

An integral part of managing receive and transmit buffers is ensuring that the back-and-forth transmission of data is successful that the speed at which the data is being received does not overflow the buffer limits. Handshaking refers to the internal communications protocol by which data is transferred from the hardware port to the receive buffer. When a character of data arrives at the serial port, the communications device has to move it into the receive buffer so that the program can read it.

4.4 Performance Analysis

The data received is found accurate without any distortion. The system works without error because of reception of sufficient power. This value is in the range of -40 dBm and the RF module's receiver sensitivity of -92dBm. The received power can also be computed using the Friis transmission formula under line-of-sight conditions, i.e.

$$P_{RX} = \frac{P_{TX}.G_{TX}.G_{RX}.\lambda^2}{16.\pi^2.d^2.L} \quad \text{.....1.1}$$

Where

G_{Tx} = transmitter antenna gain, dimensionless quantities.

G_{Rx} = receiver antenna gain, dimensionless quantities.

P_{RX}= received power in watts

P_{TX}= transmitted power in watts.

λ = wavelength (same units as d),

d = distance separating Transmitter and Receiver antenna

L = system loss factor (125.89).

A value of L=1 implies no losses in system hardware.

For distance d=10m the data rate of 250 kbps has been achieved for transmission of the data from the wireless node point.

Figure 4.10 and Figure 4.11 shows the physical hardware structure of transmitter and receiver section respectively.

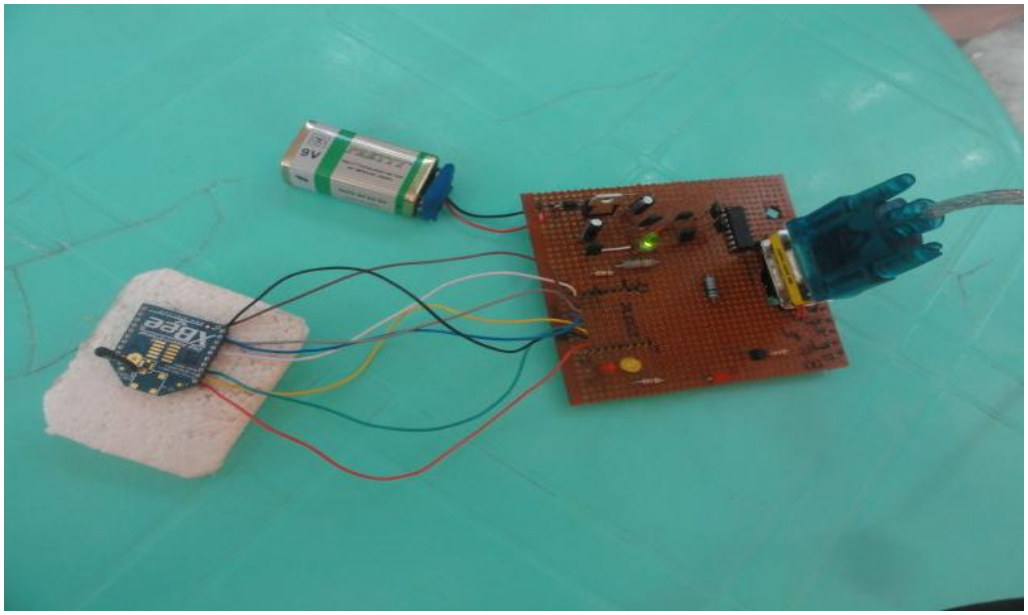

Figure 4.10 Transceiver of PC1

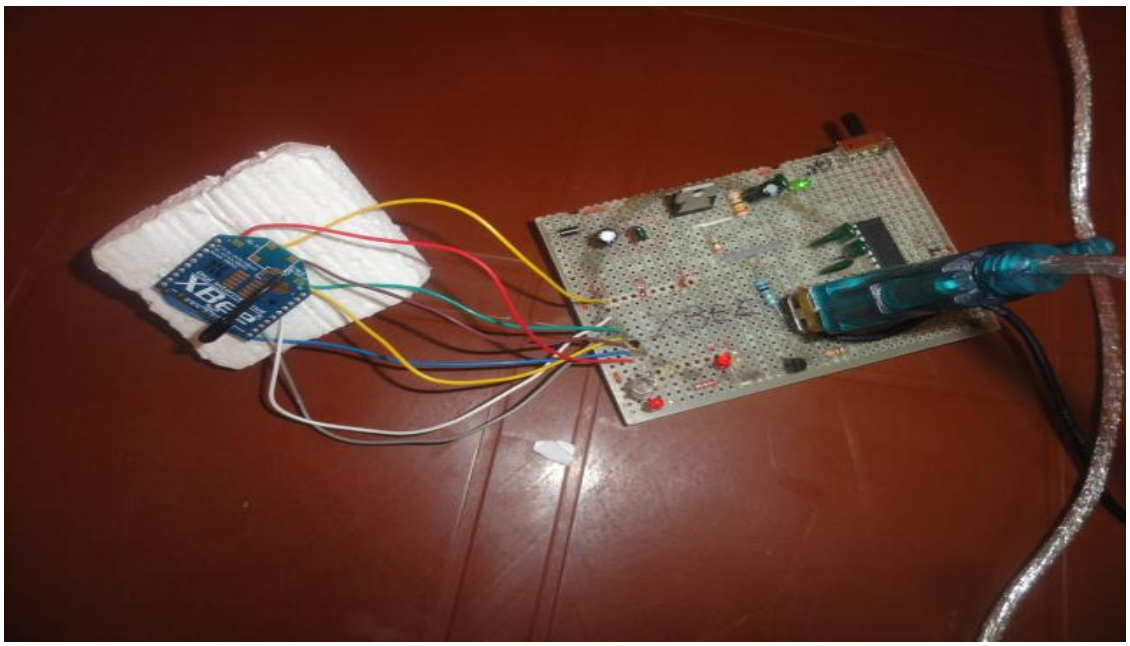

Figure 4.11 Transceiver of PC2

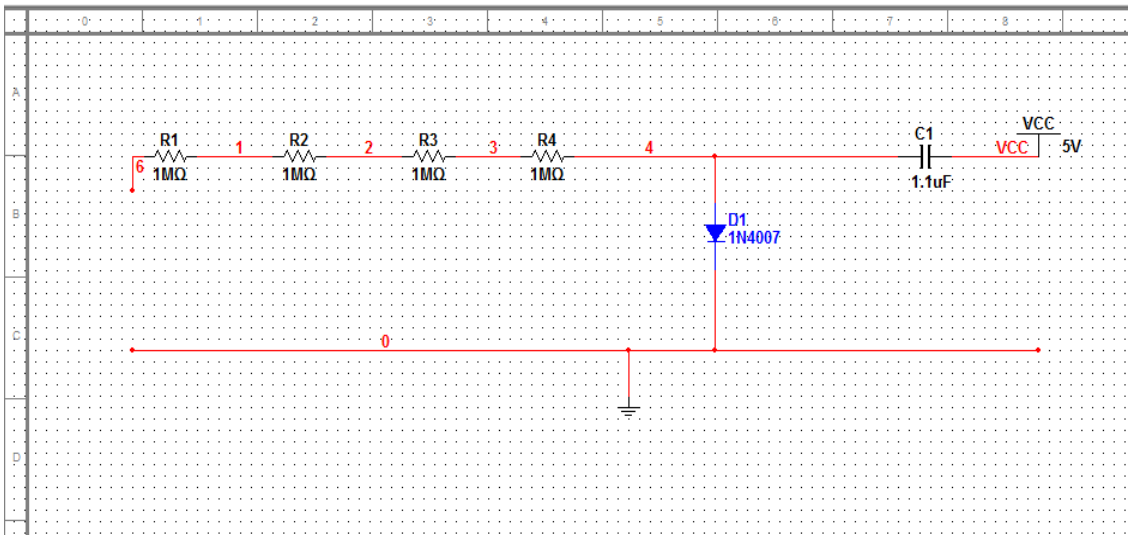

Figure 4.12 RF meter

The other parameters discussed are the RF power meter shows the amount of power radiated by the transmitting in voltmeter terms of milli volts. Using the formula which gives in relation with voltages, resistance power transmitted can be calculated which is given as, $P_t = V^2/R$…….....……..1.2

Where

P=Power in Watts.

V=Voltage in volts.

R=Resistance in ohms (4MΩ)

The Gain of antenna is related to effective aperture A_e by

$G = 4\Pi A_e / \lambda^2$ …… 1.3

Where

λ = wavelength (same units as d)

A_e = related to physical size of antenna

λ is related to frequency as

$\lambda = C/f$ ……..……..... 1.4

Where

C=speed of light ($3x10^8$ m/s)

f = frequency in Hz

Effective isotropic radiated power (EIRP) is given by

$$EIRP=P_tG_t \text{…….....……..} \quad 1.5s$$

Where

P_t is the transmitted power by the antenna.

G_t is the gain of the receiving antenna.

EIRP represents a maximum radiated power from a transmitter in the direction of maximum antenna gain as compared to other antennas. Effective radiated power ERP is used instead of EIRP to denote the maximum radiated power as compared half wave dipole antenna since, dipole antenna has got a gain of 1.64 (2.15dB above an isotropic).Antenna gains are given as units of dBi (decibel gain with respect to an isotropic antenna . Path loss is the signal attenuation as a positive quantity measured in dB is defined as difference (in dB) between the effective transmitted power & received power and may not include the effect of the antenna gains.

Friss free space model is valid predictor for values of distance d'which are in far field of the transmitting antenna. The far field or fraunhofer region of transmitting antenna is defined as the region beyond the far field distance df, which is related to the largest linear dimension of the transmitter antenna aperture and carrier wavelength.

The fraunhofer distance is given by

$$d_f = 2D^2/\lambda^2 \text{…….……..…… ….} 1.6$$

Where

D is largest physical linear dimension of antenna.

df must also satisfy df>>D, df>> λ

Friss free space model doesn't holds good for distance d = 0 for this large scale propagation models use a close in distance d0 known as received power reference point .

The received power Pr(d) at any distance d> d0 may be related to Pr at d0 . The reference distance must be chosen such that it lies in far-field region i.e., d0> df and d0 is chosen to be smaller.

1. Received power at the receiving end PRX (in watts) = 25nW.

2. Gain of antenna = 20.10dB.

3. Effective isotropic radiated power (EIRP) = 500μW.

4. Far field or fraunhofer region of transmitting antenna =1.6X109mtrs.

5. Power flux density (Pd) = 398W/

CHAPTER FIVE

RESULT AND DISCUSSION

5.1 Snap shoot

The way that the program functions is determined by the way the XBee on the module is set. The XBee configuration determines the address of a module as well as its role. An address of zero sets a node up as a coordinator. The coordinator is directly connected to a PC. An address of one set a module as the first station module and an address of two sets a module up as the router module. These two modules function the same way once powered. To start transmission simply press button one on the coordinator and router modules. Transmissions are indicated by a flashing red LED, if the LED is burning without flashing the transmission has stalled. Reception of data by the coordinator is indicated by a flashing yellow light. To stop the transmission, simply press the reset button on the transmitting module. Graphical user interface (GUI) is designed for easy user interface and storing of the received values using RS-232 serial communication. For Maintaining ZigBee communication without congestion a 10 s interval is taken. GUI is shown in figure 5.1. The XBee module which is connected to the system through RS-232 and the com port is selected and then system is started and received values are shown and are stored in the system. The features of the system is

- Checks if data has been received.
- Received data is sent in sets of 8 bytes only the last four have significance. This data is then sent via the RS232 virtual comport to the PC. If it is successful the program continues. If not the module continues to try to connect to the coordinator.
- The module now reads its A/D inputs at regular intervals.

When the program is started the user needs to inset the comport address of the user module connected to the PC and then press a set port button. If the connection is successful the program will be actively updated with values message by the modules. Changes can be made to the via one port textboxes.

- The program starts up, objects and variables are initialized.
- The program checks whether the config.dat file exists. The config.dat file is used to store user Baud, Parity, Data bits and stop bit.
- If the file exists then the contents of the file are read into the conf buffer variable and the settings contained are applied to the determined objects.

- If the file does not exist a new one is created. The default settings of comports is read into the conf buffer variable.
- If the Set port button is pressed an object of the connect class is initialized with and comport address supplied by the user via a text box.
- The program checks if the connection was successful.
- If the connection was successful the program initializes an object of the read serial class.
- This object is run in a thread and continually reads data received from the serial port and sends it to the correct data buffer.
- If the connection was not successfully made the program sends an error message.
- If the button has been pressed the changes are applied to the specified port. These changes are also saved in the conf buffer and finally the entire contents of the conf buffer are saved to the conf.dat file.

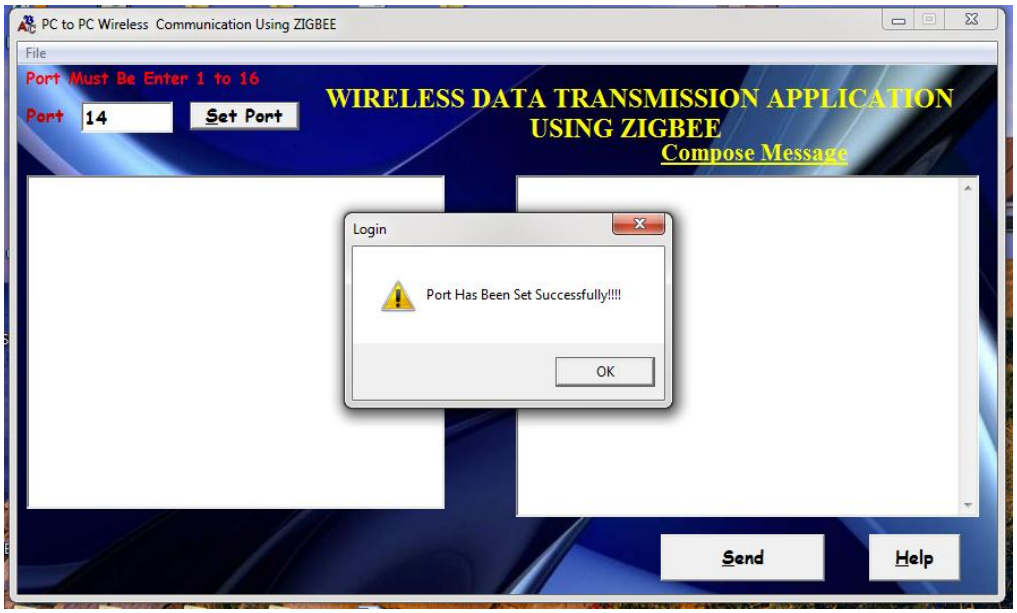

Figure 5.1 Setting Port

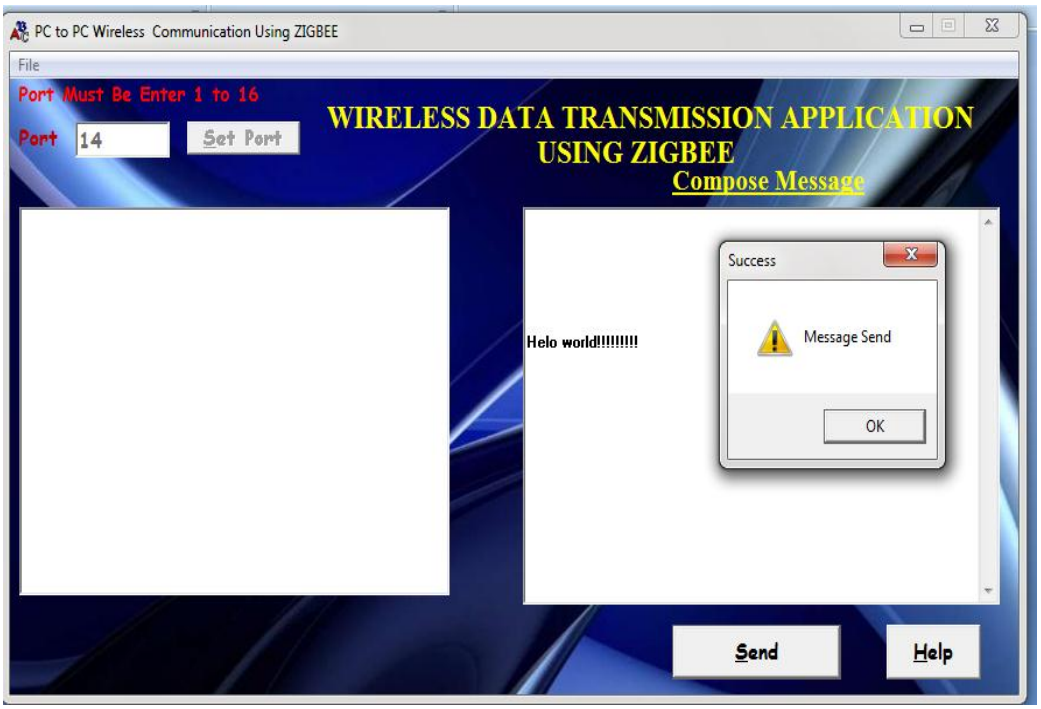

Figure 5.2 Message sent

The test bed consists of two nodes. Each of the node components comprises of MAX3232, regulated power, XBeeS2 module with having antenna. The X-CTU software was use to upgrade and upload the software to the module as either as a coordinator, router, or end device as the case may be. Particularly, the network has one coordinator, one routers or end device

Figure 5.3 Test bed and X-CTU Interface

5.1.1 Comparison of power transmission and power received with distance

A closeness test was made if the Zigbee device unit can transmit to the other Zigbee device unit with distances during time of sending the message was also conducted. This test was conducted at a reverse side location, to simulate transmissions with no obstruction. The sender was to stay put at a location with the receiver moving farther away from the sender. The following table summed up the results gathered based on the test. Note that sometimes the message was still being sent at 120m or more (up to 200m) but the rate that the messages were sent and received were unreliable. Those test produce less than 80% message sent of the messages that were attempted to be sent. There was no need to extend the testing further (more than 250m) since the device cannot handle the distance anymore. The Zigbee wireless technology used by the designers was capable of transmitting data up to 250,000 bps (bytes per second). A successful data transmission was observed between 0 – 120m values. Based on the results of the gathered data, efficient wireless transmission using the Zigbee device unit can be achieved within the range.

Table 5.1: Closeness Test

Transmitted-Receiver distance (in meter)	Was the message received?
10	Yes
20	Yes
30	Yes
40	Yes
50	Yes
60	Yes
70	Yes
80	Yes
90	Yes
100	Yes
120	Yes
200	No
250	No

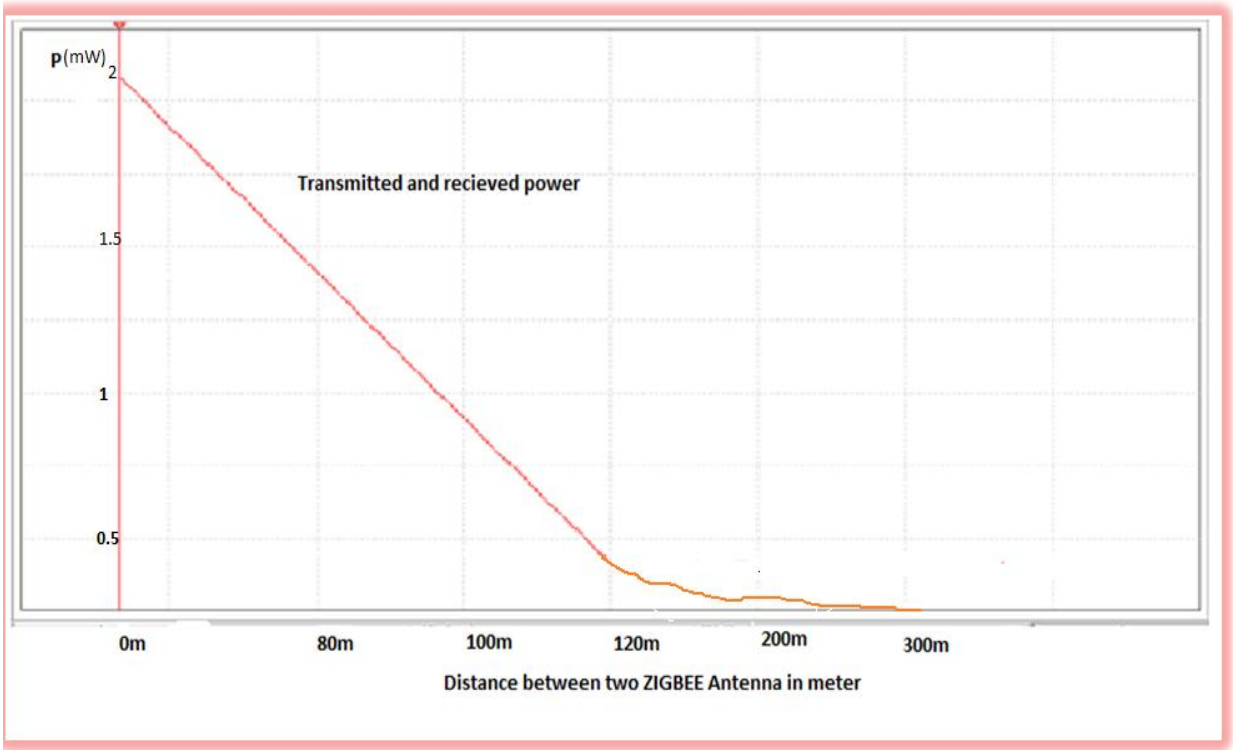

Figure 5.4 power Vs Distance

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The project, “Implemented and Analysis of Wireless Data Transmission Using Zigbee” is an effective wireless link point to point transmission. It has been successfully implemented, tested and analyzed the result. According to the project, it is aimed to transmit data point to point data transmission 1 meter to 120 meter distance using XBee transceiver module outdoor. Operation of the data transmission by using graphical user interface (GUI),configuring the two PCs using XCTU software and some program by visual basic 6 to have the Zigbee communication between the XBee module. Data is transmitted from PC1 to PC2. During data transmission, as the distance increase between the XBee transceiver modules, the transmitting and the received power was decrease because of different factors.

6.2 Recommendation

This project can be further enhanced to long distance coverage data transmission by forming mesh network there by increasing number of nodes or devices. By this many people can access wireless network (personnel area network). At last, the network security needs to be concerned to prevent remote hacking.

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APPENDIX-A

Table 1: XBee 802.15.4 Pin Assignments

Pin	Name	Type	Function
1	VCC	P	2.8 V to 3.4 V
2	DIN	O	Serial data output from XBee (received data)
3	DOUT	I	Serial data input to XBee (data to transmit)
4	D08	O	Digital data output 8
5	RESET	I	Reset module (low)
6	PWM0/RSSI	O O	Pulse Width Modulated output Received Signal Strength Indication as PWM signal
7	PWM1	O	Pulse Width Modulated output
8	(RESERVED)		
9	DTR SLEEP_RQ DI8	I I I	Data Terminal Ready: handshaking for firmware updates (low) Sleep Request: A high places XBee in sleep mode when configured Digital Output 8
10	GND	G	Ground (Vss)
11	AD4 DIO4	A IO	Analog to Digital Input 4 Digital Input/Output 4
12	CTS DIO7	O IO	Clear to Send output for controller handshaking (low) Digital Input/output 7
13	ON/SLEEP	O	Digital output, status indication: High = Awake, Low = Sleep
14	VREF	A	Analog to Digital reference voltage
15	ASSOC AD5 DIO5	O A IO	Associated indication when joining a network Analog to Digital Input 5 Digital Input/output 5
16	RTS AD6 IO6	I A IO	Ready to Send Handshaking input (Low) Analog to Digital Input 6 Digital Input/output 6
17-20	AD3-AD0 DIO3-DIO0	A IO	Analog to Digital Input 3 to 0 Digital Input/output 3 to 0

Pin Type: P = Power, G = Ground, I = Input, O = Output, A = Analog Input

Table 2 Pin description of MAX3232

No	Name	Function
1	C1+	External capacitance of positive voltage multiplier unit
2	V+	Output of positive voltage of multiplier unit
3	C1-	External capacitance of positive voltage multiplier unit
4	C2+	External capacitance of negative voltage multiplier unit
5	C2-	External capacitance of negative voltage multiplier unit
6	V-	Output of negative voltage of multiplier unit
7	T2OUT	Output of transmitter data (levels RS – 232)
8	R2IN	Input of receiver data (levels RS – 232)
9	R2OUT	Output of receiver data (levels TTL/CMOS)
10	T2IN	Input of transmitter data (levels TTL/CMOS)
11	T1IN	Input of transmitter data (levels TTL/CMOS)
12	R1OUT	Output of receiver data (levels TTL/CMOS)
13	R1IN	Input of receiver data (levels RS – 232)
14	T1OUT	Output of transmitter data (levels RS – 232)
15	GND	Ground
16	VCC	Supply voltage

Appendix-B

Detail program

Source code of visual basic 6.0

```
Option Explicit
Private Declare Sub Sleep Lib "kernel32" (ByVal dwMilliseconds As Long)
Private Sub Command2_Click()
On Error Resume Next
 MSComm1.CommPort = Text1.Text
 MSComm1.PortOpen = True
 If MSComm1.PortOpen = True Then
 MsgBox "Port Has Been Set Successfully..", vbExclamation, "Succes"
 MSComm1.PortOpen = False
 Text1.Enabled = False
Command2.Enabled = False
Text2.Text = Val(Text1.Text)
 Else
   If Err.Number > 0 Then
      MsgBox " Change the CommPort property to another port", vbInformation, "Set
properlly"
      MSComm1.PortOpen = False
      Text1.Text = ""
      Text1.SetFocus
      Exit Sub
   End If
End If
 If Text1.Text = "" Then
 MsgBox ("Enter Your Port Number"), vbInformation, "Information"
 Text1.SetFocus
 Else
 With MSComm1
      .CommPort = Text2.Text
      .Settings = "9600,N,8,1"
      .Handshaking = comRTS
      .RTSEnable = True
```

```
        .DTREnable = True
        .RThreshold = 1
        .SThreshold = 1
        .InputMode = comInputModeText
        .InputLen = 0
        .PortOpen = True
     'MsgBox "Port Number Set Is Success..."
     'Text1.Enabled = False
     'Command2.Enabled = False
     'TxtNumber.SetFocus
    End With
    End If
End Sub
Private Sub Command1_Click()
If Text1.Text = "" Then
MsgBox "Set Your Port Number...", vbInformation, "Initially"
Text1.SetFocus
Exit Sub
End If
'If TxtNumber.Text = "" Then
'MsgBox ("Please Enter port Number.. ")
'TxtNumber.SetFocus
'Exit Sub
'End If
If TxtMessage.Text = "" Then
MsgBox ("Please Enter Text Message! "), vbCritical, "Note"
TxtMessage.SetFocus
Exit Sub
End If
MSComm1.Output = TxtMessage.Text & Chr(26)
Sleep 2000
    MsgBox "Message Send", vbExclamation, "Information"
    TxtMessage.Text = ""
    TxtMessage.SetFocus
```

```
End Sub
Private Sub Command3_Click()
Txt_recv.Text = MSComm1.Input
End Sub
Private Sub mnuabout_Click()
frmHelp.Show
End Sub
Private Sub mnuexit_Click()
If MSComm1.PortOpen = True Then
  MSComm1.PortOpen = False
  End If
  End
End Sub
Private Sub MSComm1_OnComm()
Me.List1.AddItem MSComm1.Input
Dim Senddata As String
If MSComm1.CommEvent = comEvReceive Then
Senddata = MSComm1.Input
TxtMessage = TxtMessage + Senddata
End If
End Sub
Private Sub Text1_KeyPress(KeyAscii As Integer)
If KeyAscii = 32 Or KeyAscii = 8 Then Exit Sub
If KeyAscii < 48 Or KeyAscii > 57 Then KeyAscii = 0
End Sub
Private Sub Timer1_Timer()
lblchat(1).Visible = Not lblchat(1).Visible
End Sub
```