Phonocardiogram & Temperature Measurement System using PIC Microcontroller

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Abstract— This paper focuses on development of a system which provides heart sounds, pulse rate and body temperature measurement of patient with microcontroller involving the advantage of GSM network (Biotelemetry). The paper describes how the required statistics of patient are measured by microcontroller in real-time. Further, it allows doctors to access the information for monitoring the patient through mobile communication. The system provides reading and transmission of values repeatedly through mobile communication. The hardware is being kept simple and easy for home use. The real time information helps doctors to diagnose present cardiovascular conditions of patient. The usefulness and efficiency of the proposed system is being demonstrated.

Key words: PIC Microcontroller, Phonocardiogram & Temperature Measurement

I. Introduction

Today we face a high increasing rate of heart diseases. A recent study shows that heart ailments has emerged as major cause of deaths in rural & urban India. By the time these are detected they reach in an advanced stage, hence an early diagnosis is required for treatment. Heart diseases linked with lifestyle, such as coronary heart disease and valvular heart diseases are of great concern [2].

Heart conditions of a patient require a prolong real-time observation to detect any problems with normal functioning of heart. Usually, doctors tell whether a person has a heart or blood vessel disorder on the basis of the medical history and after various diagnostic tests. Diagnostic results are used to confirm the extent and nature of the ailment for medication. There are many diagnostic tests that can help doctors make a rapid, precise diagnosis.

These include electrocardiography (ECG), ultrasonography (echocardiography), magneto cardiography (MCG) and magnetic resonance imaging (MRI) [1, 8]. These procedures are not always in immediate and regular reach of patient especially in case of rural India. Earlier back in 1920's ECGs and EEGs were first send through ordinary telephone signals. Morse code and voice audio were used for medical advises to sailors. As the technology grew telemedicine [3] came in to facilitate the medical services. In 1960's two way closed circuit television system facilitated the two way transmission of medical images as well as consultation between doctors. In 1970's satellite system were used which made distant communications possible.

Heart sounds are generated by the mechanical events that occur during the heart cycle. These sounds can be from the movement of the heart wall, closure of the walls and turbulence and leakage of blood flow. Valves are responsible for proper systolic and diastolic phases of heart. The frequencies of these sounds are generally in the range of 30 to 100 Hz and duration is between 25 to 100 ms [10, 11]. When heart beats the sound it produces is very much clear and sharp, but sometimes the sounds produced are much soft. These are known as Heart Murmurs which require proper attention. They don't always signify a problem but they need to be checked. Murmurs are produced when the valves don't function accordingly. These occur when the valves don't open completely and neither close tightly hence causes the heart to pump harder. It may be caused due to a hole in heart or a narrowed valve [4, 5]. Normally doctors use stethoscope to hear these sounds. However a stethoscope requires the patient to meet the doctor in person. Now, here the system comes in application as the sound could be recorded when the doctor is out of reach. Recording requires noise cancellation and amplification of the signal. Since all the process is in digital form there is no loss in the signal. Another important measure being done is of Pulse rate. It is the number of times a person's heart beats per minute. Pulse rate gives important information about health conditions and is measured routinely [6, 7]. Normal pulse rate of a human adult lies from 60 to 80. Abnormal pulse rate means that either it is slower, faster or irregular. Slower and higher pulse rate depicts any problem with electrical system of heart or may be any hormonal changes. Irregular heart beat should be taken care of as it signifies heart attack or any change in size of the heart. The system senses the pulse rate by variable absorption of IR through blood flowing in body tissues. The sensor is placed on fingertip where blood volume changes with heart beats. Hence the system provides complete necessary information to a distant doctor for immediate cardiac diagnosis and saves patient from any delay due to lack of amenities. Body temperature also plays an important role in patient's diagnosis. Every time a person visits doctor temperature is done always. Normal body temperature is 37°C (98.6°F). Any above is said to be in state of fever. It has been found in studies that heart rate increases at the rate of 10 beats per second for every one degree centigrade rise in body temperature. Hence it helps doctor to differentiate any heart problem from normal fever [9].

II. System concept & method

The phonocardiograph includes monitoring and plotting of heart sounds along with the measurement of heart rate. The work describes the design and development of computer based bio-medical instrument for monitoring the heart rate. The heart of the projects work is "Ultrasonic transducer" which converts the mechanical function of heart into electrical signals. Electrical signals from the heart characteristically precede the normal mechanical function and monitoring of these signals has great clinical significance. This system provides valuable information about a wide range of cardiac disorders such as pulse rate, electrical wave shape. Amplitude etc. this cardiograph can be used for routine diagnostic applications in cardiology. Although the electric field generated by the heart can be best characterized by vector quantities, it is generally convenient to directly measure only scalar quantities, i.e., a voltage difference of mv order between the given points of the body.

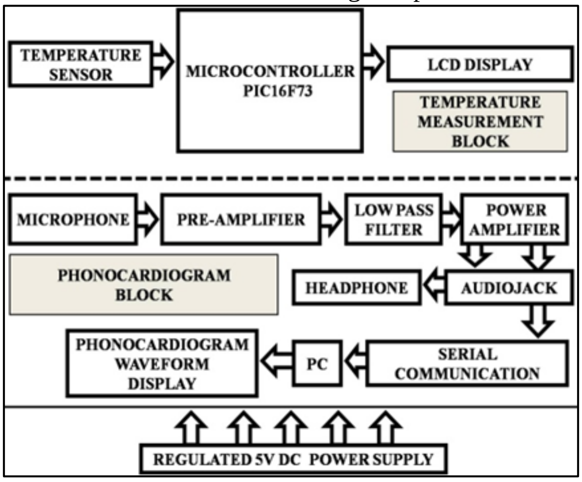

Fig. 1: Block Diagram representation of Phonocardiogram with Temperature Measurement

The diagnostically useful frequency range is usually accepted as 0.05 to 150Hz. The amplifier and writing part should faithfully reproduce signals in this range. A good low frequency response is essential to ensure stability of the base line. A Phonocardiogram or PCG is a plot of high fidelity recording of the sounds and murmurs made by the heart with the help of the machine called phonocardiograph, or "Recording of the sounds made by the heart during a cardiac cycle." Here we are developed the prototype of phonocardiogram by using sound amplifiers the heart beat is heard in headphone and also observing the spectrum on PC with that we used the PIC16F3 to display the temperature of body and environment.

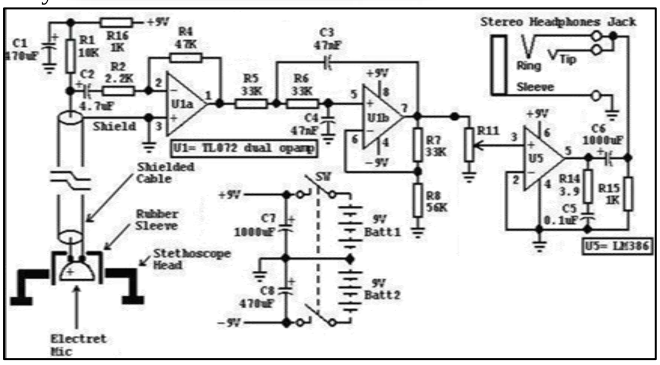

Fig. 2: Circuit Diagram of Phonocardiogram with Audio Output

In above system acquisition sensor is a low noise microphone preamplifier. Its gain is only about 3.9 because the high output impedance of the drain of the FET inside the electret microphone causes amplifier effective input resistor to be about 12.2K. C2 has a fairly high value in order to pass very low frequency (about 20 to 30Hz) heartbeat sounds. U1b operates as a low noise Butterworth low pass filter with a cut-off frequency of about 103Hz. R7 and R8 provide a gain of about 1.6 and allow the use of equal values for C3 and C4 but still producing a sharp Butterworth response. The roll-off rate is 12dB/octave. C3 and C4 can be reduced to 4.7nF to increase the cut-off frequency to 1KHz to hear respiratory or mechanical (automobile engine) sounds. The U4 circuit is optional and has a gain of 71 to drive the bicolour LED. U5 is a 1/4W power amplifier IC with built-in biasing and inputs that are referred to ground. It has a gain of 20. It can drive any type of headphones including low impedance (8 ohms) ones. The output of final stage amplifier is fed to the microphone input of PC. In pc there is spectrum analyzer software which shows change in wave spectrum with respect to heart beat.

The block diagram of phonocardiogram with temperature measurement is shown in the Fig. 3. The building blocks of project are given below:

1) DC 5V Regulated Power Supply (transformer, bridge rectifier, voltage regulator)
2) Microcontroller PIC16F873
3) LCD display
4) Serial communication to PC
5) LM35
6) Spectrum Analyzer PC Software
7) 9V Battery

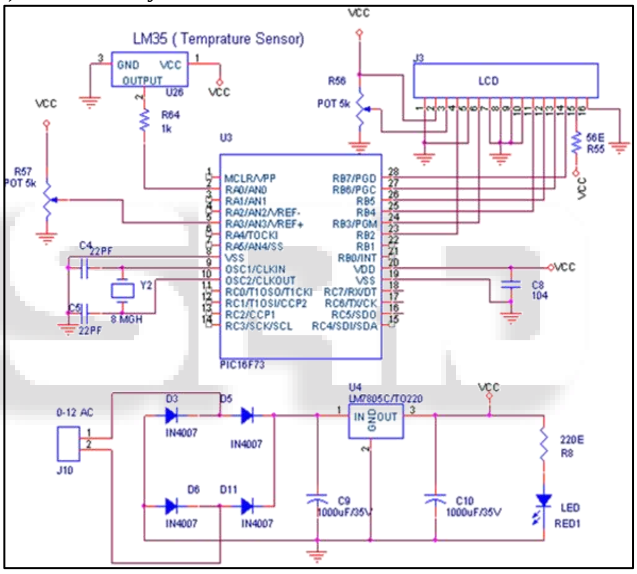

Fig. 3: Circuit Diagram of Phonocardiogram with Audio Output

III. RESULT & DISCUSSION

The heart sounds are acquired using a condenser microphone (electret) followed by a preamplifier circuit and a Butterworth low pass filter to eliminate noise components. The next stage is the power amplification of the signal. The amplified sound signal can be heard using a headphone connected with a audio jack. The sound signal is also given to the PC through an audio jack to display the acquired heart sounds on the computer screen as waveform with help of Spectrum Analyzer Software. This waveform is called 'Phonocardiogram'.

The system to acquire phonocardiogram and temperature is implemented and is shown below in Fig. 4.The output is checked and verified.

Fig. 4: Picture of the Phonocardiogram with Temperature Measurement

An additional feature of temperature measurement is added in the circuit. The temperature is measured using a temperature sensor (LM35) and displayed on an LCD using PIC167F3 Microcontroller. The system has a 05 Volt DC Regulated power supply and 9 Volt batteries as power sources.

IV. Conclusion

The use of personal computers in medical instrumentation has resulted in the integration of automation and built in intelligence in medical instruments to a great extent. This has resulted in replacement of long established recording techniques and display systems. The advantages of the PC architecture in terms of its high storage capacity of data and large screen displays have been fully exploited in clinical and research applications of biomedical instruments. In order to understand linkages between the life sciences and engineering techniques, it is necessary for engineers to have a fair understanding about the anatomy and physiology of the human body.

The power supply is the first step towards the design of this is innovative project, such that any ordinary computer can be converted as Cardio Scope. These types of designs are very well suited in the field of biomedical instrumentation. Based on this, the other information related to various parts of the human body is also can be displayed using the same A/D converter interfacing with different transducers. In addition to the information display, this information can be stored and print outs can be taken whenever we required. With the help of this project we can also develop a low cost heart beat rate counter.

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