HEART RATE MONITORING SYSTEM

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ABSTRACT

Heartbeat Sensor is an electronic device that is used to measure the heart rate i.e. speed of the heartbeat. Monitoring body temperature, heart rate and blood pressure are the basic things that we do in order to keep us healthy. In order to measure the body temperature, we use thermometers and a sphygmomanometer to monitor the Arterial Pressure or Blood Pressure. Heart Rate can be monitored in two ways: one way is to manually check the pulse either at wrists or neck and the other way is to use a Heartbeat Sensor. Pulse oximetry is used in this project to detect the heartbeat using fingers. When the heart expands (diastole) the volume of blood inside the fingertip increases and when the heart contracts (systole) the volume of blood inside the fingertip decreases. The resultant pulsing of blood volume inside the fingertip is directly proportional to the heart rate and if you could somehow count the number of pulses in one minute, that's the heart rate in beats per minute (bpm). For this an IR transmitter/receiver pair (LED) placed in close contact with the fingertip. When the heart beats, the volume of blood cells under the sensor increases and this reflects more IR waves to sensor and when there is no beat the intensity of the reflected beam decreases. The pulsating reflection is converted to a suitable current or voltage pulse by the sensor. The sensor output is processed by suitable electronic circuits to obtain a visible indication (digital display).

Keywords: Heartbeat, Heart rate, Pulse Oximetry, Fingertip Sensor, Microcontroller

INTRODUCTION

Monitoring heart rate is very important for athletes, patients as it determines the condition of the heart (just heart rate). There are many ways to measure heart rate and the most precise one is using an Electrocardiography, but the more easy way to monitor the heart rate is to use a Heartbeat Sensor. It comes in different shapes and sizes and allows an instant way to measure the heartbeat. Heartbeat Sensors are available in Wrist Watches (Smart Watches), Smart Phones, chest straps, etc. The heartbeat is measured in beats per minute or bpm, which indicates the number of times the heart is contracting or expanding in a minute. In this project we show that how we monitor the heart beat by pulse oximetry technique. In this project we use innovative technique to measure the heart beat measurement.(Okeoghene Enalume 2017) This is achieve by pulse oximetry logic. We use this technique to get the pulse from body and to amplify the signal and display this data on the LCD. A pulse oximeter is a particularly convenient non-invasive measurement instrument. A pulse oximeter measures the amount of oxygen in a patient's blood by sensing the amount of light absorbed by the blood in capillaries under the skin. In a typical device, a sensing probe is attached to the patient's finger with a spring-loaded clip or an adhesive band. On one side of the probe is a pair of Light- Emitting Diodes (LEDs), and on the other side is a photodiode. One of the LEDs produces red light, and the other produces infrared light. Pulse oximetry depends on the optical characteristics of hemoglobin, the blood protein that carries oxygen. When hemoglobin is more highly oxygenated, it becomes more transmissive to red light and more absorptive to infrared light. When hemoglobin contains little oxygen, it becomes relatively more transmissive to infrared, and more absorptive to red light. This property means that by measuring the ratio of red light to infrared light passing through the patient's finger, the probe can produce a signal proportional to the amount of oxygen in the blood. In addition, the surge of blood on each heartbeat generates a signal representative of the patient's pulse rate("Website" n.d.).

RECENT PROGRESS

Over the last 20 years, heart rate monitors (HRMs) have become a widely used training aid for a variety of sports. The development of new HRMs has also evolved rapidly during the last two decades. In addition to heart rate (HR) responses to exercise, research has recently focused more on heart rate variability (HRV). Increased HRV has been associated with lower mortality rate and is affected by both age and sex. During graded exercise, the majority of studies show that HRV decreases progressively up to moderate intensities, after which it stabilises. There is abundant evidence from cross-sectional studies that trained individuals have higher HRV than untrained individuals. The results from longitudinal studies are equivocal, with some showing increased HRV after training but an equal number of studies showing no differences. The duration of the training programmes might be one of the factors responsible for the versatility of the results. HRMs are mainly used to determine the exercise intensity of a training session or race. Compared with other indications of exercise intensity, HR is easy to monitor, is relatively cheap and can be used in most situations. In addition, HR and HRV could potentially play a role in the prevention and detection of overtraining. The effects of overreaching on submaximal HR are controversial, with some studies showing decreased rates and others no difference. Maximal HR appears to be decreased in almost all 'overreaching' studies. So far, only few studies have investigated HRV changes after a period of intensified training and no firm conclusions can be drawn from these results. The relationship between HR and oxygen uptake (VO (2)) has been used to predict maximal oxygen uptake (VO2max)). This method relies upon several assumptions and it has been shown that the results can deviate up to 20% from the true value. The HR-VO(2) relationship is also used to estimate energy expenditure during field conditions. There appears to be general consensus that this method provides a satisfactory estimate of energy expenditure on a group level, but is not very accurate for individual estimations. The relationship between HR and other parameters used to predict and monitor an individual's training status can be influenced by numerous factors. There appears to be a small day-to-day variability in HR and a steady increase during exercise has been observed in most studies. Furthermore, factors such as dehydration and ambient temperature can have a profound effect on the HR-VO(2) relationship.(Achten and Jeukendrup 2003)

Recent advancement in wearable technologies, particularly smart watches embedded with powerful processors, memory subsystems with various built-in sensors such as accelerometer, gyroscope and optical sensor in one single package has opened a whole new application space. One of the main applications of interest is the monitoring of movement patterns, heart rate, ECG and PPG particularly for longer durations in natural environments.The heart rate acquired from the smartwatch is reasonably accurate with a high degree of correlation. (Phan et al. 2015)

Wearable sensors have diagnostic, as well as monitoring applications. Their current capabilities include physiological and biochemical sensing, as well as motion sensing(Teng et al. 2008)(Bonato 2010). It is hard to overstate the magnitude of the problems that these technologies might help solve. Physiological monitoring could help in both diagnosis and ongoing treatment of a vast number of individuals with neurological, cardiovascular and pulmonary diseases such as seizures, hypertension, dysrhythmias, and asthma. Home based motion sensing might assist in falls prevention and help maximize an individual's independence and community participation.

Integrating physiological monitoring in a wearable system often requires ingenious designs and novel sensor locations. For example, Asada et al.(Asada et al. 2003) presented a ring sensor design for measuring blood oxygen saturation (SpO2) and heart rate. The ring sensor was completely self-contained. Worn on the base of the finger (like a ring), it integrated techniques for motion artifact reduction, which were designed to improve measurement accuracy. Applications of the ring sensor ranged from the diagnosis of hypertension to the management of congestive heart failure. A self-contained wearable cuff-less photoplethysmographic (PPG) based blood pressure monitor was subsequently developed by the same research group (Shaltis, Reisner, and Asada 2006). The sensor integrated a novel height sensor based on two MEMS accelerometers for measuring the hydrostatic pressure offset of the PPG sensor relative to the heart. The mean arterial blood pressure was derived from the PPG sensor output amplitude by taking into account the height of the sensor relative to the heart.

Another example of ingenious design is the system developed by Corbishley et al. (Corbishley and Rodríguez-Villegas 2008) to measure respiratory rate using a miniaturized wearable acoustic sensor (i.e. microphone). The microphone was placed on the neck to record acoustic signals associated with breathing, which were band-pass filtered to obtain the signal modulation envelope. By developing techniques to filter out environmental noise and other artifacts, the authors managed to achieve accuracy greater than 90% in the measurement of breathing rate. The authors also presented an algorithm for the detection of apneas based on the above-described sensing technology.

In recent years, physiological monitoring has benefited significantly from developments in the field of flexible circuits and the integration of sensing technology into wearable items (Barbaro et al. 2010). An ear-worn, flexible, low-power PPG sensor for heart rate monitoring was introduced by Patterson et al.[1] . The sensor is suited for long-term monitoring due to its location and unobtrusive design. Although systems of this type have shown promising results, additional work appears to be necessary to achieve motion artifact reduction (Yan and Zhang 2008)(Wood and Asada 2007). Proper attenuation of motion artifacts is essential to the deployment of wearable sensors. Some of the problems due to motion artifacts could be minimized by integrating sensors into tight fitting garments. A comparative analysis of different wearable systems for monitoring respiratory function was presented by Lanata et al. (Lanatà et al. 2010). The analysis showed that piezoelectric pneumography performs better than spirometry. Nonetheless, further advances in signal processing techniques to mitigate motion artifacts are needed.

Biochemical sensors have recently gained a great deal of interest among researchers in the field of wearable technology. These types of sensors can be used to monitor the bio-chemistry as well as levels of chemical compounds in the atmosphere (e.g. to facilitate monitoring people working in hazardous environments). From a design point of view, biochemical sensors are perhaps the most complex as they often require collection, analysis and disposal of body fluids. Advances in the field of wearable biochemical sensors has been slow, but research has recently picked up pace due to the development of micro and nano fabrication technologies [2]. For example, Dudde et al. (Dudde et al. 2006) developed a minimally-invasive wearable closed-loop quasi-continuous drug infusion system that measures blood glucose levels and infuses insulin automatically. The glucose monitor consists of a novel silicon sensor that continuously measures glucose levels using a microperfusion technique and continuous infusion of insulin is achieved by a modified advanced insulin pump. The device has integrated Bluetooth communication capability for displaying and logging data and receiving commands from a personal digital assistant (PDA) device(Patel et al. 2012).

MATERIAL AND DESIGN

This study used Both hardware and software component. **Hardware components** included:

1. **The fingertip sensor**
   The heart rate monitor builds to test the value of users' heart rate currently. The circuit will base on the non-invasive PPG sensor which detects the variation of the blood flow in finger when the mechanical contraction of heart. The sensor contains an infrared LED as an IR transmitter and photodiode as an IR receiver(Ravi 2017). The light intensity of the infrared and red light is measured by the photodetector after it has passed through the finger. Electronically, the heart rate monitor consists of the following:

   a. Analog signal conditioning and/or processing
   b. Data acquisition
   c. Digital signal processing
   d. Display and control system

2. **Intel MCS-51 MICROCONTROLLER (8051)**
   The 8051 Microcontroller was designed in 1980's by Intel. Its foundation was on Harvard Architecture and was developed principally for bringing into play in Embedded Systems. At first it was created by means of NMOS technology but as NMOS technology needs more power to function therefore Intel re-intended Microcontroller 8051 employing CMOS technology and a new edition came into existence with a letter 'C' in the title name, for illustration: 80C51. These most modern Microcontrollers need fewer amount of power to

function in comparison to their forerunners(Agarwal 2014).There are two buses in 8051 Microcontroller one for program and other for data. As a result, it has two storage rooms for both program and data of 64K by 8 size. The microcontroller comprise of 8 bit accumulator & 8 bit processing unit. It also consists of 8 bit B register as majorly functioning blocks and 8051 microcontroller programming is done with embedded C language using Keil software. It also has a number of other 8 bit and 16 bit registers.For internal functioning & processing Microcontroller 8051 comes with integrated built-in RAM. This is prime memory and is employed for storing temporary data. It is unpredictable memory i.e. its data can get be lost when the power supply to the Microcontroller switched OFF("Heart Rate Monitor Using 8051 Microcontroller .measures the Heart Rate from Finger Tip" 2013).

3. **OTHER AUXILIARY COMPONENTS**

These include components that are either basic requirement or are employed for other necessary functions.

TABLE I: Components List

COMPONENT	USE
9v DC Battery	Required for circuit component
Battery Clips Connector	Required for Battery
20pf capacitors	Required by crystal oscillator of the microcontroller
Button Switch	Required for MCU's reset
Resistors	Required by the fingertip sensor and microcontroller
LEDs	For the circuit
LCD Display	Display

The software component:

There are several software tools that have been used to program the system. The microcontroller needs to program using their own software before the system operated.

Here keil compiler was used to code the program.

CIRCUIT DESIGN:

The diagram here shows the circuit diagram.

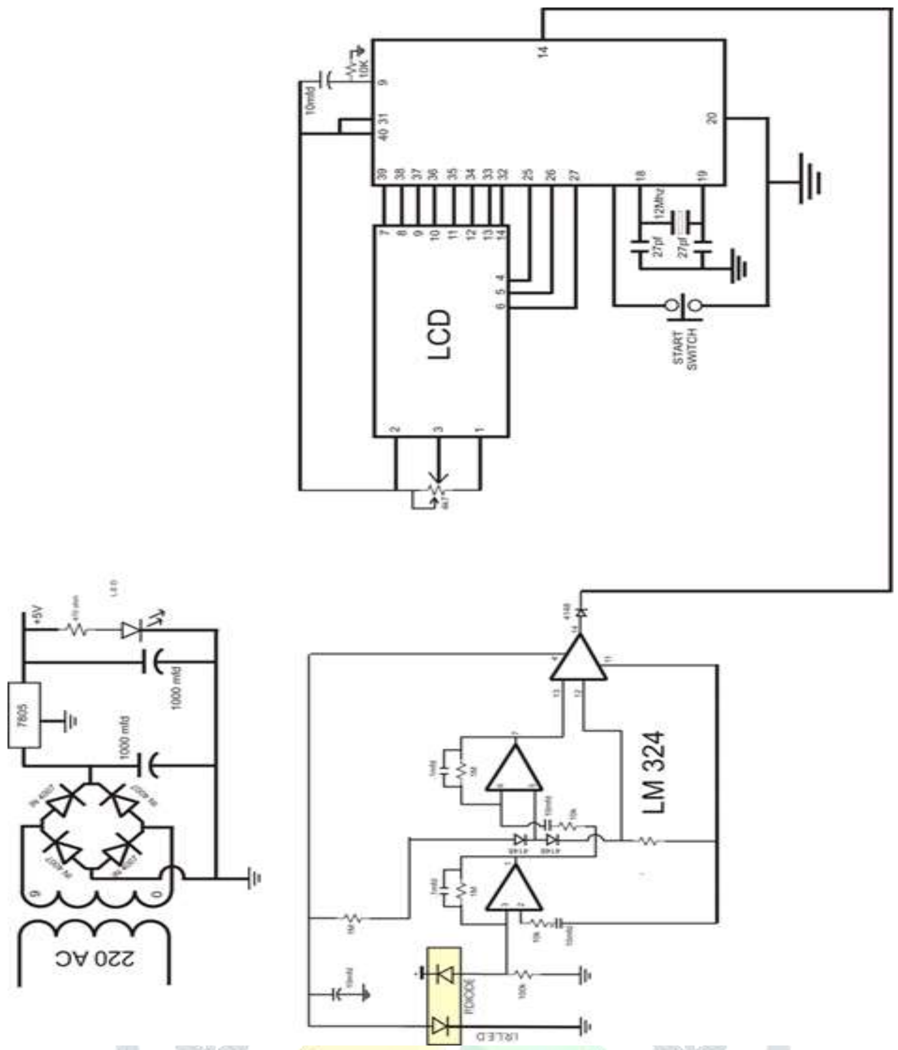

Figure 1: Circuit Diagram

WORKING

A pulse oximeter measures the amount of oxygen in a patient's blood by sensing the amount of light absorbed by the blood in capillaries under the skin. In a typical device, a sensing probe is attached to the patient's finger with a spring-loaded clip or an adhesive band. On one side of the probe is a pair of Light- Emitting Diodes (LEDs), and on the other side is a photodiode. One of the LEDs produces red light, and the other produces infrared light. Pulse oximetry depends on the optical characteristics of hemoglobin, the blood protein that carries oxygen. When hemoglobin is more highly oxygenated, it becomes more transmissive to red light and more absorptive to infrared light. When hemoglobin contains little oxygen, it becomes relatively more transmissive to infrared, and more absorptive to red light. This property means that by measuring the ratio of red light to infrared light passing through the patient's finger, the probe can produce a signal proportional to the amount of oxygen in the blood. In addition, the surge of blood on each heartbeat generates a signal representative of the patient's pulse rate(Dwivedi 2014).
Since the output of the photodiode is a low amplitude current, some signal conditioning must be applied before it can be used. Operational amplifier is an ideal choice for use in a resistor-feedback transimpedance amplifier configuration. This configuration is also used in other bioelectric sensing applications. The resulting output voltage is read by an analog-to-digital converter on a microcontroller microcontroller calculates the ratio of red light to infrared light, and determines the corresponding oxygen saturation level using a lookup table. This value is then sent via serial communications link to a data acquisition system, or, in the care of a stand-alone pulse oximeter, displayed for the user. In this project we show that how we monitor the heart beat by pulse oximetry technique. In this project we use innovative technique to measure the heart beat measurement. This is achieve by pulse oximetry logic. We use this technique to get the pulse from body and to amplify the signal and display this data on the lcd .We use this technique

in the exercise machines, where measurement of the heartbeat is very much important for controlling the speed of treadmill automatically.
A pulse oximeter is a particularly convenient noninvasive measurement instrument. Typically it has a pair of small light-emitting diodes (LEDs) facing a photodiode through a translucent part of the patient's body, usually a fingertip or an earlobe. One LED is red, with wavelength of 660 nm, and the other is infrared, 905, 910, or 940 nm. Absorption at these wavelengths differs significantly between oxyhemoglobin and its deoxygenated form; therefore, the oxy/deoxyhemoglobin ratio can be calculated from the ratio of the absorption of the red and infrared light. The absorbance of oxyhemoglobin and deoxyhemoglobin is the same (isosbestic point) for the wavelengths of 590 and 805 nm; earlier oximeters used these wavelengths for correction for hemoglobin concentration.
The monitored signal bounces in time with the heart beat because the arterial blood vessels expand and contract with each heartbeat. By examining only the varying part of the absorption spectrum (essentially, subtracting minimum absorption from peak absorption), a monitor can ignore other tissues or nail polish and discern only the absorption caused by arterial blood. By examining only the varying part of the absorption spectrum (essentially, subtracting minimum absorption from peak absorption), a monitor can ignore other tissues or nail polish and discern only the absorption caused by arterial blood. As we insert the finger in the tube, then light is crossed through the finger and focus on the photodiode. Photodiode resistance is to change as per the light on the photodiode is to be change. Photodiode is connected to the op-amp amplifier. Here we use LM324 amplifier IC. Here op-amp work as an amplifier circuit.The light emitted from the LEDs were transmitted through the skin and detected by photodiodes. An infrared rejection filter photodiode was then placed across from the red LED in order to detect transmitted red light and prevent infrared light interference. Photodiodes were then connected to a transimpedance amplification circuit that converted the current to an appropriately-enhanced voltage signal.
The LM324 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems.
For example, the LM124 series can be directly operated off of the standard a 5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional g15V power supplies.
Change of signal is further converted into pulse. We count the pulses with the help of the 89s51 controller, internal timer (counter). Count pulses within 60 second is further converted into ASCII code for LCD display. Here we use alphanumeric LCD to display the total pulse count. On this LCD we display the content of any value is only in ASCII code.

RESULT

Figure 2: Project Hardware

The heart rate monitoring system was successfully made and worked fine. The Heartbeat Monitoring System is the part of Patient Monitoring System, can be extended to measure other parameters of patient like ECG & temperature etc. Heart Beat is measured by passing a high intensity red light through a finger which is collected by LDR, amplified and displayed over an LCD display via microcontroller.

CONCLUSION

Biomedical engineering (BME) is the application of engineering principles and techniques to the medical field. It combines the design and problem solving skills of engineering with medical and biological sciences to improve patient's health care and the quality of life of individuals.
A medical device is intended for use in the diagnosis of disease, or in the cure, treatment, or prevention of diseases. Heart beat is measured using LED, LDR and operational amplifier. Hence both parameters are displayed on a LCD display. Then both the parameters are transmitted and displayed in a distant location.
This project will eventually reduce man power in the very near future.

FUTURE SCOPE

- EEG, ECG and other health parameters can also be monitored.
- Continuous monitoring and future diagnosis can be performed via the same system (TELEMEDICINE).
- More than a single patient at different places can be monitored using single system.

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