Wireless Ecg

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Abstract- *Changing lifestyles are having a tremendous impact on people's health. Increasing risks of heart diseases has led to further research and development of medical systems. Our project aims at making the ECG system wireless. The project includes ECG signal acquisition, digitizing, wireless transmission, reception, processing and storing. Such a system will help patients and doctors by reducing time and attention for continuous monitoring, reducing costs, hardware and allowing easier portability of the hardware.*

Keywords- ECG, Wireless Transmission,

I. INTRODUCTION

Cardiovascular diseases are the principal causes of death worldwide. Body sensor networks are a key driving force for the wireless health evolution by allowing patients access to their physiological state at any time in their daily life. Cardiac bio-potential signals in the form of electrocardiogram(ECG) is a critical health indicator to show proper functioning of the heart.

The continuous ECG, which indicates the overall rhythm of the heart, can be monitored using non-invasive electrodes on the chest or limbs, has been demonstrated with prognostic significance for cardiovascular diseases.

With advancements in technology and the world moving towards a trend of miniaturization to reduce cost, time etc a wireless heart monitoringsystem will be of major advantage to heart patients and doctors making it more convenient and less intensive.

This paper aims at developing a wireless ECG system which extracts, amplifies, filters, digitizes and transmits the incoming analog signal along with the heart rate, which is then wirelessly received, processed and displayed at the receiver end.

Heart diseases are identified by analyzing an ECG Signal to detect arrhythmia. Arrhythmia is detected by continuous monitoring of heart rate. Deviation of the measured heart rate from a desired range (60-100 bpm in resting condition) is the indication of arrhythmia. The cardiac signal, typically 5 mV peak to peak, is an AC signal with a bandwidth of 0.05 Hz to 100 Hz. The heart rate is measured from an ECG signal and the typical ECG signal along with its parameters are as shown in Fig 1[].

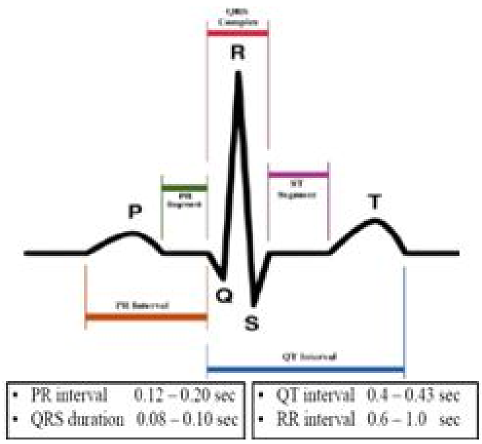

Figure 1.a ECG Signal

Parameter	Explanation
P Wave	First wave of ECG ,depolarization of the atrium
QRS Wave	The start wave of ventricular contraction
R Wave	The positive wave, the highest peak in the cardiac phase. The R-R interval is the time period of the R-peak linked to the next R-peak in cardiac cycle
T Wave	The ventricular repolarization occurs after ventricles contract for a few milliseconds
QRS Complex	Significantly, domination of the signal, the greater amplitude of the atrial repolarization(typically occurs between 0.15-0.20s after P wave)

Fig 1.b. ECG Parameters

II. EXPLANATION OF IDEA

The block diagram of a wireless ECG system is as shown in figure 2. It consists of hardware and software components which are explained above

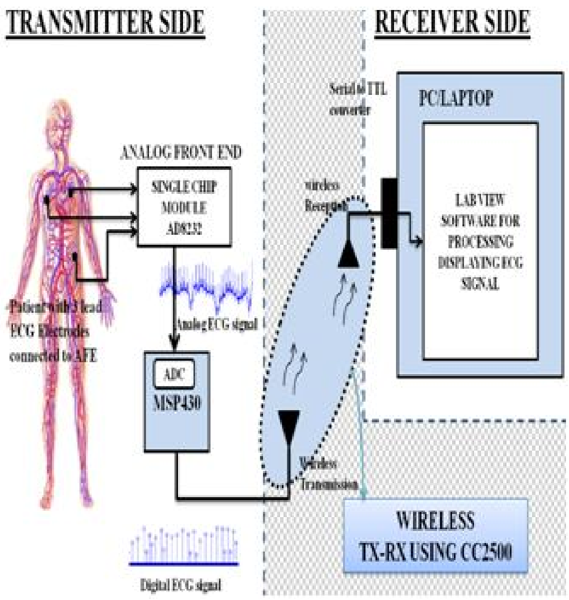

Figure 2 Wireless ECG Diagram

II.A. ECG Electrodes

Electrical activity of the heart over a period of time is measured by ECG electrodes placed on the skin. Contraction and relaxation of heart muscles leads to blood circulation all over the body. This activity causes a cycle of electrical activity which is termed as ECG. Electrodes sense this bio-potential caused by heart muscle cells. Leads act as electrode connectors. We use a single lead ECG which means 3 electrodes are connected to give a single ECG signal. Single lead refers to potential between right and left electrode with respect to a reference electrode. The placement of these electrodes is crucial for obtaining an accurate ECG signal. Right electrode is placed on the right side of the chest or right limb and left electrode is placed on the left side or left limb whereas reference electrode is placed on the right leg.

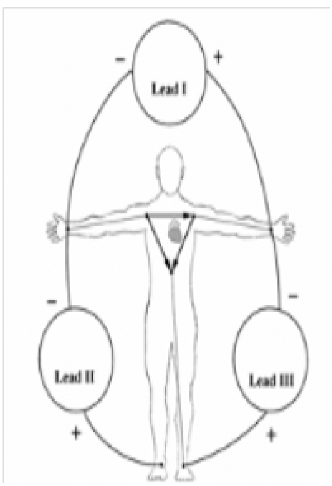

Figure 3 Placement of ECG Electrodes

Lead I measure the differential potential between the right and left arms.
Lead II between the right arm and left leg, and
Lead III between the left arm and left leg.

II.B. Analog Front End

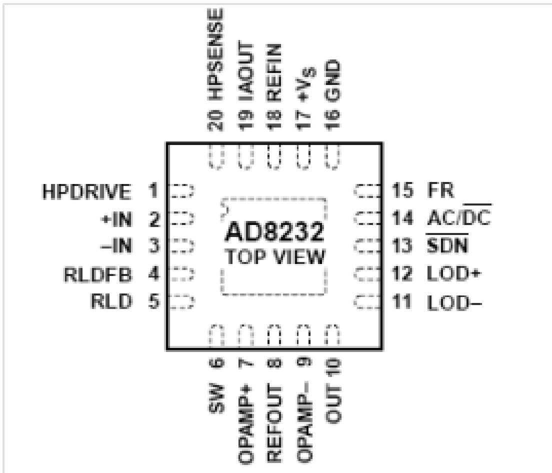

Figure 4 AD8232 Pin Diagram

AD8232 is used as an analog front end to extract, filter and amplify the incoming analog ECG signal and in turn connect it to a low power ADC. It is a single lead single channel ECG front end circuit. Its low power typically 170µA and high common mode rejection ratio of about 80dB make it an efficient option. It can be used in two or three electrode configuration modes. For amplification it uses an internal instrumentation amplifier. Filtering capability is provided by its internal 2 pole adjustable high pass filter (0.5 Hz), 3 pole adjustable low pass filter (40 Hz), its fast restore feature and internal RFI filter. Performance is specified from 0°C to 70°C and is operational from −40°C to +85°C. Its pin configuration is as shown in fig…

II.C. Microcontroller

Analog signal coming out of AD8232 is not suitable for transmission therefore we use microcontroller MSP430 to convert analog ECG to digital form which can then easily be transmitted wirelessly.Msp430 is a low power microcontroller with its peripherals used for various applications and it is also equipped with 5 power saving modes

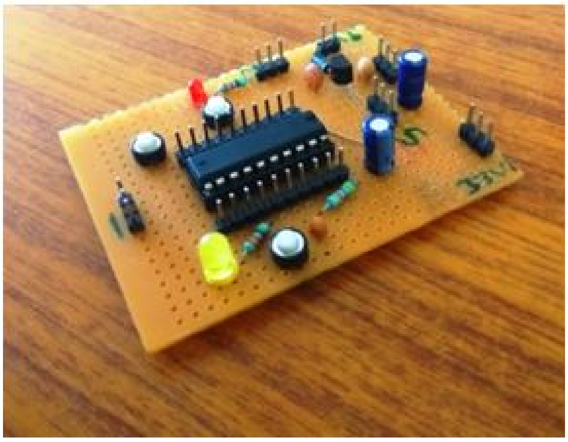

Figure 5 Msp430

In addition MSP430 has other features like ADC, Opamps, DAC and USART. It is programmed to output digital ECG signals along with average heart rate calculated for every 5 peaks as input to the transmitter

Sampling: The amplified ECG signal given to MSP which is having an internal on chip analog to digital converter(ADC12). Precise sampling period is achieved by the ADC12 conversion with the Timer A pulses. Timer A is clocked by the ACLK which is generated from 32,768 kHz crystal oscillator. The most important signal is captured is the ECG signal and its fastest time is 20ms. By keeping the sampling period of about 2ms we can capture 10 samples of QRS Complex.

II.D.CC2500

The Digital ECG signal from MSP430 is wirelessly transmitted using a wireless transreceiver module. Wireless trans-receiver module is chosen based on its range, data-rate, data-volume, cost, size and power consumption. Very popular low cost wireless trans-receiver module operating at 433Mhz is too noisy and not efficient in transmitting 8bit of data, on the other hand zigbee is too costly and that much data rate and range is not required for our application.

Figure 6 AD8232 Pin Diagram

Therefore, in our project we make use of a zigbee equivalent low cost CC2500 RF trans-receiver module which operates at same frequency as zigbee but is low cost, low range and low data rate. The CC2500 is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications. The circuit is intended for the 2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band. The RF transceiver is integrated with a highly Configurable baseband modem. The modem supports various modulation formats and has a configurable data rate up to 500 kBaud.CC2500 provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication, and wake-on-radio. The main operating parameters and the 64-byte transmit/receive FIFOs of CC2500 can be controlled via an SPI interface. In a typical system, the CC2500 will be used together with a microcontroller and a few additional passive components

II.C. LabVIEW:

The received signal from CC2500 receiver is connected to a PC for plotting the received ECG signal using LabVIEW software installed on the PC. LabVIEW is a productive development environment for creating custom applications that interact with real world data or signals in fields such as science and engineering. Usage of this software reduces the overhead of writing lengthy codes as it uses graphical programming approach instead of the traditional programming languages. Thus higher quality projects can be completed in lesser time and with fewer people involved. LabVIEW software contains many components which can be used for any type of test, measurement or control application.
LabVIEW block diagram is created to capture the incoming ECG signal from a serial port, read and plot the signal on the ECG waveform chat. In addiction the bpm information coming along with ECG signal is displayed. Initially serial port where ECG signal is received is reserved and this reserved port is set with required baud rate and timeout value. Then the string of numbers is read with byte count of 3 and converted to numbers. We observed that ECG signal was within the amplitude range of 100-800 and bpm was in the range of 60-100. In order to distinguish between ECG signal values and bpm values we transmit bpm with higher amplitude by adding some high constant value. So, the number within the range 100-800 is put in an array and plotted on ECG waveform chat. The number above the amplitude value 800 is considered as bpm value and displayed by subtracting the high constant value which was added while transmitting.

III. STEPS OF IMPLEMENTATION

To begin with the implementation we researched on potential ECG sensors. After much research and comparison we found the AD8232 to be a suitable option.

After reading the datasheet and researching about ECG signals and how and where to take them, we proceeded using a single lead system. Two points on the left and right arm respectively are used to measure the potential and the right leg drive is used for feedback to reduce the common mode noise. We verified the working of the AD8232 module using the arduino IDE signal plotter and msp430 as intermediate interface. MSP was chosen because of its low power operation mode and its ease of programming.

Initially we worked with the launch-pad to see the data obtained by ad8232 on the arduino IDE. This was done by using the msp board's 3.3v and ground pin to power on the ad8232 and connecting the output of ad8232 to pin 1.4 of the launchpad to avoid using the default TX and RX pins of the controller (to prevent conflicts in the communication to the PC).

The msp was used to convert the analog data to discrete data and plot the same in arduino's serial plotter and convert the data using the inbuilt 10 bit ADC for wireless transmission. We further decided to build the microcontroller board to enhance the electronic aspects of the project. This was done using the M430G2553, a combination of resistors and capacitors, voltage regulator etc.

In pursuit to determine how to wirelessly transmit the signal we initially considered low power bluetooth modules however on further research found the cc2500 to be an efficient RF module. The cc2500 is a trans-receiver module .The transmitter is powered through the msp or an external battery of 5v.At the transmitter end the default TX pin of the controller p1.2 is connected to the RX pin of the cc2500, whereas at the receiver end the TX pin of the cc2500 is connected to the RX pin of the USB to TTL converter.

IV. STUDIES AND FINDINGS

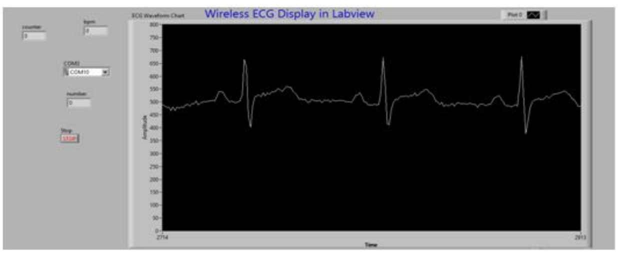

Figure 7 Transmitted ECG Signal.

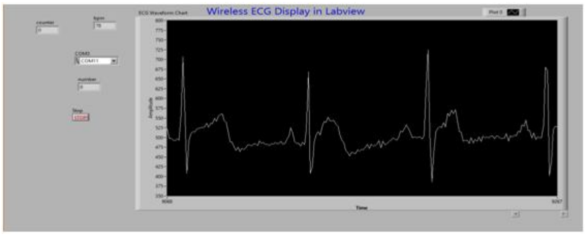

Figure 8 Wirelessly received ECG signal

Figure 6 shows the analog signal obtained directly from the ad8232 and being transmitted by cc2500 after digitization using MSP430.

Figure 7 shows the signal at the receiver side, viewed after processing in LabVIEW in order to enhance characteristics such as peaks in the signal and eliminate very low value distorted data.

However it needs to be noted that ad8232 is very sensitive to the power lines in its vicinity and therefore if not kept away from high power electronics appliances may cause severe distortion in the received signal.

V. CONCLUSION

The aim of the project to receive wirelessly transmitted ECG and to calculate the heart rate was successfully accomplished.

This project can be extended to longer range applications using modules such as GSM /Zigbee etc.

A further enhancement would be to identify the type of arrhythmia and alert a distant doctor about the same, so that necessary medical action can be taken.

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