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DEVELOPMENT OF A MODERN VISUAL STETHOPHONE USING GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS (GSM)

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Abstract- *Stethoscope is an essential device for cardio-pulmonary auscultation, which is very primary step of diagnosing diseases. This project focuses on a portable medical kit. It deals with developing a home diagnosis and tele-health care system, using GSM-based fully portable Stethophone. This device performs real-time auscultation after signal collection, signal processing and amplification. At the same time, the embedded processor samples the signal and gives output to LCD as well as compares the result with the standard result. In addition, the output data can be transmitted to a cellular phone via short message service using GSM module which can be a great help for tele-health care system.*

Keywords: Stethoscope, Auscultation, Tele-healthcare, Self-diagnosis

1. INTRODUCTION

During diagnosis and treatment of a patient primarily, stethoscopes are used regularly by medical personnel to listen to acoustic signals picked from the internal parts of the human body. Typically, signals that are picked from the body for diagnosis include that of the heart, lungs, and bowels [1].

From several years by now amplified electronic stethoscopes with noise filtering systems have been developed to improve diagnostic accuracy [2-3]. These solutions have allowed a better perception of biological sounds by the physician as well as the recording and the archiving of sounds acquired and developed a modern tele-health care system. However there remains the problem of the need for the doctor to be close to the patient to a certain range (for Bluetooth or zigbee module based stethoscope) or necessity of costly internet connection [4-5].

With our designed device, we meet these requirements obtaining an objective auscultatory home diagnosis as well as sending the systolic and diastolic pressure value compared with standard `value of a remotely located patient to a distantly located physician (tele-auscultation) by GSM module, using real-time spectral analysis of the biological sounds In fact, there is a deterministic relationship between the spectrum of biological sounds and pathologies [6-7]. We also give importance to improve sound quality, allow variable amplification of the sound and minimize interference noise.

2. ORIGIN AND PROPERTIES OF HEART SOUND

Heart sounds are produced by the movement of the valves and the turbulent flow of blood [2]. There are two classical sounds of heart, known as the first (Lub) and the second (Dub) sound and also there exists two other sounds, known as third and fourth sounds which can be detected by graphical recording. The first sound occurs at the onset of ventricular systole and is primarily composed of energy in the 30 Hz - 45 Hz range. It is caused by the closure of the atrioventricular valves and the vibrations set up in the valve leaflets due to increase in the intraventricular pressure. The second sound occurs at the onset of diastole and lies with maximum energy in the 50 Hz - 70 Hz range with higher pitch. It is caused by the closure of the semi-lunar valves in the aorta and pulmonary artery. The third sound, particularly heard in young adults takes place just after the second sound and coincides with the opening of the atrioventricular valves and is caused by the sudden rush of atrial blood into the ventricles. It is a weak vibration with its energy level at or below 30 Hz. The fourth sound also known as atrial sound is caused by the contraction of the atria and the rush of blood into the ventricles and has a low energy level below 30 Hz [7-8]. Thus, the heart sound information can be related as follows:

- first sound — mitral valve closure and tricuspid valve closure
- second sound — aortic and pulmonary valves closure
- third sound — termination of ventricular filling
- fourth sound — atria contract

Murmurs, which are additional sounds are heard in case of abnormal hearts and are caused either by improper opening of valves, regurgitation or due to a small opening in the septum, by passing the systemic circulation. It lies within a range of 100 Hz-1000 Hz.

3. SYSTEM DESIGN

System design consists of five essential parts that includes 1) Preamplification and filtering circuit, 2) Signal processing on embedded microcontroller, 3) Embedded visualization on 16x2 character LCD 4) Visualization of final result on PC and 5) Remote visualization on mobile device through sms. The measurements of the heart sound signals are transferred to the frequency band through a digital filter. We have chosen the frequency range 100-1000 Hz to judge any heart murmur.

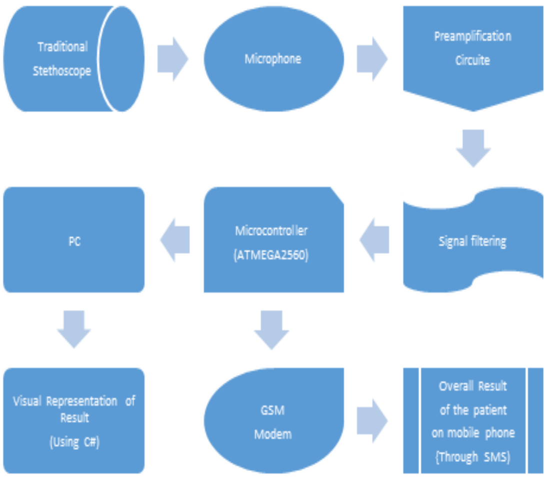

Fig. 3: Flow chart of our system.

3.1 Pre-amplification and Filtering Circuit

This part is signal acquisition and preprocessing system. First part is sensor. Microphone is preferred as a sensor for this application which gets signal from the chest piece and feed this signal to signal pre-processing module. Signal pre-processing circuit consists of two parts, which are amplification and filtering circuit. 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 of ATMEGA2560 microcontroller. This circuitry is designed by using operational amplifier LM324. The preamplifier is created to increase the low-signal from the condenser microphone to line-level for further amplification. It is having gain of 100 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.

3.2 Microcontroller

The ATMEGA2560 forms the central part of the system. The whole system is built around it. The arduino programming interface is used for programming. Some Features:

- Program Memory 256KB(Flash)
- CPU Speed 12 MIPS
- RAM Bytes 2,048
- Digital Communication Peripherals 4-A/E/USART, 2-MSSP(SPI/I2C)
- ADC 10 channel, 10-bit.

3.3 Embedded Visualization

We used a 16x2 character LCD to displays the numeric value of systolic and diastolic pressure and the BPM from acquired data. The user of the system can visually observe the data and make out his decision for the state of his health.

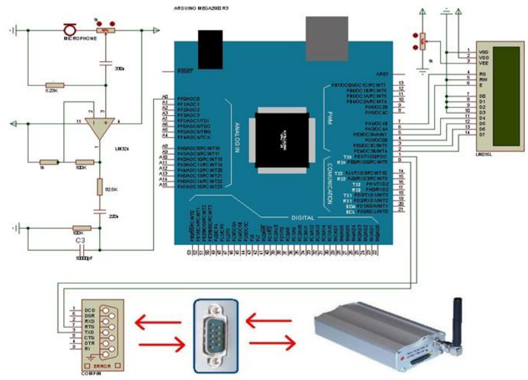

Fig. 3.3: A pre-amplification and filtering circuit with GSM & PC connectivity

3.4 Graphical Visualization of Result on PC

We have developed a visual interface using C-Sharp programming language that acquires data from the microcontroller through serial interface. The baud rate of this serial interface is 9600bps which can be adjusted as per requirement. The visual interface is updated on serial data receive event and usually the GUI updates on every 100 milliseconds. By analyzing the real time graph a doctor can give valuable opinion about the patient or the software compares the acquired data with a standard data set and publish a result based on comparison.

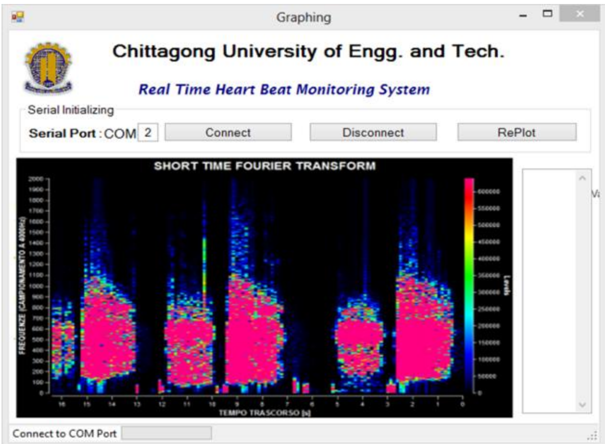

Fig 3.4: A GUI of real time graphing software.

4. SIMULATED SIGNAL PROCESSING IN MATLAB

To ascertain the performance of the electronic stethoscope design, a numerical model of the system was first created in MATLAB Simulink environment. Parameters used in the test model were: 14dB amplifier gain for the chest-piece circuit, variable (volume control) gain of 25.5 dB to 30 dB for the head-piece circuit, ATMEGA2560 microcontroller, and chirp waveform with frequency range of 10 Hz – 1 kHz as input source. Heart sound audio file is given as input shown in fig 4(a).

When it is check for filters with cut off 10 and 1000 Hz, it is noticed that proper amplified output is for 100 Hz frequency filter. Output at different stages is observed. It is shown in fig 4 (b) to fig 4(d). Simulation of circuit is done for different types of lung sounds like normal vesicular lung sound, Inspiratory stridor lung sound, Coarse crackles lung sound, Pleural friction lung sound and wheezing lung sound. It is observed that there is proper amplified output for filter with cut off 1000 Hz. Results of simulation for normal vesicular lung sound as input are shown. Input is in fig 4 (e). See the changes in output for filter which is shown in fig 4 (f). When lung sound is given as input and filter with cut off frequency 1000Hz is selected, better lung sound is obtained than that of when filter with cut off 100 Hz is selected. In same way simulation for other lung sounds (mentioned previous) is done.

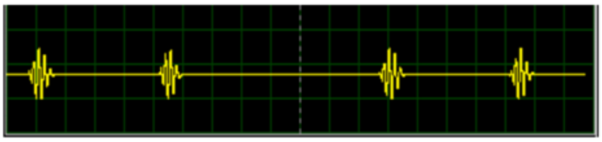

Fig. 4 (a): Heart sound as input

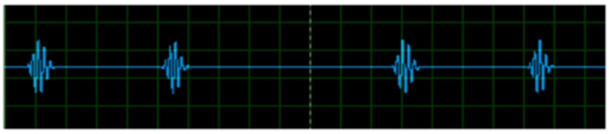

Fig. 4 (b): Output at preamplifier stage

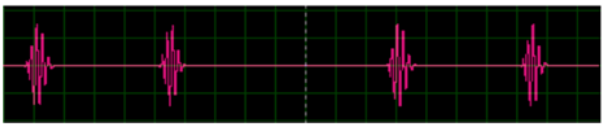

Fig 4 (c): Output at filter stage

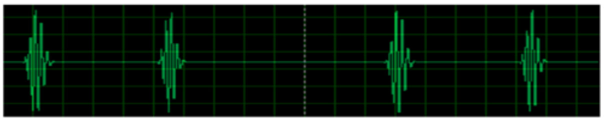

Fig. 4 (d): Output at Power amplifier stage

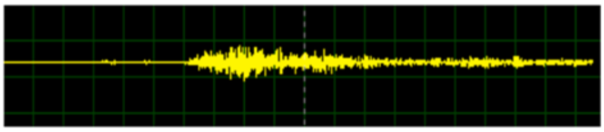

Fig. 4 (e): Normal vesicular lung sound as input

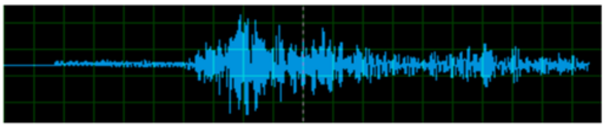

Fig. 4 (f): Output at Power amplifier stage when filter with cut off 100Hz

5. EXPERIMENTAL RESULTS

Several acquisitions of lung sounds and heart sounds have been analyzed with the electronic stethoscope. The comparable results indicates the reliability of the new diagnostic device. A few pictures are shown as examples of the sound spectrum. The sound spectrum of a tracheal sound acquired and recorded by the reference stethoscope and in Figure 5(a), the same sound acquired by the developed device in Figure 5(b) and 5(c).

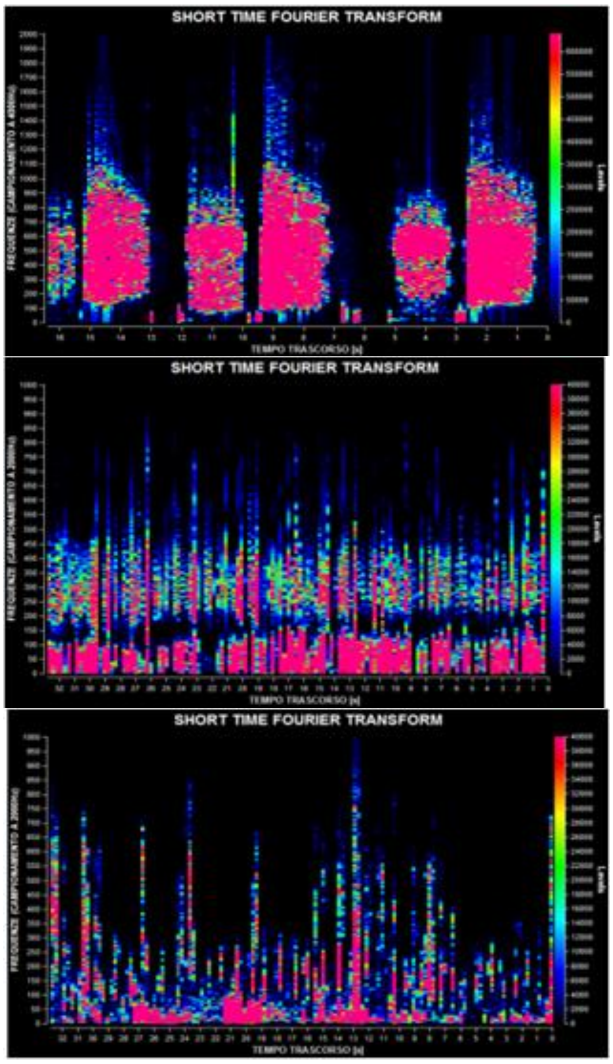

Fig. 5(a,b,c) : Heart and tracheal sound acquired by the reference electronic stethoscope

Remote transmission test were also performed to assess the feasibility and accuracy of a GSM Based Heart and Lung sounds Auscultation system. Our system performed well when we compared it with traditional (T) HLA.

6. RECOMMENDATION

In future, network of real-time transmitters and receivers can be formed by GPRS module. It will decrease the delay time and increase accuracy of diagnosis.

7. ACKOWLEDGEMENT

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8. CONCLUSION

In this paper, a novel design idea of integrating wireless GSM technology into a electronic stethoscope has been presented. GSM protocol is known for its effectiveness in long range peer-to-peer communication and can therefore offer long range high efficiency data transfer in a simple device. The designed device, able to objectify and to send compared value in real-time via GSM module, seems to be of great interest both to improve the diagnostic potential of one of the most simple, fast and completely devoid of drawbacks medical examination such auscultation, and for telemedicine applications that now seems affixed course for reducing healthcare costs and improve quality of life of chronically ill patients through the implementation of treatment protocols in homecare. The device is also very useful for monitoring patients through accurate comparisons of auscultation and reports the evolution of a disease. This type of monitoring can be shared with other doctors. It could be a great training tool on academic point of view.

9. REFERENCES

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