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Construction of a Low Cost Electronic Heart Sound Monitoring System

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ABSTRACT

Heart Auscultation is defined as the process of interpreting acoustic waves produced by the mechanical action of heart. It is a non-invasive, low-cost screening method and is used as a fundamental tool in the diagnosis of heart sound. The low cost heart sound monitoring system constructed in this work has 5 parts. The heart sounds are first acquired using a modified stethoscope fitted with normal condenser microphone. The acquired signals are fed in to simple audio amplifier which amplifies the original signal. Then a preamplifier is used to provide high amplification and better hum rejection. A low pass filter is used to filter the signal from the preamplifier. The graphical display of heart sounds were observed on a PC. This system is able to detect the heart sound of healthy individuals successfully.

1. INTRODUCTION

In the present scenario, rapid growth of medical electronics is possible due to the advent of microelectronics, imaging, microprocessors, transducers, data conversion techniques, digital signal processing etc. The progress in medical care is possible as mankind has acquired powerful tools to diagnose and prevent diseases. One of the most common tool is cardiography, which can detect electrical and mechanical defects of the heart thereby preventing heart diseases.

Though new advanced imaging techniques like ECG,MRI and CT provide more direct evidence, these techniques require expensive equipment, specialized technicians to operate, experienced cardiologists to interpret the result, high maintenance cost, a permanent place to be installed and generally require more resources to function properly. These requirements are usually met in advanced hospitals and not suitable in rural hospitals [1].

An important diagnostic tool is the analysis of heart sounds which are normally produced by various mechanical activities of the heart during the heart cycle. The principle cause of heart sound can be from the vibrations set up in the blood inside the heart by the closure of valves and leakage of blood flow. There are two classical sounds of heart, known as the first(S1) and the second(S2) sound as also there exist two other sounds, known as third(S3) and fourth(S4) sounds which can be detected by graphical recording (Figure1).[2]

- S1 occurs when the mitral and tricuspid valves closure.

- S2 results from closure of the aortic and pulmonic valves. S2 has higher pitch compared to S1.
- S3 occurs shortly after S2, due to rapid ventricular filling as soon as the mitral and tricuspid values open. It may be heard from young adult, athletes, and pregnant women.
- S4 occurs just before S1, at the time of atrial contraction.

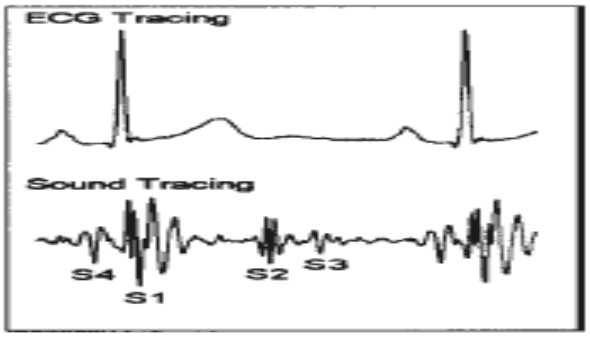

Figure1: PCG display against ECG [3]

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-600 Hz.

The objective of this work is to construct a low cost electronic device for recording heart sounds. Similar type of devices have been constructed by others (e.g. by D Patnaik (2003) [2]) but their construction, components used and software are different from the present construction and also the cost is higher. For example, the device constructed in [2] utilized a dynamic microphone directly but in the present work, an ordinary stethoscope has been used directly with modifications.

2. METHODOLOGY

Heart sounds is in the audible frequency range. In this work, it has been attempted to develop a heart sound monitoring system with lower cost, which will faithfully detect and amplify the heart sounds of healthy individuals. The data acquisition and graphical display will be taken by the sound card of PC. Heart sound signals were recorded using 'Cool Edit Pro' software. The block diagram of the developed system is shown in Figure 1.

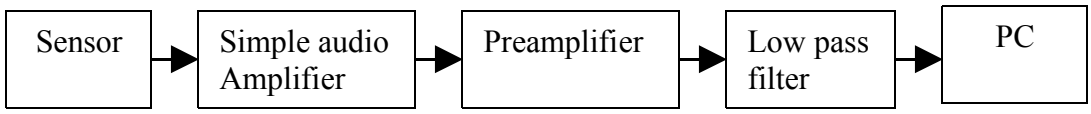

Figure 1: Block diagram of the heart sound monitoring system

The Sensor senses the physiological variable, *i.e.*, heart sound and generates an equivalent electrical signal. These signals are of very low amplitude and frequency usually below 600 Hz (heart sounds are less than 100Hz but murmurs lies within a range of 100Hz-600Hz). In this work a normal condenser microphone is used for detecting the heart sound. The output of sensor is fed to the BC547 based simple audio amplifier (if the output of sensor is fed directly to preamplifier, it is difficult to identify the heart signal), which amplifies the original signal. The circuit diagram of the simple audio amplifier is shown in the Figure 2 [4].

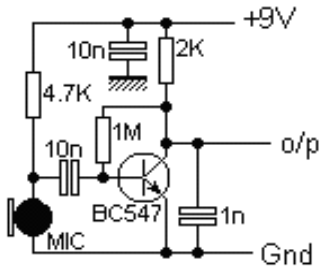

Figure 2: Circuit diagram of the simple audio amplifier

The output of simple audio amplifier is fed to the *LM*381 based preamplifier, which provides high amplification and better hum rejection. The circuit diagram of the preamplifier is shown in the Figure 3 [2].

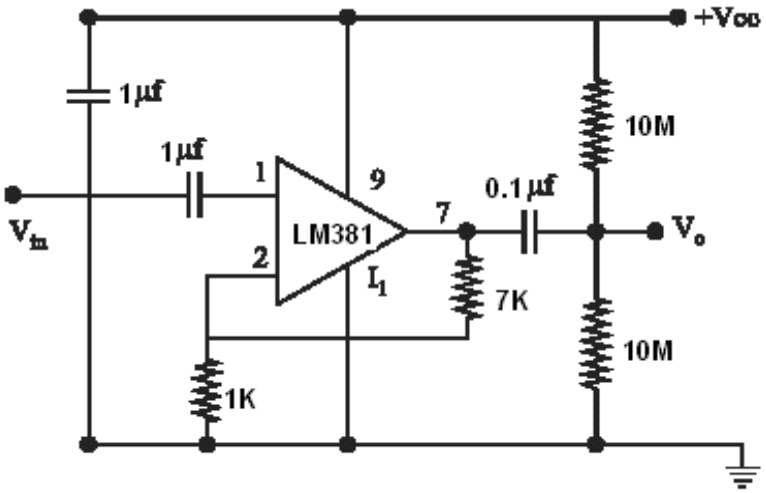

Figure 3: Circuit diagram of the preamplifier

The output of the preamplifier is fed to an active low pass filter shown in the Figure 4. Signals of frequencies below 600 Hz are of medical interest. The output signal from the filter is fed to sound card of PC. Heart sound signals were recorded using 'Cool Edit Pro' software.

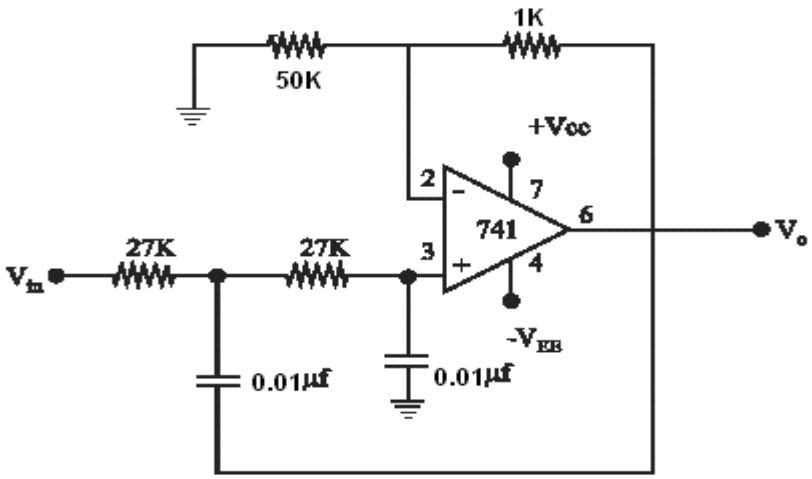

Figure 4: Circuit diagram of the active low pass filter

When the spectral view button in Cool Edit Pro is clicked, the frequency spectrum of recorded signal appears.

3. RESULTS AND DISCUSSION

The instrument constructed gave audible heart sounds of healthy individuals and the graphic display was observed on PC for different samples. Figure 5 shows a healthy individual's heart signal with time.

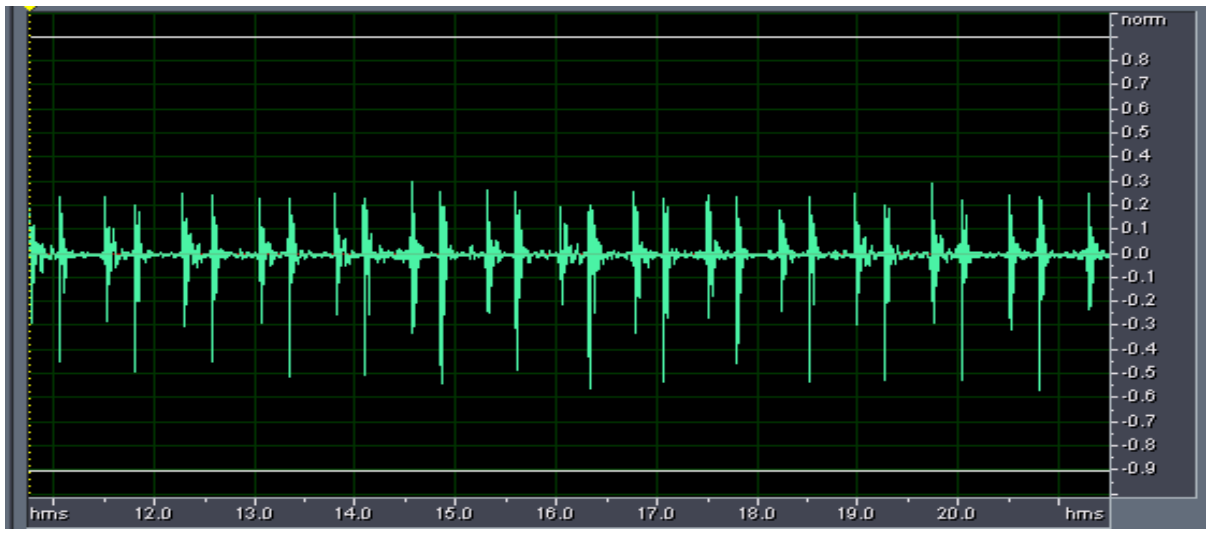

Figure 5: The output signal from the filter at 'Cool Edit Pro'

Figure 6 shows the frequency spectrum of recorded signal.

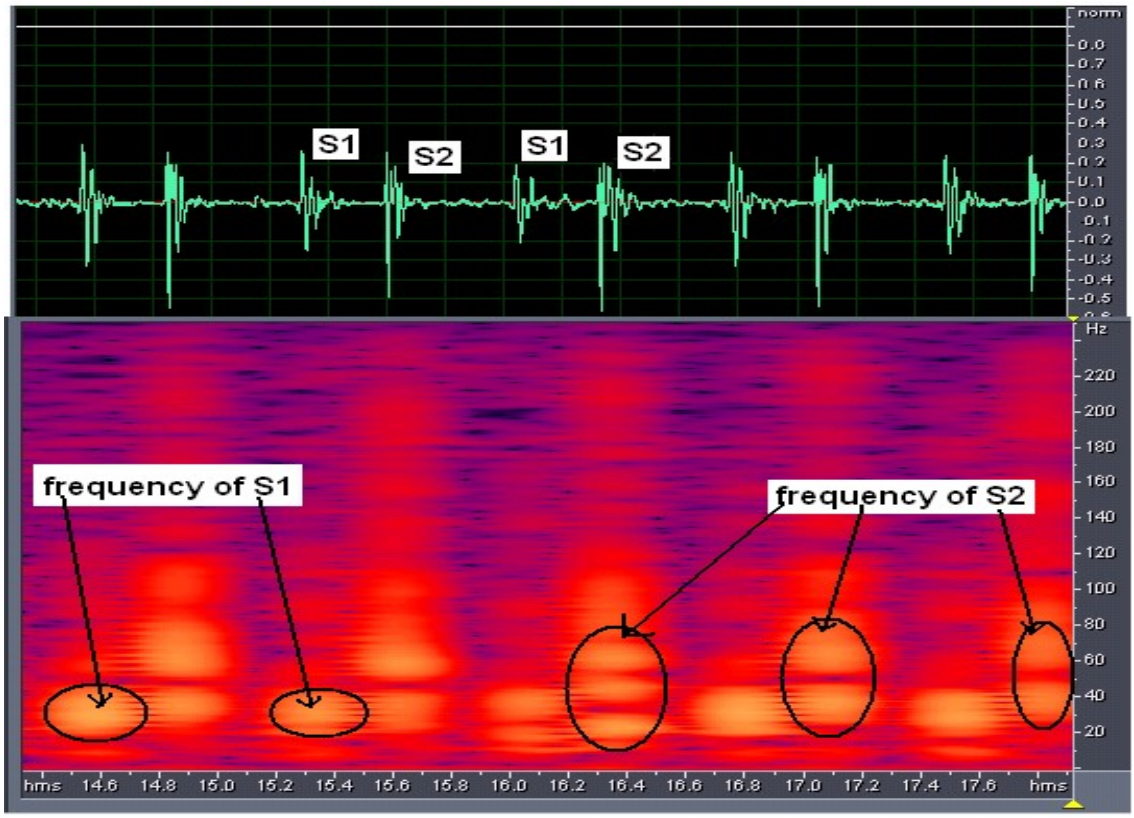

Figure 6: Frequency spectrum of the healthy individual.

Spectral view makes it easy to view the frequency components of a recorded signal with time. Bright colour represents frequencies in this range where they are high in amplitude (Figure 6). Frequency of first and second heart sounds of healthy individuals vary within the range of 15-100Hz as detected by the device constructed.

The potential of this construction is that a general physician can interact with this monitoring system and do a quick preliminary diagnosis of heart problems of patients who cannot be easily shifted to advanced hospitals which are at a distance and also who cannot afford high consultation fee and traveling cost. This monitoring system will be a step towards the development of efficient electronic medical care devices at low cost.

4. CONCLUSION

The heart sound monitoring system developed in this work is able to detect the heart sound of healthy individuals successfully. If it is successful after testing with heart patients, this low cost device may be a useful primary medical investigation tool at home care and rural hospitals. Therefore, the development of such instrument may help diagnosis of the defects in the heart condition economically and quickly under emergency situation by a normal physician. It has been possible to show that the frequencies of heart sounds of healthy

individuals vary within the range of 15-100Hz as detected by the device constructed in the present work.

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