WIRELESS ELECTRONIC STETHOSCOPE USING ZIGBEE

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ABSTRACT

Heart sound stethoscope is primary stage to access diseases. In this paper design of an electronic stethoscope with the functions of wireless transmission is discussed. This electronic stethoscope based on embedded processor. The data can be transmitted through wireless transmission using Zigbee module. A microphone is used to pick up the sound of the heart beat. Acoustic stethoscope can be changed into a digital stethoscope by inserting an electric capacity microphone into its head. The signal is processed and amplified to play with or without earphone. Heart sounds are processed, sampled and sent wirelessly using Zigbee module so that multiple doctors can do auscultation. PC connectivity is provided through serial port where from audio and video can be made available through LAN and internet for telemedicine consultation. Heart beat signals are sensed, sent, displayed, monitored, stored, reviewed, and analysed with ease.

Keyword: - *Zigbee module, Wireless Electronic stethoscope.*

1. INTRODUCTION

The Stethoscope is an acoustic medical device for listening to internal sounds in human body which is known, in medical terms, as auscultation. Heart sound auscultation is one of the most basic ways to assess the state of the cardiac function. The heart sounds and mummers are band limited to about 100-1000Hz [1].Some research concluded that an abnormal heart-rate profile during exercise and recovery is a predictor of sudden death. Because the incidence of cardiovascular disease increased year by year, cardiovascular diseases relating to heart has become worldwide common and high prevalent disease. As a result of the development of wireless technology, the diagnosis based on the analysis of heart sound will become a new method to diagnose cardiovascular disease. Anh Dinh & Tao Wang had processed heart beat signal and sent wirelessly using Zigbee protocol [2]. Some electronic stethoscopes are designed which are using Bluetooth for wireless transmission. At receiver side heart signal can play on earphone and it can be store on PC or PDA [3-6]. One problem with acoustic stethoscopes is that the sound level is extremely low and there are some short comings in the heart sound analysis [3]. 1. The mechanism of the heart sound production is still being debated in the clinical diagnosis. 2. Lack of quantitative analysis techniques or a combination of PCG diagnosis. 3. Auscultation is easily affected by the subjectivity of the doctor and measuring environment. 4. A large amount of heart sound components is low-frequency, which is important for the diagnoses but cannot been clearly distinguished by doctors. 5. The current major clinical application of the heart sound auscultation is a mechanical stethoscope whose accuracy is low [7]. This paper presents wireless electronic stethoscope which overcome these drawbacks. Rest of the paper organized as related work done for this idea, different heart sounds and design of whole system including circuit of signal processing system with its simulation and finally features of system with conclusion.

1.1 Objective

The electronic stethoscope is based on embedded processor. The data can be transmitted through wireless transmission using Zigbee module. A microphone is used to pick up the sound of the heart beat.

Acoustic stethoscope can be changed into a digital stethoscope by inserting an electric microphone into its head. Heart sounds are processed, sampled and sent wirelessly using Zigbee module so that multiple doctors can do auscultation. PC connectivity is provided through serial port where from audio and video can be made available through LAN and internet for telemedicine consultation.

2. SYSTEM DESIGN

System design consists of two parts that is transmitter and receiver. The transmitter system consists of the following hardware components:

1) Front end circuitry – sensor, preamplifier, filter and power amplifier with variable gain
2) Microcontroller
3) Zigbee module.

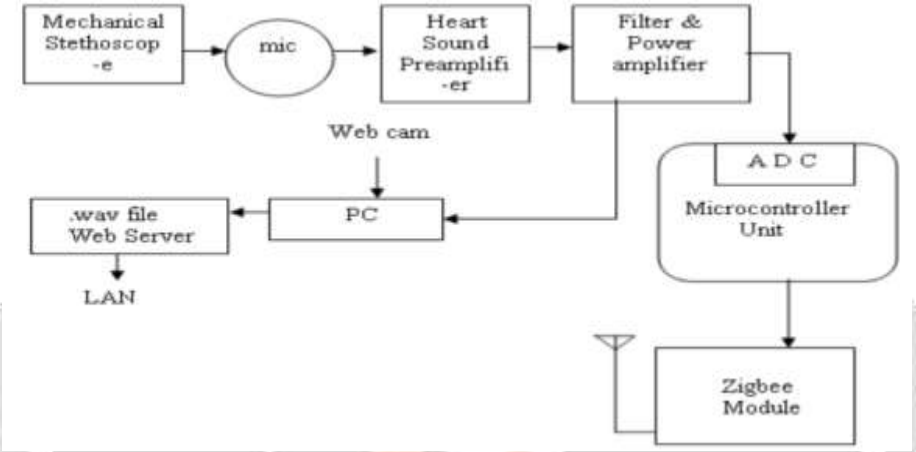


Fig -1: Transmitter

2.1 Front End Circuitry

Front end circuitry is signal acquisition and preprocessing system [8]. First part is sensor. There are multiple types of sensors that can be used in the chest piece of an electronic stethoscope to convert body sounds into an electronic signal [9]. Microphones and accelerometers are the common choice of sensor for sound recording. Microphone is perfect for the application [10]. The output of the microphone is fed to signal pre-processing module. Signal pre-processing circuit consists of three parts, which are primary amplification circuit, filter circuit and second amplification circuit [11-12]. The role of signal pre-processing circuit is to adjust the signal from sensor with a series of amplification and filtering so that it meets the follow-up A/D sampling demands and the signal-noise ratio is improved. This circuitry is designed by using operational amplifier [13]. The preamplifier is created to increase the low signal from the condenser microphone to line-level for further amplification. Here op-amp LM741 is used for designing of preamplifier. It is having gain of 20 which is calculated by feedback resistor value. The output of the preamplifier is fed to an active low pass filter with cut-off of 100 Hz and 1000 Hz so that Heart sounds and respiration sounds are passed and background sounds are reduced. Frequency is selected by selecting capacitor value. Filter is having gain of 1.6. The output signal from the filter is processed by power amplifier to supply the necessary power to drive the headphones for further amplification. The LM386 circuit is an audio amplifier designed for use in low voltage consumer applications which provides both voltage and current gain for signals [14]. Hence power amplifier with variable gain is designed with the help of op-amp LM386. Gain can vary by varying input given to amplifier through pot. Fig 2 shows signal pre-processing circuit.

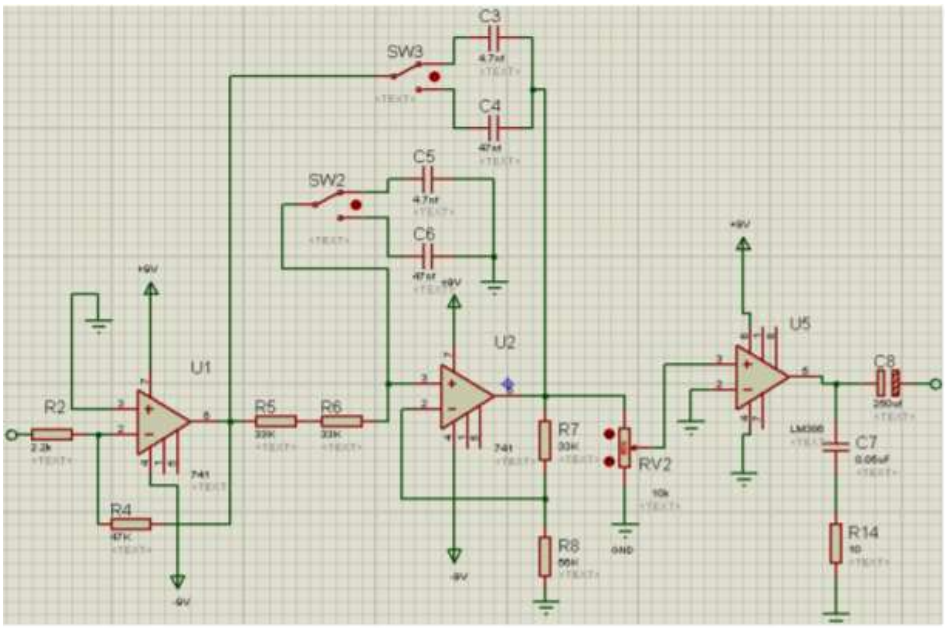


Fig -2: Signal Pre-processing Circuit

2.2 Microcontroller and Zigbee module

The output of signal Pre-processing Circuit is converted into digital form by ADC. Inbuilt successive approximation 12 bit ADC of microcontroller is used. Here PIC18f2423 microcontroller is used. Some features are as follows:-

- 0-40 MHz Operating frequency
- 16 Kbytes flash program memory
- 768 bytes data memory
- 12-bit ADC (10 input channels)
- Serial communication :- SSP and USART

For wireless transmission Zigbee module JN5148 made by Jennic is preferred. The JN5148-001 is a range of ultra low power, high performance surface mount modules targeted at JenNet and Zigbee PRO networking applications, enabling users to realize products with minimum time to market and at the lowest cost. Its operating frequency is 2.4GHz and data rate is 250 kbps [15-16]. The modules use Jennic's JN5148 wireless microcontroller to provide a comprehensive solution with large memory, high CPU and radio performance and all RF components included.

2.3 PC Connectivity

Signal from conditioner system (analog signal) is given to PC through auxiliary input pin for storage purpose [17-18]. This audio signal is stored in form of .wav file for further analysis. This audio video interface is provided using web camera through internet for proper positioning of stethoscope. The LAN support is also provided for this system using JAVA.

2.4 Receiver

The hardware design of receiver consists of following parts: Zigbee module, microcontroller, DAC, Power amplifier. Zigbee module captures the signal in the air and transmits to microcontroller. We have to play this signal on speaker phone. But received signal is in digital form hence we have to first convert it into analog. Hence signal from microcontroller is given to 12 bit digital to analog converter. Here PIC16f873 microcontroller is used. Signal from microcontroller is given to 12 bit DAC MCP4822 [19-20]. The MCP4822 devices are designed to interface directly with the Serial Peripheral Interface (SPI) port available on many microcontrollers. Then this analog signal is amplified by power amplifier with gain control same as at transmitter side. And now this signal is given to speaker. In this way wireless electronic stethoscope system is implemented with provision of heart signal storage on PC for further analysis [21-22]. This signal is also accessed through over internet for consulting with other physicians.

Simulation of signal pre-processing system is done which is discussed in next section. Fig. 3 shows the receiver system.

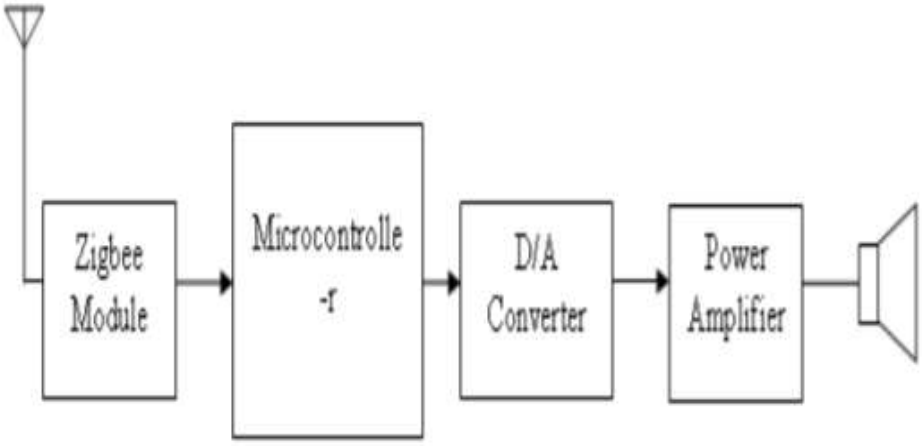


Fig -3: Receiver

3. Why Zigbee over Bluetooth?

Parameter Bluetooth Zigbee Range Up to 10metres 1.5 to 2km Frequency band 2.4 to 2.485 GHz 2.4 GHz Power consumption High Very low Topology Star Mesh, tree, star, cluster Complexity High Low Device types Mobile Stationary Application Industrial control and monitoring building automation, home control and automation Wireless connectivity between devices such as phones, laptops.

- Zigbee aims at automation whereas Bluetooth aims at connectivity of mobile devices in close proximity.
- Zigbee uses low data rates, low power consumption on small packet devices while blue tooth uses higher data rates, higher power consumption on large packet devices.
- Zigbee networks support longer range devices and more in number compared to Bluetooth networks whose range is small.
- Given Zigbee's almost instant network join times (30 milliseconds) it's more suitable for critical applications while Bluetooth's longer join time is detrimental (3 seconds).
- The electronic stethoscope is based on embedded processor.
- The data can be transmitted through wireless transmission using Zigbee module.
- A microphone is used to pick up the sound of the heart beat.
- Acoustic stethoscope can be changed into a digital stethoscope by inserting an electric microphone into its head.
- Heart sounds are processed, sampled and sent wirelessly using Zigbee module so that multiple doctors can do auscultation.
- PC connectivity is provided through serial port where from audio and video can be made available through LAN and internet for telemedicine consultation.

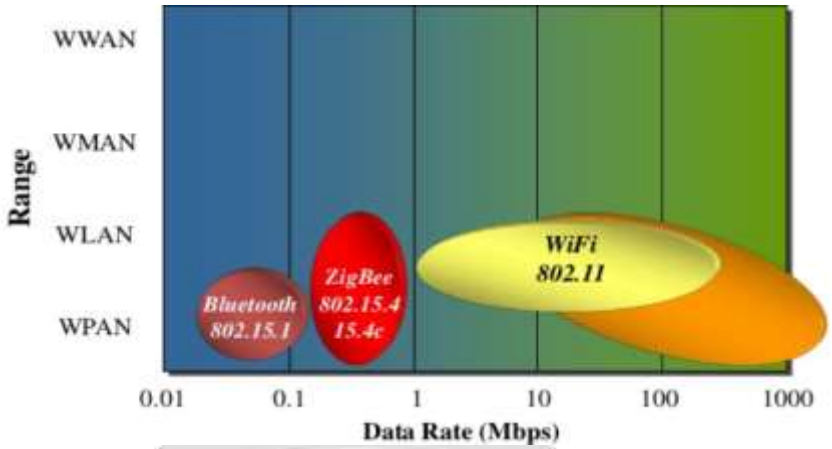


Chart -1: 802 Wireless Space

4. COLLABRATIVE DESIGN

- The Society for Scholarly Publishing (SSP) defines how to set up virtual serial ports and connect two Bluetooth enabled devices. Usage scenarios would be using two devices, such as PCS or Laptops, virtual serial ports and then connecting the two devices via Bluetooth technology.
- The full range of human hearing extends from 20- 20000 Hz. The accepted frequency range of human heart sounds is about 20-200 Hz and the accepted frequency range of human lung sounds is about 25-1500 Hz.

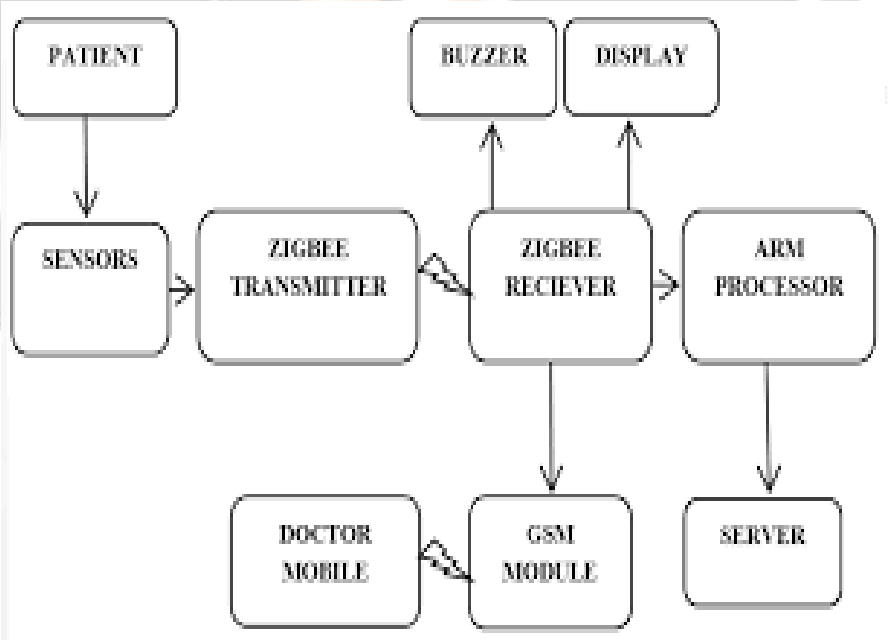
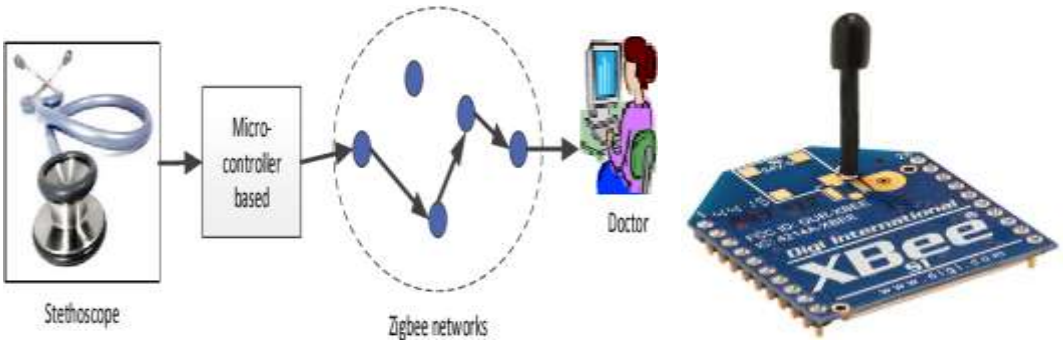


Fig -4: Human machine interface



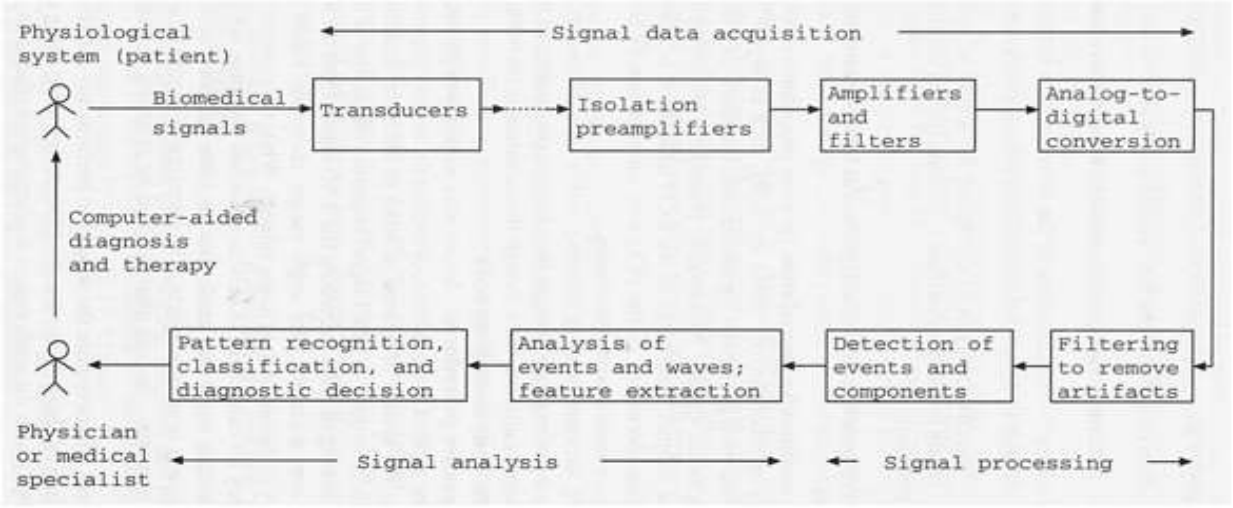


Fig -5: Tools and design

4.1 Evaluation

Development of the electronic stethoscope is gaining an edge over traditional stethoscope mainly due to the advanced sensor technologies, digital signal processing techniques as well as the digital sound transmission capabilities of digital stethoscopes.

Most stethoscope manufacturers are focusing on developing the devices with enhanced acoustics, better performance and innovative designs.

Unlike acoustic stethoscopes, which are all based on the same physics, transducers in electronic stethoscopes vary widely:

- The simplest and least effective method of sound detection is achieved by placing a microphone in the chest piece. This method suffers from ambient noise interference and has fallen out of favour.
- Another method, used in Welch–Allyn's Meditron stethoscope, comprises placement of a piezoelectric crystal at the head of a metal shaft, the bottom of the shaft making contact with a diaphragm.
- 3 M also uses a piezoelectric crystal placed within foam behind a thick rubber-like diaphragm.

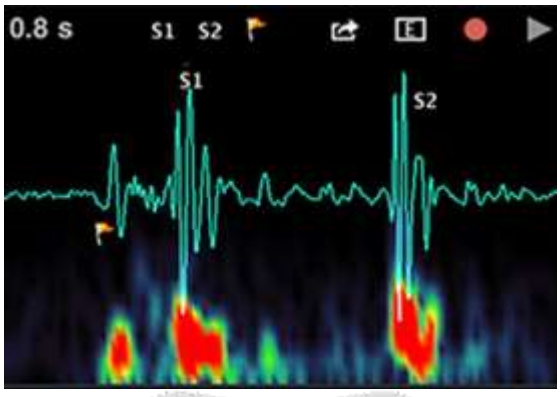


Fig -5: Two primary heart sounds: S1 and S2.

4.2 Features

Low level heart and lung sounds are amplified with clear audibility so that in noisy area also proper auscultation is possible. Noise reduction takes place by filter that's why accuracy increases. There is gain control facility provided by power amplifier and frequency selection facility provided by filter design. Heart sound can be stored on PC and accessed through internet to consult with other physician. Using Zigbee, wireless auscultation is possible and patient can be monitored by multiple physicians at a time.

5. CONCLUSION

An embedded digital stethoscope is designed and simulated by using an embedded processor. With the help of PC connectivity, system can also store data and replay for further analysis and consultation. It will help to improve the accuracy of the cardiovascular diseases diagnosis. Preamplifier is amplifying signal for gain 20. Designed filter is giving proper output until cut off frequency and showing attenuation above that frequency [23-24]. Frequency selection can be possible by selecting capacitor value with the help of switch. Gain of power amplifier can be controlled by changing value potentiometer connected at input due to which volume control is possible. Signal acquisition and signal pre-processing system of electronic stethoscope which is very important part of system is designed. With the help of Proteus software, circuit of signal preprocessing system is simulated. By simulation results it is clear that the designed circuit gives better heart and lung sounds. In future, network of multiple transmitters and receivers can be form by using Zigbee PRO. When there will be more transmitters, it means diagnosis of heart sound from multiple patients can be possible [25-27]. As there will be more than one receiver, more than one physician can hear heart sound at a time. It will increase accuracy of diagnosis.

6. REFERENCES

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