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Heart Rate Monitor using Average of Two Fingertip Sensors with Graphical ECG Record

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Abstract: ***This project proposes the measurement of heart rate accurately using an average of two readings of two different fingertip sensors and feeding them to a microcontroller and record simultaneously the photoplethysmographic data, using which an ECG waveform is plotted. The earlier projects on this topic used only one fingertip sensor in calculating the heart rate. This lacked accuracy and thus, even if the projects were economical, they could not be used at small hospitals in rural areas and village clinics. Also, they lacked the feature of graphical ECG plot that may be extremely useful for diagnosis by the medical experts. Our project is based on obtaining the heart rate by averaging the readings of two fingertip sensors. The average is then fed to the microcontroller after proper signal conditioning, and then displayed on a LCD screen. The graph of electrical activity of the heart is displayed on a graphical LCD. Also, it features sending of SMS to family members via GSM module in case of an abnormal condition. The novelty in this project is increased accuracy.***

I. INTRODUCTION

Nowadays, with increased stress of workload and unhealthy eating habits of individuals, they are more prone to the risk of heart attacks and several other cardiovascular problems. In such cases, it calls for the regular and routine check up of the heart in order to prevent further complications. Microcontroller based Heart rate monitor is an effective and efficient way of knowing the state and activity of the heart with the help of pulse count, as it is not always possible to reach the hospital (in case of rural areas) and perform ECG. Thus, Microcontroller based Heart rate monitor can be used to measure heart rate at home.

The heart rate is a measure of cardiovascular activity of the heart. For a healthy adult, the resting heart rate is 72 beats per minute. During any physical activity, the heart rate rises and then again falls back to normal after the exercise. Heart rate lower than normal indicates a condition called Bradycardia. The actual heart rate is directly proportional to the pulse rate, thus somehow if we are able to count the pulses flowing through the fingertips, we will be able to get the heart rate. Now, this itself is a problem because in case of seriously ill cardiac patients and patients having other serious cardiovascular problems, the actual heart rate differs largely from the pulse rate. In such cases, it is very difficult to maintain the accuracy in measurement using fingertip sensors. This is because as we move farther from the heart, the variation between actual heart rate and measured pulse rate increases rapidly. Thus, it calls for increasing the accuracy of the measurement so that heart rate and pulse rate is almost similar and the error is minimal.

The projects made earlier on this topic have only a single fingertip sensor that gives a photoplethysmographic(PPG) reading which is then processed by the microcontroller and the reading is then displayed on a LCD screen. Our project makes use of two fingertip sensors and thus, two photoplethysmographic readings are obtained from two different parts of the body(i.e both the hands), the two readings are then averaged and thus a more accurate reading of heart rate may be obtained. This reading will be then sent to the signal conditioning circuit, having a low pass filter and amplifier, to obtain a much amplified and noise free PPG signal. This amplified signal is fed to a microcontroller, which based on certain precoded instructions displays the heart rate on a LCD screen. Along with that our project utilises a graphical LCD to plot the ECG waveform of the heart and a GSM module to send SMS to family members in case the heart rate is abnormal and there is a risk of cardiac arrest.

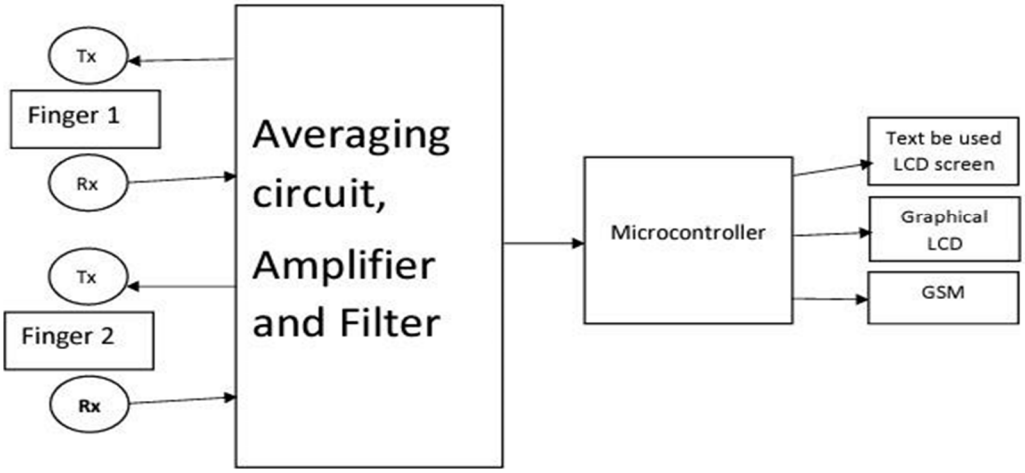
II. LITERATURE REVIEW

ECG is an expensive device and its use for the measurement of heart rate only is not economical. Although ECG is effective and accurate, it's cost becomes a major uneconomical issue. A low cost device is designed to measure heart rate of the subject by clipping sensors on one of the fingers and then displaying the result on a text based LCD. The device consists of an infrared LED transmitter and an infrared sensor photo-transistor. The LED emits infrared light into the finger of the subject, and the photo-transistor detects this light beam and measures the change in blood volume. This signal which is in the form of pulses is then amplified and passed through a low pass filter. The conditioned signal is then fed to microcontroller for analysis and display on a text based LCD. The output is a 3 digit number between 1 and 999. The circuit consists of an operational amplifier, an active low pass filter, a microcontroller and LCD.

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III. WORKING



The system consists of the following components :
2 IR LED Transmitter and IR Photo-transistor
Averaging Circuit
Amplifier
Low Pass Filter
Microcontroller
LCD Screen
Graphical LCD Screen
GSM

A. Photoplethysmography

Photoplethysmography refers to the estimation of volumetric measurement of blood optically. During the expansion of heart i.e, diastole, the volume of blood inside the finger tip increases. The pulse flowing through fingertip is directly proportional to the heart rate. During a heart beat, the volume of blood in the finger tip increases thus more IR waves are reflected. The blood volume pulse reflections are converted into a suitable current or voltage pulse by the sensor.

B. Infrared Led And Photo-Transistor

The pulses flowing through fingertips are obtained by LED transmitter and photo-transistor combination. When the infrared light from the LED transmitter passes through the tissues of the finger, the variations in blood volume regulates the amount of light falling on the photo-transistor which is the infrared detector. Two of these transmitter-sensor pairs are clipped on one finger each of both hands. The microcontroller counts the number of pulses over a fixed time interval and thus obtains heart rate of the subject. Such readings are obtained over a known period of time and are averaged. Here we considered the duration of measurement as 15 seconds. Thus, if no. of pulse counts in 15 seconds is T, then heart rate in beats per minute = 4T.

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C. Averaging Circuit

The averaging circuit is used for averaging the signals obtained from the two IR sensors. The averaging circuit may be a passive circuit or an active one. Here, in this paper, we propose the use of an active averaging circuit using OP-AMP.

D. Amplifier And Low Pass Filter

The amplifier is used to amplify the low magnitude voltage or current signal. The output of the sensor is amplified using Operational Amplifier. Here the use of instrumentation amplifier is proposed, which has high input impedance to reduce distortion of signal and high gain.

To reduce the noises associated with the signal and signal distortion, two Low Pass Filters are used. The filters proposed here are active Low Pass Filters, with cut-off frequency of 2.2 Hz. The gain of each stage is set to 100. The gain provided by this two stage filter is sufficient to boost the weak sensor output signal. It is converted into pulses. These pulses are given to the input of the Microcontroller.

E. Microcontroller

A microcontroller is a computer on chip, i.e, it consists of input, processor, memory and output. It is a programmable device. It has RAM, ROM and I/O Ports and Timers. The first Microcontroller developed was 8051 in 1980 by Intel. It was an 8 bit Microcontroller with 8 bit ALU, 16 bit program counter, 16 bit data pointer, 8 bit stack pointer, 8 bit PSW, 4 kB internal ROM, and 128 bytes internal RAM, and 6 interrupt sources. It has become obsolete nowadays. Families of Microcontrollers from Atmel Corporations have replaced 8051. The project proposes the use of PIC 16F877 Microcontroller. The PIC 16F877 is an 8 bit microcontroller which has on-chip 10 bit Analog to Digital Converter. The amplified and filtered signal is fed to the input port of the microcontroller. The analog data is then converted and stored in the memory of the microcontroller as two 8 bit unsigned integers. It then forms the message, and communicates with a mobile phone using GSM to send the message.

The Analog to Digital Converter converts the analog data into digital form. It is not used explicitly as PIC has an inbuilt A/D converter.

F. LCD Screen

Two LCD screens are used, one text-based and another, Graphical LCD. The text-based LCD is of type 16×2. The LCD module is connected to the output port of the microcontroller. It displays the heart rate based on the counting, and whether the rate is normal or higher or lower than normal. As the heart rate falls down below a threshold, a message indicating alarm is sent to the cellphone of family members.

The Graphical LCD is used for the plotting of ECG waveform which is plotted on the basis of the photoplethysmographic data acquired by the microcontroller. The text based LCD and the Graphical LCD are interfaced with the Microcontroller.

G. GSM

There is an internal TCP/IP stack in GSM/GPRS TTL Modem to enable the connection with the internet via GPRS. It is suitable for SMS as well as data transfer application in M2M interface. It requires only two wires (Tx, Rx) except the power supply to interface with the microcontroller. We can send SMS, data and read SMS through a simple AT command. There is an in-built Powerful TCP/IP protocol stack for internet and data transfer over the GPRS.

TTL is built with tri-band GSM/GPRS which is compact in size and enables direct connection to a 5V microcontroller.

IV. ADVANTAGES AND AREA FOR IMPROVEMENT

Advantages	Areas for Improvement
Useful in medical Applications and has less cost and size than ECG	A Data logger system can be added to keep a record of all readings and measurements.
Portable and more accurate due to the use of two fingertip sensors.	It can be made to act as an integrated unit in hospitals.

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Useful for village clinics, small hospitals in remote areas and for individuals who live far from their families.	The ECG graph and data can be transmitted to a computer for keeping record and analysis.
Graphical record of heart activity can be provided for medical reference and expert analysis.	It can be modified for the measurement of oxygen level in the blood, blood pressure and temperature.
It can be modified to measure the oxygen level in blood i.e Pulse Oximetry and for measurement of Blood pressure and temperature using non-invasive techniques.	Phonocardiogram can be added to obtain heart sounds. Also, a Vectorcardiograph plotting system can be added for further medical diagnostics.

V. RESULT AND CONCLUSION

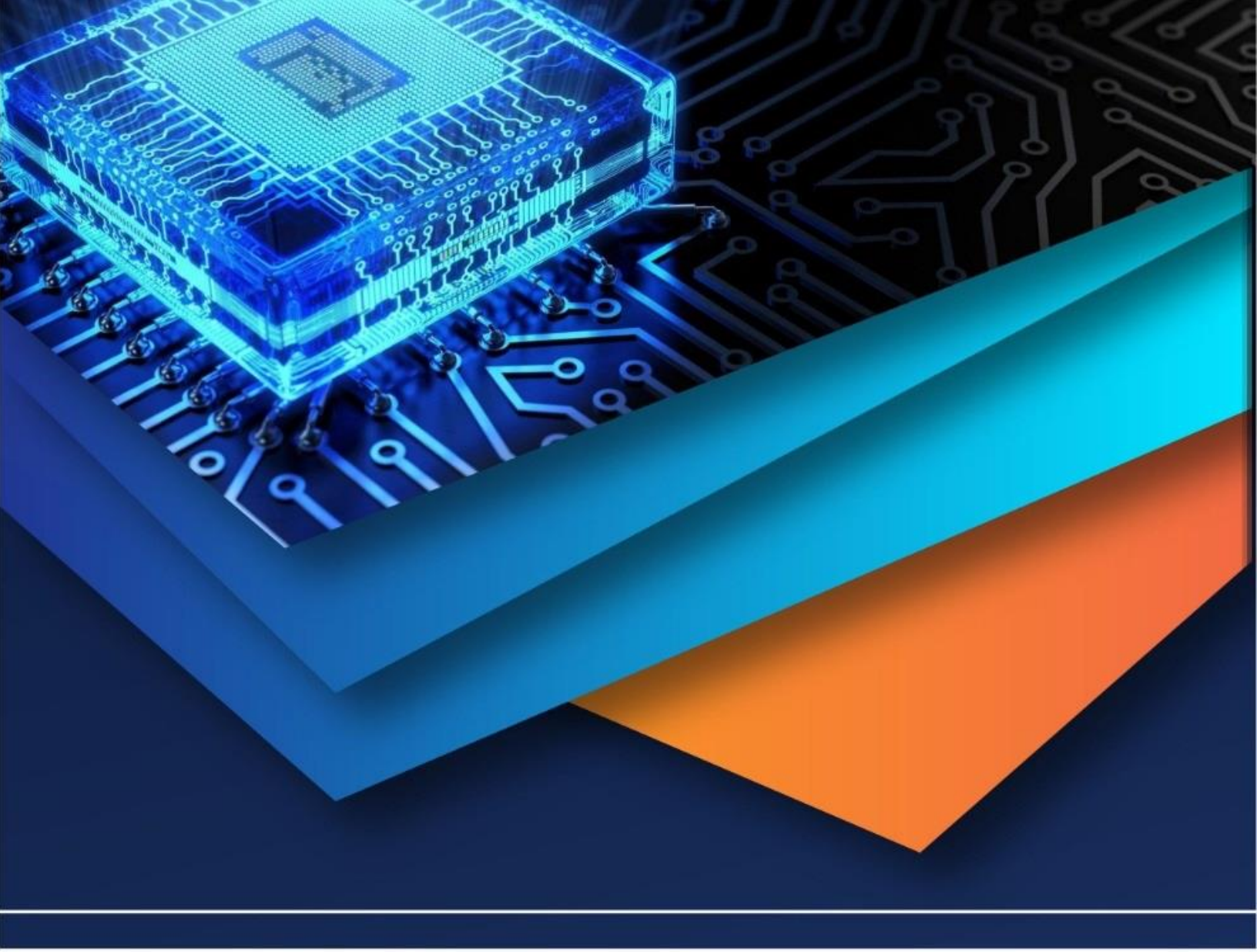
The design of a low cost, portable, accurate and easy to use Heart rate monitor is described. The advantages of this device are:

A. Each reading is the average of two readings from the two fingertip sensors, so it is more accurate.
B. It has a graphical LCD for obtaining ECG.
C. It has the feature of sending SMS to the family of the subject in alarming situations.
D. It can be used by unprofessional people at their homes, and also by medical professionals at remote locations such as village clinics and small rural hospitals.

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