Real-Time Monitoring of ECG using Zigbee Technology

Ramu R, A. Sukesh Kumar

Abstract- Cardiovascular disease is one of the leading causes of death around the world. Telemedicine has a great impact in the cardiac monitoring of patients in remote environment. A wireless electrocardiograph monitoring system is implemented with Zigbee module for remote monitoring of cardiac patient. ECG Acquisition system is designed and the signals are plotted in LabVIEW. The Signal from ECG acquisition module is given to Zigbee module. The transmitted signals are then received by Zigbee Transceiver. TTL output from the receiver Zigbee module is converted to RS232 using MAX232 level converter. The serial data are then plotted in Laptop using LabVIEW.

Keywords- ECG, LabVIEW, Telemedicine, Zigbee.

I. INTRODUCTION

About 35 percent of deaths in India are due to cardiovascular diseases and majority of them die due to heart attack because they cannot reach hospital within an hour. One of the leading developments in telemedicine is the monitoring of patients with cardiac disorders within the home or rural hospitals [1]. Early detection of heart disease sign has important significance for heart disease prevention and timely treatment. Wireless technologies are developing very fast and medical devices also use wireless connectivity to maintain a connection to monitoring systems. There are different wireless technologies that are used to transmit ECG signals such as Bluetooth, Zigbee Wi-Fi and GSM. This work is an extension of the earlier works of the authors [2]. Bluetooth low energy technology is used in the existing ECG monitoring system eliminates the wired connection and also reduces the power consumption of long term monitoring system. Bluetooth technology enables low power and short range wireless connection. In the wireless ECG monitoring system the microcontroller and bluetooth module serves as an intermediate node between ECG acquisition module and smart phone [3]. Wireless ECG transmission using Wi-Fi technology is developed which consist of a single chip ECG signal acquisition module, Wi-Fi module and a smart phone [4]. An internet based ECG telemonitoring in which communication between the patient and doctor is done through client-server architecture [5]. In this work ECG signal from the acquisition module is transmitted to the Laptop using Zigbee module.

II. SYSTEM DESCRIPTION

The aim of the work is to design an inexpensive highly accurate ECG acquisition and wireless transmission system using Zigbee. The Fig.1 shows the main block diagram of the system.

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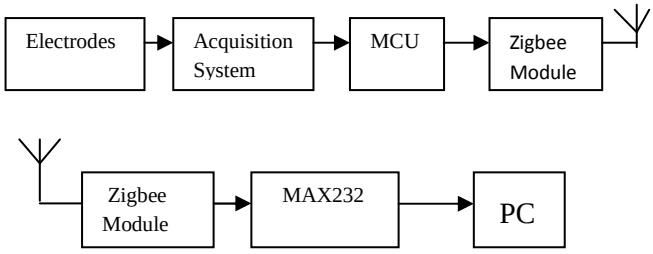

Fig. 1 Block Diagram of the System

The ECG Acquisition System contains electrodes, instrumentation amplifier and filters. It captures the ECG signal, amplifies and filters this to a desirable range. The analog output from the filter is given to microcontroller for analog to digital conversion (ADC) and the serial data from the output of microcontroller is wirelessly transmitted using Zigbee transmitter module. The Zigbee receiver module will receive the transmitted ECG data .The output of Zigbee module are TTL level. These levels should be converted to RS232 level for interfacing Zigbee module with PC. The ECG acquisition system is designed first and the output is displayed in the laptop using LabVIEW software. Then the acquisition part is interfaced with the Zigbee module and transmitted the signal to Zigbee receiver module which is interfaced with the PC. Finally the transmitted ECG signals are plotted in the PC using LabVIEW in real time.

III. ECG ACQUISITION SYSTEM

The signals acquired from the electrodes are amplified, filtered, digitized, and transmitted. The differential amplifier differentiates the signals coming from the two lead electrodes and amplifies it to fit in to the analog input range of an analog-to-digital converter (ADC). Unwanted frequency components are then removed using filters. The processed signal is then digitized with an ADC in Atmega microcontroller and sent to PC. Block diagram of ECG acquisition system is shown in Fig. 2.

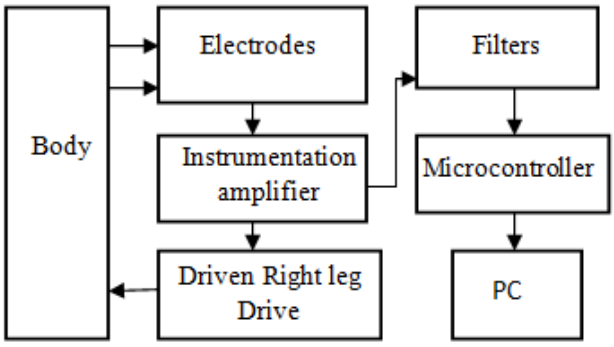

Fig. 2 Block Diagram of ECG Acquisition System

Electrodes work as transducers converting ionic flow from the body through an electrolyte into electric potential. For

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three lead systems, electrodes RA, LA and LL are used, two of the electrodes are used to form lead and the third is used as the ground .ECG signals vary from microvolt to the millivolt range. Due to this small range, the signals measured need to be amplified in order to be better interpreted [6]. Thus amplification is required in order to increase the signal amplitude for further processing and for display. Texas Instrument's instrumentation amplifier INA321 EA is used here. Fig. 3 shows the schematic of TI's INA321 EA.

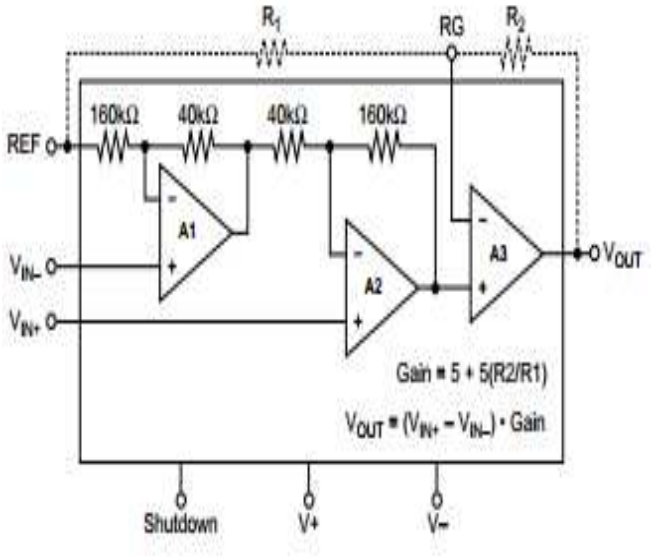

Fig. 3 The Schematic of TI's INA321 EA

The ratio of R2 to R1, or the impedance between pins 1, 5, and 6, determines the gain of the INA32 [7]. With an internally set gain of 5, the INA321 can be programmed for gains greater than 5 according to the following equation:

$$G = 5 + 5(R2/R1) \quad (1)$$

When a differential amplifier records bio potentials, the voltage of the patient with respect to the amplifier's common is called the common mode voltage Vc. It can be minimized by attaching a third electrode to the patient. The most common and effective use of the third electrode is to connect it to a driven-right-leg circuit. It reduces the effective electrode resistance by several orders of magnitude, and it allows only a safe amount of current to flow through the third electrode.The last stage of the analog front end unit is the analog to digital converter (ADC). The analog front-end hardware for an ECG acquisition unit could be reduced if we use with it an ADC with very high resolution and high-speed. Different types of microcontrollers are used in ECG monitoring. ATmega 328 microcontroller by atmel is used for this.

A. ATMEGA 328

It is an 8-bit AVR RISC-based microcontroller with 32KB ISP flash memory and consumes low power. It has a 10 bit analog to digital converter which converts from ground (0 V) to 5V.The value range from 0 to 1023 that means it have 10 (2^10 = 1024) bit resolution. A0-A5 are the 6 analog pins in the microcontroller [8]. Output of filter is connected to pin A0 (pin 23) of microcontroller. Arduino firmware is loaded into the Atmega chip in the arduino board. The Arduino Uno is used in this work to upload sketches to Atmega 328. Fig. 4 shows the analog to USB conversion.

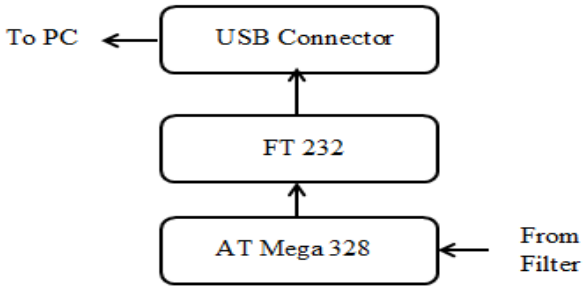

Fig. 4 Analog to USB Conversion

Analog signals from the filter are converted to digital signals using Atmega328. The output of microcontroller is serial data and this is converted to USB standard using FT232RL USB to Serial UART adapter. It is a simple and inexpensive way to connect Atmega microcontroller to a PC via USB connection. FT232RL chip implements full v2.0 USB protocol, it is easy to send and receive data from Atmega microcontrollers.

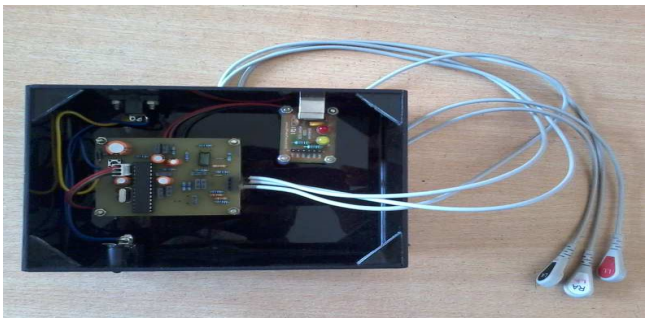

Fig. 5 ECG Acquisition System Hardware

Hardware of ECG Acquisition system is shown in Fig. 5. Lead 1 configuration is used in this work. Potentials between RA and LA are taken and RL is taken has ground. These three electrodes are connected to the instrumentation amplifier. The serial data from the output of microcontroller is converted to USB standard using FT232. These signals are then transferred to PC using USB cable.

IV. WIRELESS TRANSMISSION

ZigBee is a low-cost, low power, wireless mesh network standard which operates in the industrial, scientific and medical (ISM) radio bands [9]. Zigbee Module XBee-S2 is used in this work for the real time wireless transmission of ECG Signal. ZigBee is based on an IEEE 802.15 standard. Data rate is 250 kbits/s and transmission distances range from 10 to 100 meters. The circuit diagram of transmitter is shown in Fig. 6.

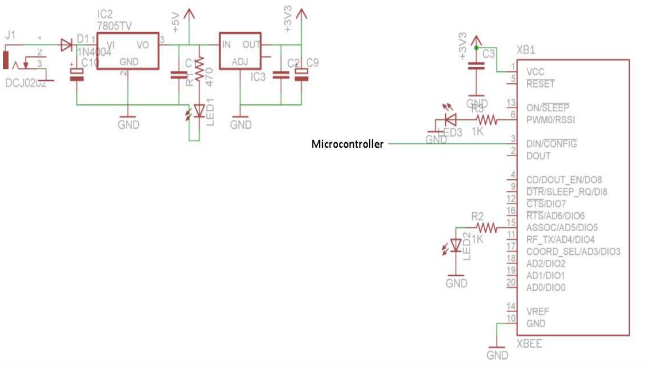

Fig. 6 Circuit Diagram of Transmitter

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Power Supply for microcontroller is +5 V and IC 7805 is used for this. For Zigbee module it is 3.3 V and for this IC 1117 is used. Analog ECG Signals are digitized and converted to serial data by Atmega microcontroller. This serial data is fed to the Din pin of Zigbee module. These signals are then transmitted wirelessly using Zigbee technology. The ECG acquisition system is interfaced with the Zigbee module. Fig. 7 shows the hardware of ECG acquisition system interfaced with Zigbee module.

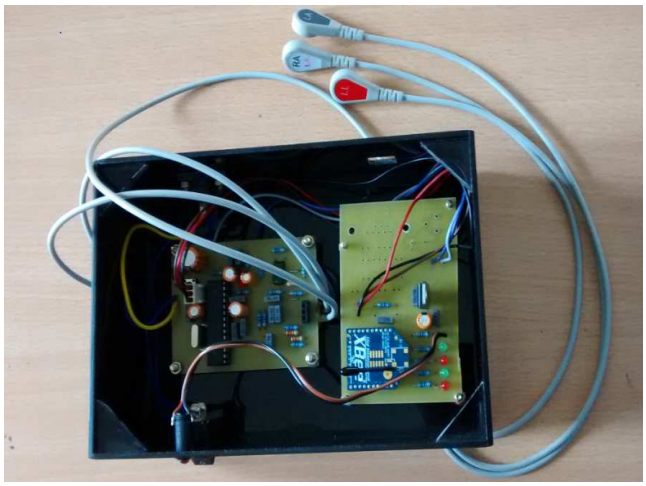

Fig. 7 ECG Acquisition Module Interfaced with Zigbee Transmitter Module

V. RECEPTION AND DISPLAY OF THE ECG SIGNAL

The circuit diagram of receiver is shown in Fig. 8. Zigbee module and MAX232 IC are used. Power supply circuit of the receiver section is the same as that used in transmitter section. +5V is used for MAX232 IC and 3.3V for Zigbee module. The received signal from the Zigbee module is TTL level, so it should be converted into RS232 level. For this level conversion MAX232 IC is used. The Signals from the Dout pin of Zigbee module is connected to T1IN pin of MAX232 where this TTL signals are converted to RS232 and the output are taken from T1OUT pin of MAX232.These Signals are then fed to PC using Serial connector DB9.For connecting to laptop FT232 can be used for serial to USB conversion. Fig. 9 shows the hardware for receiver section.

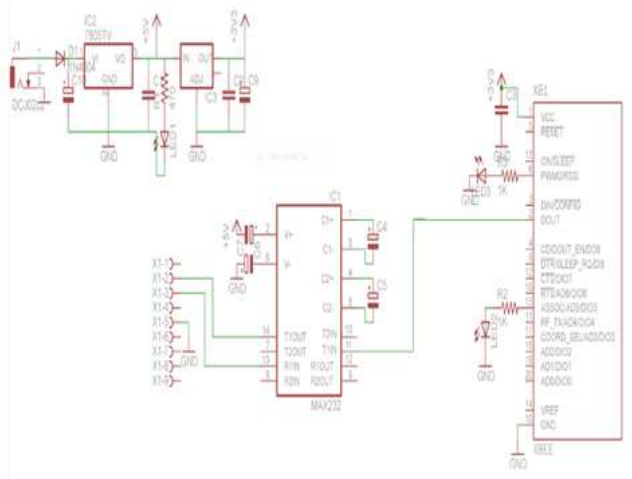

Fig. 8 Circuit Diagram of Receiver

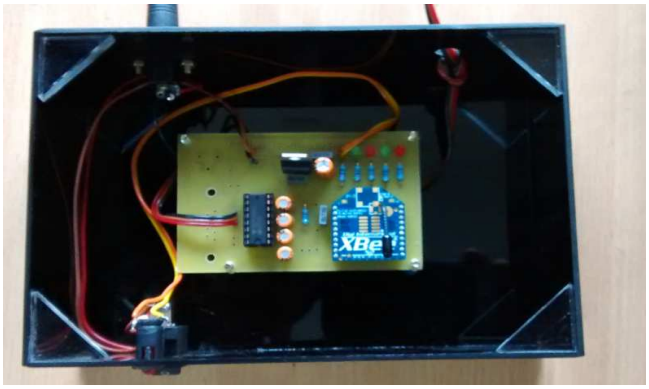

Fig. 9 Receiver Section Hardware

VI. SOFTWARE USED

1) Arduino Software

Arduino Software (Arduino 1.0.4) is used in this work. The open-source Arduino is easy to write code and upload it to the microcontroller

2) Labview

Labview2011 is used to view the ECG signal in computer.

VII. RESULTS

The ECG signal obtained from the ECG acquisition circuit is plotted and displayed in the laptop using LabVIEW software. Fig.10 shows the screen shot of the obtained ECG signal and Fig. 11 shows transmitted ECG signal received and plotted in PC using LabVIEW.

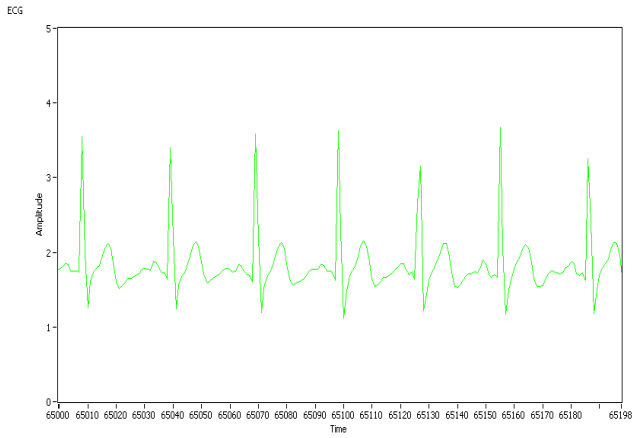

Fig. 10 ECG Signal Obtained in Laptop

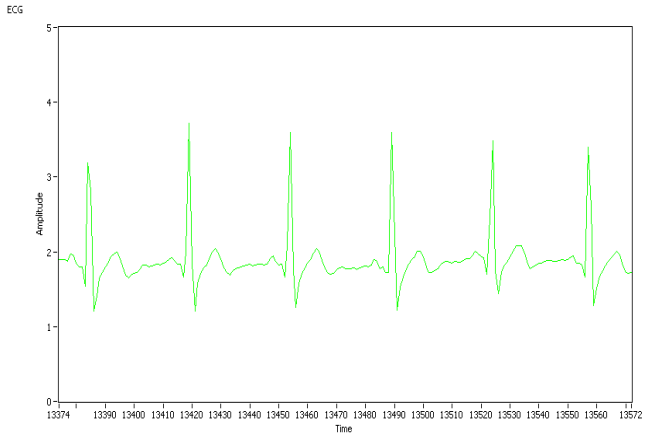

Fig. 11 Transmitted ECG Signal Received and Plotted in PC using Lab View

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VIII. CONCLUSION

The ECG Acquisition system is implemented and plotted the waveform in the laptop in real time. The ECG signals from the acquisition system are then wirelessly transmitted to a remote PC using Zigbee technology. LabVIEW 2011 is used to plot the signal in PC. Zigbee S2 modules are used for transmission and reception. Transmitted range of the ECG signal is 40m.We can increase the range by mesh networking in which data are hopped from one node to other until destination is reached.

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