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RESEARCH ARTICLE

Design and Implementation of Bluetooth Based Data Logging of Processed Real Time Signal Using PIC16F877A

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Abstract— The growing implementation of technology had significant impact on its methods and practice. One technology with such an impact is the ever growing use of wireless systems in hospitals, industries and biomedical institutions. The objective is to transfer processed real time signal over Bluetooth using PIC Microcontroller. This is applicable for monitoring certain parameters such as temperature, bio-medical signals and more. The system is implemented for real time data, audio and analog signal transfer using Bluetooth communication. PIC microcontroller (PIC16F877A), Audio Codec Board, Bluetooth module (Ezurio Blu2i) and MAX232 level converter are used to build the proposed system. Software design process is carried out using MPLAB IDEv6.50, XC8 compiler and PPPv3 (PICmicro parallel programmer).

For Implementation of real time data, PIC microcontroller will initialize the Master Bluetooth module with set of protocols and it transfers real time data to receiver. Slave Bluetooth module will access the real time data using PIC microcontroller receive program. Data is monitored on the Terminal tool using serial interface. For Implementation of audio and analog signal, Audio codec board is connected to both master and slave Bluetooth devices. PIC microcontroller will initialize Bluetooth module and audio codec board both in the transmitter and receiver. Audio mode is enabled and analog signal is transferred between Bluetooth modules by using audio codec board. This project aims to develop a prototype model through which the user can send any real-time signal via Bluetooth communication using PIC16F877A.

Keywords— ***PIC microcontroller; Bluetooth; Real time signal; Audio codec board; Data logging***

I. INTRODUCTION

In today's hospital, research laboratories and industries there are several numbers of electronic gadgets that have become important to daily life. Generally these devices are very expensive and consequently only available to institutions with adequate resources. "Bluetooth based data logging of processed real time signal" will attempt to provide a cost effective alternative to various commonly used devices.

Information communication between individuals is now frequently performed because of the spread of cellular phones and the Internet. However, when disaster and traffic congestion occur over a wide area, network access using a cellular phone might be concentrated in one area and immediate communication might thereby become impossible. At that time, user should pass necessary information to other user. Bluetooth is one of the ad-hoc network, this can be used to alleviate the network congestion for short range, when disaster and congestion occur. Bluetooth technology is becoming common in hand held devices such as mobiles, laptops, PDAs are now for useful applications. Keeping that in mind, the core objective is to transfer real time signals and make them available wirelessly over Bluetooth. This would allow for convenient and round-the-clock monitoring of patients in hospitals or test subjects from essentially over particular range. Furthermore, Bluetooth is already pre-existing in almost all hand held devices, certain costs are significantly reduced and Bluetooth signals are not hazardous so we can use in hospitals, industries and research laboratories. The technological aspects of this project are data logging of real time signals using Bluetooth communication, configuration of PIC microcontroller and serial communication.

II. System Description

The system consists of mainly three modules: PIC Microcontrollers (PIC16F877A), Bluetooth modules (Ezurio Blu2i) and audio codec boards in both transmitter and receiver units See figure 1. PIC Microcontrollers (PIC16F877A) are used for programming and to enable the Bluetooth modules (master and slave) using AT commands. Processed real time signal is transferred using Bluetooth communication. Audio codec boards are used to transfer audio/voice and analog signal between Bluetooth modules.

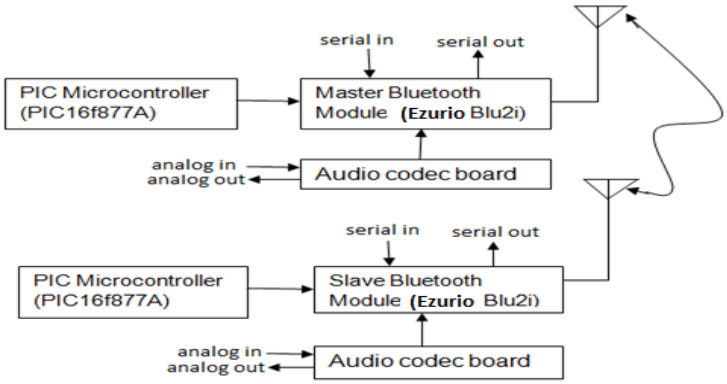

Fig. 1 system description

A. Selected technology

We have chosen Bluetooth as transmission protocol as it is the one used by most commercial devices. It is a short range technology that allows secure and robust communications, apart from a universally accepted standard. It supports both voice and data, making it an ideal technology to enable many types of devices to communicate and it uses an unregulated frequency band available anywhere in the world described in [1].

B. Development environment

The specification, design and implementation of the module were carried out using MPLAB IDE [2]. The PIC micro Parallel Programmer (PPP) can be used as standalone program, or it can be incorporated into a programming environment to provide a seamless flow from code to chip. It will accept 8-bit Intel HEX format files.

III. Hardware Description

A. Audio codec board

The audio codec board (EB032-30-1) is designed to incorporate Codec technology, and is capable of compressing and decompressing data. This has onboard chip MC145483 and is a 13 bit linear PCM Codec filter with 2's compliment data format. Block schematic is as shown in figure 2.

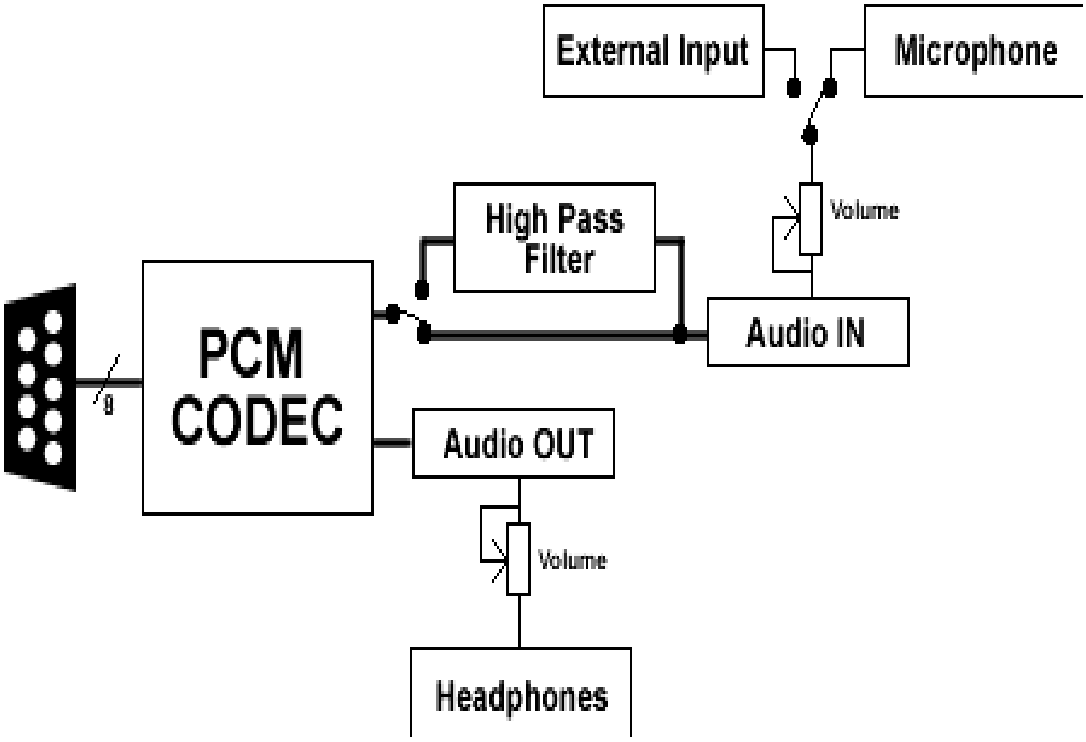

Fig. 2 Block schematic of audio codec board [3]

The device performs the voice digitization and reconstruction as well as the band limiting and smoothing required for the voice coding in digital communication systems.

B. Bluetooth wireless transmission and configuration

The Bluetooth module used is EZURIO BLU2i device [4] (Figure 4).

Fig. 3 EZURIO BLU2i Bluetooth module

The BLU2i device is a self contained Bluetooth module that can communicate using a set of BLU2i AT commands. This device allows users to connect and use other Bluetooth devices at the application level. The BLU2i module is sometimes called BiSM. The module contains all of the hardware and firmware for a complete Bluetooth solution, requiring no further components. The Module has an integrated, high performance antenna which is matched with the Bluetooth RF and baseband circuitry. The firmware integrated into the BC04 chipset implement the higher layer Bluetooth protocol stack. A virtual processor is used within the BC04 to implement an AT command processor. The variety of interfaces and the AT command set allow the Embedded Intelligent Bluetooth Module to be used for a wide number of short range wireless applications, from simple cable replacement to complex multipoint applications, where multiple radio links are active at the same time.

C. System Integration

Circuit diagrams 4 & 5 depicts the real time data, audio/voice and analog signal transfer between two EZURiO BLU2i Bluetooth devices using PIC microcontroller (PIC16F877A).

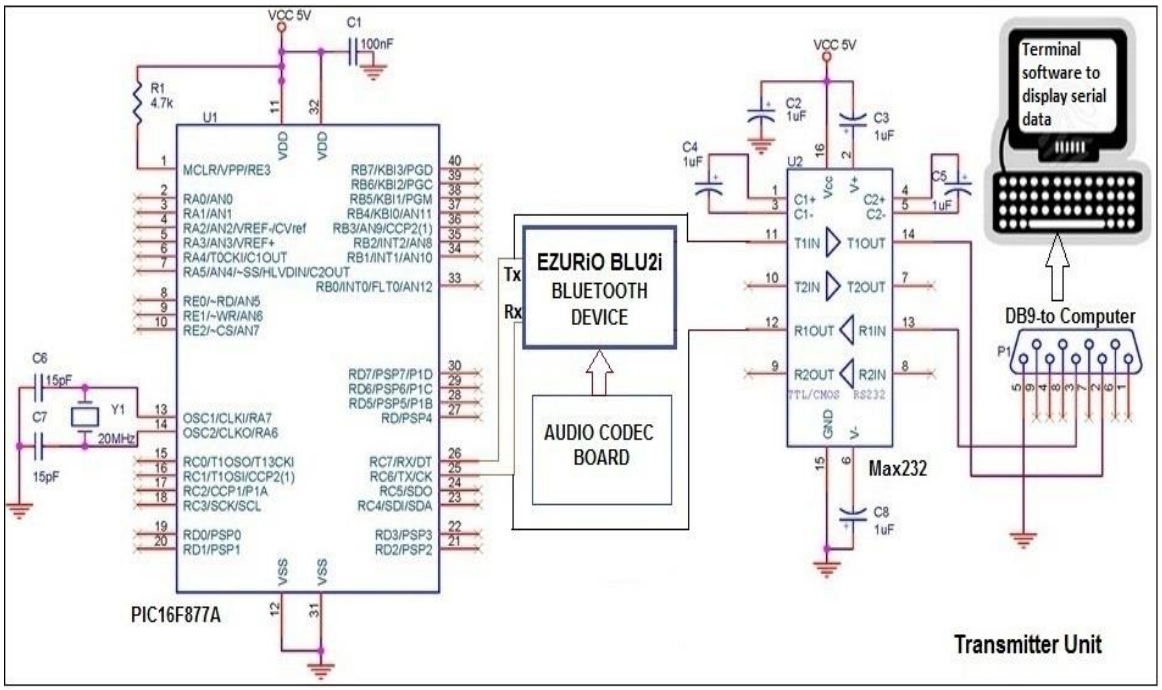

Fig. 4 System integration of transmitter unit

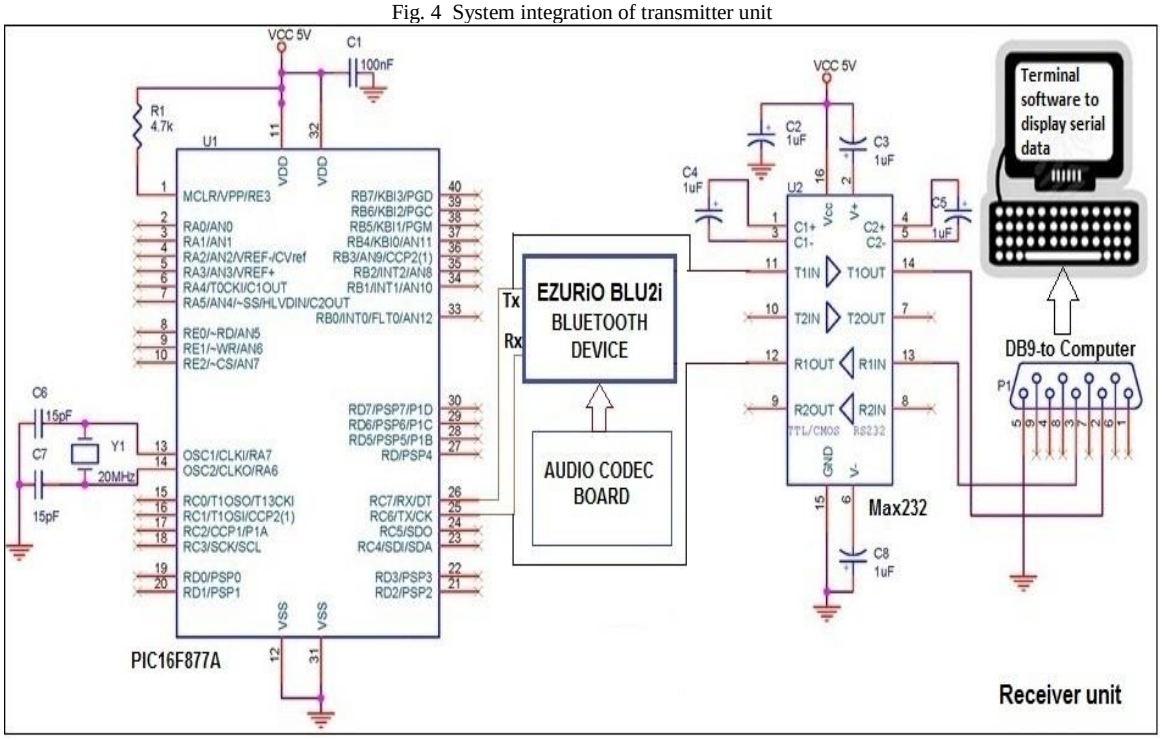

Fig. 5 System integration of receiver unit

Both the microcontroller and the Bluetooth chip are involved in this process. Code has been written in Embedded C using MPLAB IDE and it includes special function registers of PIC16F877A and AT commands. Power supply is given and the code is loaded to PIC microcontroller using PICmicro Parallel Programmer (PPP). Signal information are sent to the chip, using UART (It is a serial communication interface which uses two lines for sending (TX) and receiving (RX) data) module as interface. Therefore, Master Bluetooth device is activated. When Power supply is given to receiver unit, the slave device is also activated. Using inquiry command master Bluetooth device will check the other Bluetooth devices in the vicinity. Once if slave device is found, master device will initialize slave with particular set of AT commands and check for authentication and pairing then enter to data command mode. Now master Bluetooth device will able to send real time data to slave Bluetooth device along with program or using keypad of PC. We can also send digitized data with help of digitized sensors like temperature, pressure sensors, etc. In receiver unit, Slave Bluetooth device will access the data and transfer to PIC Microcontroller using RX and TX pins. Data is displayed on the terminal software using serial interface. This process can be terminated by passing local command mode to Bluetooth devices.

To transfer audio signal, Audio codec board is connected to EZURiO Blu2i Bluetooth device as shown in figure 4 & 5. Audio is handled in a special way in Bluetooth. Bluetooth has the ability to fast track audio signals through the system allowing for low latency communications i.e. voice communications. An audio specific AT command is available that opens or closes the fast track audio channel. To transfer audio signal, master and slave device should be in active mode. Here also Master Bluetooth device will check the other Bluetooth devices in the vicinity. Once if slave device is found, master device will initialize slave with particular set of AT commands and check for authentication, pairing, data command mode then enter to local command mode. After that audio command is sent to master, it will connect to slave Bluetooth device and AUDIO ON term is displayed on both (transmitter and receiver unit) terminal software using serial communication. Hence Audio/voice is able to transfer and receive between Bluetooth devices. In this way, Analog signals also can be transferred by using audio codec board.

IV. SYSTEM SOFTWARE DESIGN PROCESS

The MPLAB IDEv6.50 with XC8 Compiler is used to written the embedded C code. MPLAB IDE is a software program that runs on a PC to develop applications for Microchip microcontrollers and it provides a single integrated environment to develop code for embedded microcontrollers.

A. PIC Microcontroller Initialization

The PIC microcontroller has been programmed to establish the connection to the Bluetooth device using UART. In PIC microcontroller six major Registers are associated with the UART, that has to be initialized. They are: SPBGR (Serial Port Baud Rate Generator), TXREG (Transmit Register), RCREG (Receive Register), TXSTA (Transmit Status and Control Register), RCSTA (Receive Status and Control Register), PIR.

B. EZURiO BLU2i configuration and flow chart

This Bluetooth module provides an API for communication through the AT level, freeing the programmer from implementing the complete Bluetooth stack. Some of important EZURiO BLU2i AT commands are as follows.

1) *Finding other Bluetooth devices:* An inquiry command AT+BTI , that can be used to find the other devices in range.

2) *Discovering Bluetooth devices:* All devices will not respond to the Inquiry signal. AT+BTP command makes the device Discoverable.

3) *Connecting Bluetooth devices:* ATD<bt_addr> command is used. Where <bt_addr> is the 12 digit hexadecimal address of the device to initiate connection. Bluetooth device is connectable and the address is known then other Bluetooth devices can initiate connection.

4) *Passkey and pairing*: The basic security system used with Bluetooth is called Pairing. Pairing is when two devices connect to each other using both device address and the devices secret "link key" known as the Passkey. A passkey command is AT+BTK="<passkey>" Where <passkey> is the passkey value of the device to be paired with. A pairing command is: AT+BTW<bt_addr> Where <bt_addr> is the address of the Bluetooth device to be paired with.

5) *Sending data and commands:* Data mode should be used when sending data – not when sending commands. Local command mode is "^^^" where commands are sent to a remote device.

6) Audio command: AT+BTA<n> Where <n> is 0 for Audio channel closed, or 1 for Audio channel open.

The AUDIO response will be either AUDIO ON or AUDIO OFF indicating the audio state, or AUDIO FAIL if the audio state could not be set for any reason. The response will need checking to ensure that the audio channel is now on. Figure 6 is basic design process of Bluetooth module (EZURiO BLU2i).

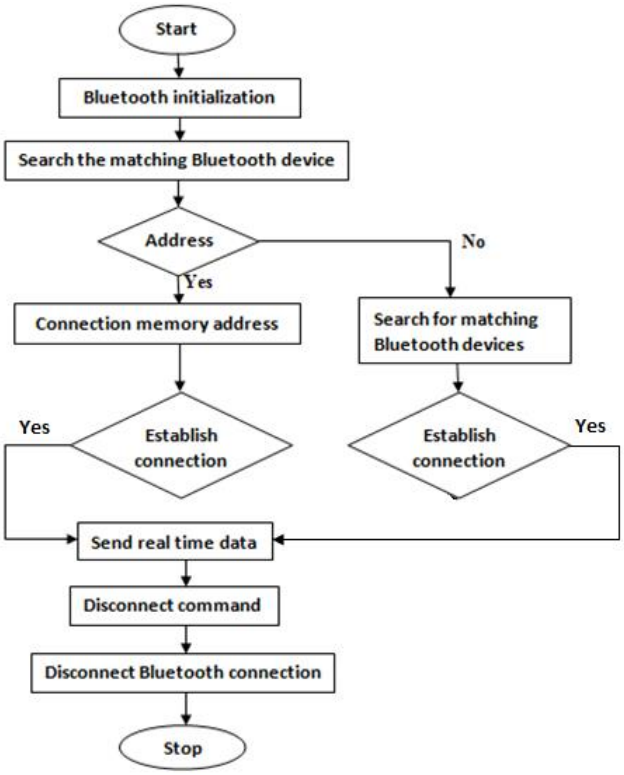

Fig. 6 basic design flow chart of Bluetooth device

The system starts, first the host device inquire nearby Bluetooth devices if no memory address, then query to Bluetooth device, the host device matches in the state, if the authentication passed, the host device will remember the address of the device and connect with the device successfully. If it has memory address, the host device is connected directly with the memory of the device, but will not inquire and match. If address not matches again it will search for Bluetooth device. When address matches Bluetooth devices establish connection each other. Real time data can be transfer between those devices.

V. IMPLEMENTATION RESULTS

In this paper, we got a result of processed real time data and audio/voice (analog signal) transfer by using EZURiO BLU2i Bluetooth devices and PIC16F877A. Transmit unit Bluetooth device address is 00809897D5E5 and Receiver unit Bluetooth device address is 00809897D60C. Windows hyper terminal has been used as display debug interface of entire process and as result window.

A. Implementation result of real time data transfer between two Bluetooth devices using PIC Microcontroller

Figure 7 shows real time data transfer using EZURiO BLU2i AT commands. To transfer the data between two Bluetooth devices, PIC microcontroller is serially connected to the Bluetooth module and it is connected to MAX232 level converter to monitor data in Terminal software. Transmitter unit contains master Bluetooth device and it check for basic configuration set up then it inquiry for surrounding Bluetooth device address later get connected with slave Bluetooth device using command 'ATD<12 digit address>'. In receiver unit, slave device will get connected with the master device, by this Bluetooth devices will enter to data command mode. Here data "hello world" is transferred between two Bluetooth device using PIC16F877A.

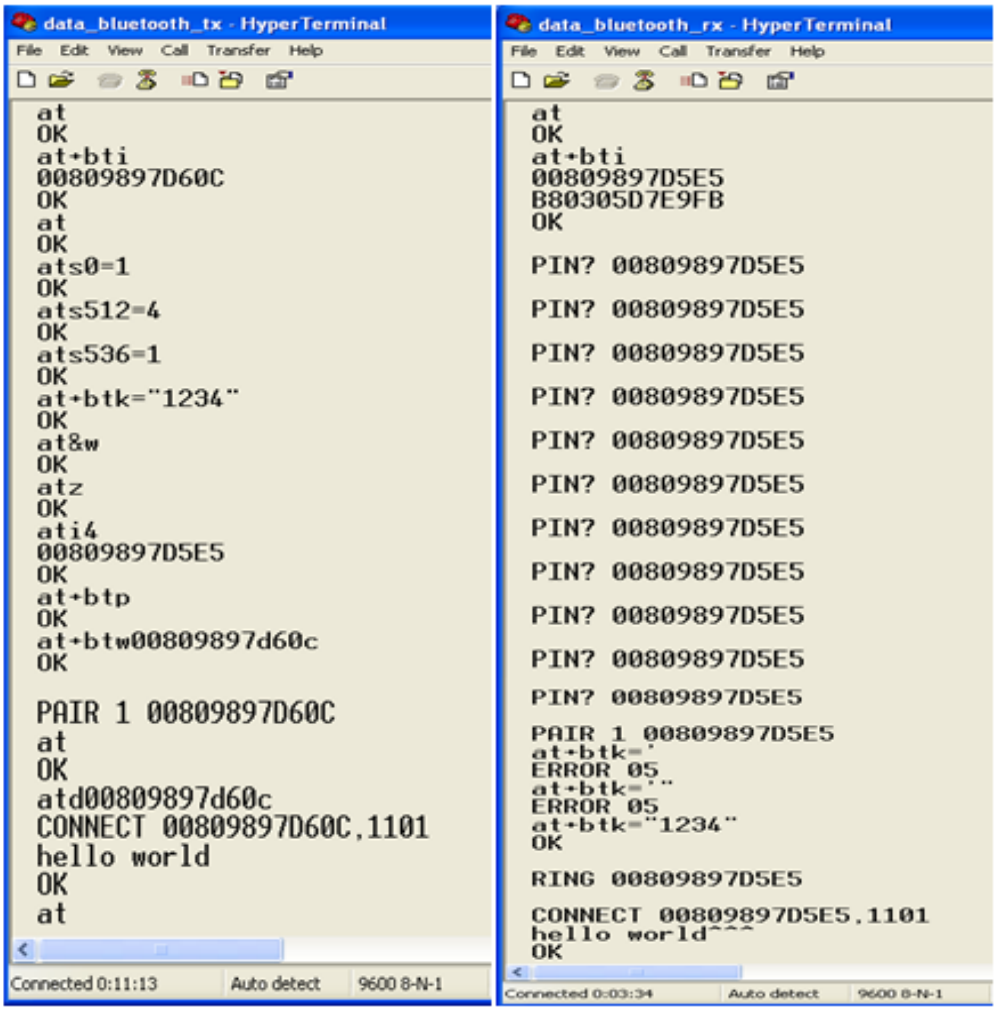

Fig. 7 Results of real time data transfer between transmitter (left side) and receiver (right side) units on windows hyper terminal.

B. Implementation result of Audio/voice and Analog signal transferred between two Bluetooth devices using PIC Microcontroller

Figure 8 & 9 shows implementation of audio/voice and analog signal transfer using EZURIO BLU2I AT commands. Here first Bluetooth devices will get paired next enter to data command mode and local command mode then audio is established by passing at+bta1 audio command using PIC16F877A. AUDIO ON message is displayed on the hyper terminal. Audio can be terminated using at+bta0 command.

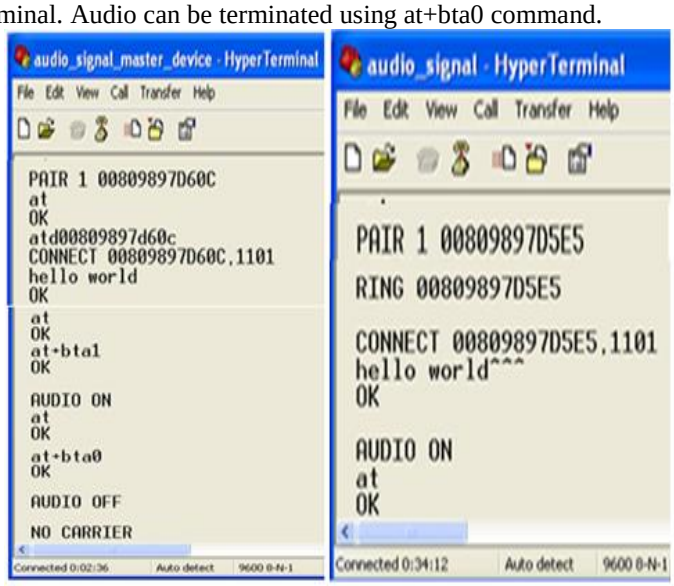

Fig. 8 Results of audio/voice transfer between transmitter (left side) and receiver (right side) units on windows hyper terminal.

Audio codec board is also used to transfer the analog signal between transmitter and receiver unit. PIC Microcontroller PIC16F877A is serially connected to the Bluetooth module and it is connected to audio codec board both in transmitter and receiver units. To generate the sine wave, sine wave generator is used. It is connected to audio codec board and to oscilloscope in transmitter unit. In the receiver unit audio codec board is connected to oscilloscope to receive analog signal. After establishing the audio mode, analog signal can be transferred from the transmitter to receiver unit (fig. 9).

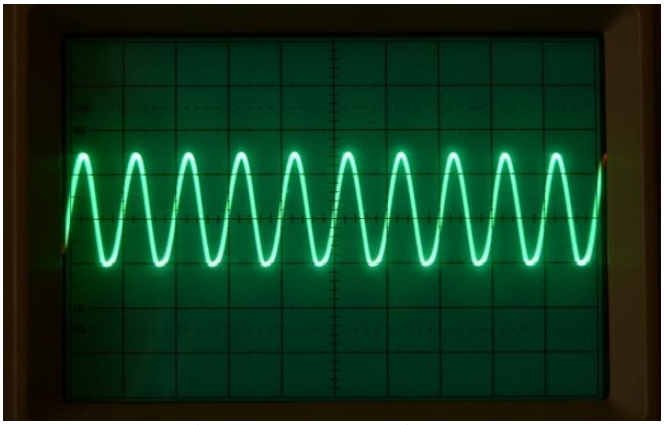

Fig. 9 Result of analog signal captured from oscilloscope.

VI. CONCLUSION

The purpose of this system is to transfer processed real time signals from master to slave Bluetooth devices (Ezurio Blu2i) using PIC microcontroller (PIC16F877A). Transferring data and audio signal (analog) between two Bluetooth devices (Ezurio Blu2i) using PIC16F877A is implemented successfully. Windows hyper terminal has been used as result window to show the entire process. The project is applicable in biomedical field, where the doctors can interact with each other by sending and receiving the reports of the patients they are treating. If a doctor finds any difficulties in treating a patient, he can send the observational status to other doctor and get the best medical assistance. We can use digitized sensors to measure temperature, pressure and force etc which is applicable in industries. As audio mode is enabled we can pass analog signals through audio codec board which is helpful in transferring biomedical signals. Bluetooth is already pre-existing in almost all hand held devices, so certain costs are significantly reduced and Bluetooth signals are not hazardous so we can use in hospitals, industries and research laboratories.

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