ABSTRACT-Acoustic stethoscope is primary diagnostic tool used by doctors for effective analysis of various diseases. But, it suffers defects such as low level sounds and presence of murmurs. This paper aims at developing ‘Wireless electronic stethoscope using Butterworth filter’. Low level heart sounds are amplified with high gain pre-amplifier circuit. A review of basic filters like low pass RC filter, Butterworth filter, Chebyshev filter and Bessel filter are done for elimination of murmurs and best suited filter is suggested. Finally, amplified noise free heart sounds are simulated and results are shown in Proteus 7.4. The results prove that efficient filter for designing is ‘Butterworth filter’. This work can be further extended for a hardware prototype where amplified noise free heart sounds are wirelessly transmitted using RF module which could be heard by headphones or stored for further analysis.

INTRODUCTION

Auscultation refers to the listening of heart sound in human body and the tool used for such purpose is known as a stethoscope. Traditional stethoscopes use mechanical means for auscultation resulting in poor sound quality and low accuracy as the signal can get affected by the listening capability of the doctor as well as by the unfavourable environment.[1-4] This paper proposes the design of low cost affordable wireless stethoscope based on RF technology to process the heart beat signal, which can transmit and stores the signal for further analysis. Previously implemented wireless electronic stethoscopes are based on Zigbee and Bluetooth technology which makes them a better choice for implementation of wireless stethoscope but keeping in mind the cost incurred for developing such systems we have to think for the alternatives to make the system affordable with a trade-off in terms of quality and cost, however zigbee and Bluetooth provides better sound quality but this problem is almost eliminated in RF based wireless stethoscope by using pre-amplifier, filter and power amplifier with variable gains to achieve the noise free results as proposed by zigbee and Bluetooth.

There are two major problems with the conventional stethoscope i.e. Low level sound and short time period analysis and some limitations are associated with current models of stethoscope available which includes lack of amplification of heart sound, variability of gain, storage of the analogy data [10-12] for further analysis etc. The proposed method empowers the user for varying the amplification as per there desired audible needs.

ILLITERATURE SURVEY

Rene Laennec, a French physician invented the first ever stethoscope in 1816. First of their kinds were comprised of wooden tubes having trumpet-like ends, since then this particular tool saw many improvements in itself such as binaural constructions, flexible
tubes and interactive designs but the basic functionality and use of mechanical means for listening the heart sound remained unchanged for almost one and a half century. Chien et al. in 2004 proposed an idea for wirelessly transmitting the heart sounds by using Bluetooth as a transmitting medium at both ends to display and store in a PDA as a phonocardiograph data. Jatupaisoon et al. [13-15]

In 2010 proposed a prototype for storing the heart beat sound filtering it by means of low pass filters, the purpose of this paper was focused on reducing the noise from the said data (Tang et al. in 2010), proposed a wireless electronic stethoscope by using Bluetooth in integration with embedded processors for displaying the data on LCD and storing the data for computer-aided diagnosis. (Harsola et al. 2011) proposed a design of Peripheral Interface Controller based electronic stethoscope for visualizing and storing of sound data suggesting that the stethoscope should be physically connected and data will be sent through Lab View. [16-17] (Gururajan et al. 2011) conducted a study based on different de-signs of wireless electronic stethoscopes and their feasibility based on user’s perspective to identify issues when using these stethoscopes in telemedicine and e-health platforms. (Patil, et al. 2012) proposed the design of contact vibration sensor to minimize the ambient noise in acquiring the heart sound signal, for wireless transmission the authors used Bluetooth for e-healthcare implementation. [18-21]

III.BODY SOUND

Heart sounds are referred to as acoustic waves generated by the resultant flow of blood and heartbeat. These vibrations are generated by opening and closing of systole/diastole valves. Heart sound is of two type waves i.e. S1 wave (Systole) and S2 wave (Diastole).

Sometimes the valve doesn’t work normally, either the valve doesn’t open properly which causes less blood flow or the valve doesn’t close tightly causing blood leak backwards, these abnormalities are referred to as murmurs. Murmurs can be systolic or diastolic as shown in (Fig. 2). Murmurs and heartbeats have band limit frequencies between 100-1000 Hz and have a relative low intensity that makes the human hearing perceptible to heart sound signal, [22-29] therefore the auscultation using acoustic stethoscopes seems to be a bit difficult. Keeping in view that the traditional stethoscopes have two sides for observing internal sounds, the bell and the diaphragm, different frequencies are used for diagnosis. One uses 20 – 500 Hz range for hearing heart sound and pumping of blood vessels and other uses 200–1000 Hz frequency range to listening respiratory signals 1 and 5. Considering the system architecture of traditional method a low pass filter is designed to eliminate the frequencies above
1000 Hz for reducing the noise, hence picking up sounds having low frequencies. [30-36]

IV. PROPOSED SYSTEM METHODOLOGY

Fig. 3. Transmitter

Heart sounds are picked up by chest piece of mechanical stethoscope. It is then amplified with high gain pre-amplifier. Murmurs are eliminated using “Low pass Butterworth filter” & wirelessly transmitted using RF module. Power amplifier is used for driving signals which could be heard by headphones or stored in MP3 player for further analysis.

Fig. 4. Receiver

IV.1. PREAMPLIFIER

A preamplifier is an electronic amplifier that prepares a small electrical signal for further amplification or processing. A preamplifier is often placed close to the sensor to reduce the effects of noise and interference. It is used to boost the signal strength to drive the cable to the main instrument without significantly degrading the signal-to-noise ratio (SNR). An OP-AMP (Operational Amplifier) is used in pre-amplifier section for achieving a voltage gain of 3. For achieving this, LM358 OP-AMP was chosen due to its low power consumption which draws a small amount of current and can be powered by a 3-volt DC supply, another reason for choosing LM358 OP-AMP is its low cost which helps us achieve two of three proposed objectives.

IV.2 FILTER

In order to minimize the murmurs occurring in heart sounds, analog low pass filters such as Low pass RC filter, Chebyshev filter, Bessel filters and Butterworth filter are designed and simulated using Proteus 7.4. Chebyshev filter, Bessel filters and Butterworth filter are designed using Sallen Key topology.

IV.2.1 Low-pass RC filter

Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations, and leaving the longer-term trend. Low-pass RC filter can be used for limiting the audible frequencies. [15-19] The cut-off frequency for this particular filter is set to be 500 Hz, which means that the frequencies below the cut-off frequencies will be passed and frequencies above the cut-off frequency will be left out.

IV.2.2 Chebyshev low pass filter

Chebyshev low pass filters are analog digital filters having a steeper roll-off and more passband ripple (type I) or stopband ripple (type II) than Butterworth filters. Chebyshev filters have the property that they minimize the error between the idealized and the actual filter characteristic over the range of the
filter, but with ripples in the passband. Because of the passband ripple inherent in Chebyshev filters, the ones that have a smoother response in the passband but a more irregular response in the stopband are preferred for some applications. [14-18]

**IV.2.3 Bessel low pass filter**

Bessel low pass filter is a type of analoglinear filter with a maximally flat group/phase delay (maximally linearphase response), which preserves the wave shape of filtered signals in the passband. Bessel filters are often used in audio crossoversystems. It is very similar to the Gaussian filter, and tends towards the same shape as filter order increases. This filter has bettershaping factor, flatter phase delay, and flatter group delay than a Gaussian of the same order, though the Gaussian has lower time delay. The timedomain step response of the Bessel filter has some overshoot, but less than common frequency domain filters.[18-19]

**IV.2.4 Butterworth low pass filter**

The Butterworth low pass filter is a type of signal processing filter designed to have as flat a frequency response as possible in the passband. It is also referred to as a maximally flat magnitude filter. The frequency response of the Butterworth filter is maximally flat (i.e. has no ripples) in the passband and rolls off towards zero in the stopband. Finally, simulated results in Proteus 7.4 proves that murmur is eliminated to a great extent in this filter. So, Butterworth LPF is used for design.

V. RF TRANSMITTER AND RECEIVER

Due to low cost RF modules used for transmitting and receiving heart signals. RF transmitter and receiver helps doctors in diagnosing signals irrespective of location and distance. [20-21] This module also helps in analysis of heart sounds by more doctors.
VI. AUDIO POWER AMPLIFIER

An audio power amplifier is an electronic amplifier that amplifies low-power audio signals (heart sounds composed primarily of frequencies between 20 - 200 Hz.) to a level suitable for driving headphones. Amplification is achieved by using LM386 which is a power amplifier and can achieve the gain up to 40.

VII. STORAGE

Heart sounds can be continuously recorded. This can be achieved by connecting condenser microphones [22-29] to headphones which are further connected to MP3 player, storing heart sounds. MP3 player can be interfaced with PC for further analysis.

VIII. SIMULATION AND RESULTS

Design of pre-amplifier, analog filters such as Low pass RC filter, Chebyshev LPF, Bessel LPF, Butterworth LPF are simulated using Proteus 7.4 and following results are obtained. [40-45] The designed architecture of entire circuit with pre-amplifier, Butterworth LPF and power amplifier are implemented in hardware.

Fig 8. Pansystolic murmur input
IX. CONCLUSION AND FUTURE WORK

A design of low cost wireless electronic stethoscope has been proposed and analysis based on simulations has been carried out in this paper. The proposed system have the functionality to store the data for further analysis and effective diagnosis hence improving the accuracy in diagnosis of cardiovascular diseases. The hardware design can be implemented in future with additional functionalities such as provision for viewing heard sounds in GLCD. This system will help doctors in accurate diagnosis and analysis of heart sounds.

X. REFERENCES

4. Parameswari, D., Khanaa, V., Deconstructing model checking with hueddot, International Journal of


17. Peter, M., Thooyamani, K.P., Srinivasan, V., A study on performance of the commodity market based on technical analysis,


31. Prakesh, S., Sherine, S., Forecasting methodologies of solar resource and PV power for smart grid energy management, International Journal of Pure and Applied Mathematics, V-
45. Pradeep, R., Vikram, C.J., Naveenchandran, P., Experimental evaluation and finite element
analysis of composite leaf spring for automotive vehicle, Middle - East Journal of Scientific Research, V-17, I-12, PP-1760-1763, 2013