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Design and Development of Pulse Oximetry for Continuous Monitoring of Pregnant Ladies using Arduino

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Abstract: *The continuous monitoring and caring patient's condition is an important area of research in the field of Biomedical. These required multi-parameters system for continuous sensing processing and displaying the condition of the patients. Pregnancy brings many changes in a woman's body. Including pulse rate, which increases during pregnancy. A pulse rate is different for every woman, and is based on level of fitness before pregnancy and age. Doctor will monitor pulse rate throughout the pregnancy, and recommendations to care accordingly. The objective of this paper is to design a non-invasive Arduino based optical pulse oximetry .The pulse oximetry consists of a fingertip sensor and an Arduino microcontroller. In it Photo transistor sensor is used for the pulse wave's detection and the Arduino microcontroller is used to analyze the pulse wave to calculate the oxygen saturation (sao2).The pulse oximetry uses the Arduino as a microcontroller.*
Keywords: *Pulse rate, Pulse oximetry, Arduino microcontroller, Phototransistor.*

I. Introduction

The pulse oximeter is one of the medical device used to measure spo2 and pulse rate of a person. It became a standard procedure for the measurement of blood oxygen saturation in the hospital operating room and recovery room [1].It is also one of the important parameters for old people, pregnant women in several critical situation. It is non-invasive and allows immediate and real time monitoring, its use has expanded to include other purpose such as screening, diagnosis, patients follow up and self-monitoring. Good nutrition and regular determination of finger pulse is the guarantee of improved health conditions of a pregnant women and future children. Physicians recommend pregnant women pulse oximeter for accurately measure the oxygen level. Pregnant women have been using pulse oximeter technology throughout the decade. Digital technology has produced new medical devices such as networked glucose reader, digital thermometers and stethoscopes as well as innovative application such as motion sensors and video conferencing tools. A pulse oximeter is one of them it is intended for the non –invasive measurement of arterial blood oxygen saturation and pulse rate [2].It provides an important function in the intensive care unit, as an early warning system for patient emergencies [3].

II. Biological Principles Of Oxygen Movement

The oxygen is important for functioning of each cell in the human body. Without oxygen cells will die. Oxygen saturation is an indication of oxygen transport in the body. Several methods have been developed to analyze oxygen delivery. Blood red cells contains a protein called hemoglobin. Hemoglobin is a stable only when bound to 1 to 3 molecules of oxygen. Red cells with oxygenated hemoglobin circulate in the blood through the whole body .When blood gets in contact with a cell the red cells hemoglobin releases oxygen and becomes Deoxyhemoglobin (Hb) (deoxygenated hemoglobin)[4].The volume of the arteries become larger before the blood enter the capillaries. This changes makes possible for the oximetry system to differentiate the arterial blood from all other absorbing substances [5] [6].

III. Methodology

During the last few years there has been a significant increase in the number of various pulse oximetry on the market ranging from pulse monitors to portable wireless digital oximeters[7][8]The study of working principle and the components of pulse oximeter module is derived from[9][10].It is Characterized into three different stages.

1. Sensing stage: - Design and development of pulse oximetry probe sensor.
2. Processing stage: - Development of pulse oximeter module.
3. Displaying stage: Display of results.

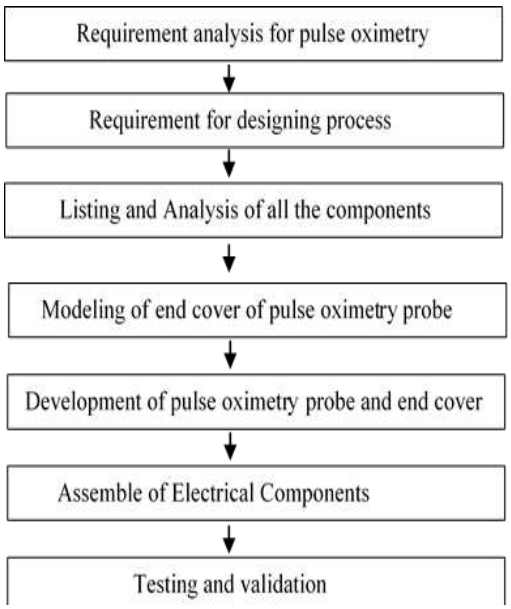

Figure 1. Block diagram of pulse oximetry

The methodology to design the pulse oximetry probe is displayed in the form of block diagram as shown in the figure1. The functional requirements for designing the pulse oximetry probe are studied. It is developed using a prototyping machine. The electrical components are assembled with the end covers. The pulse oximetry probe sensor is tested and validated for normal working conditions.

IV. The Woking Process

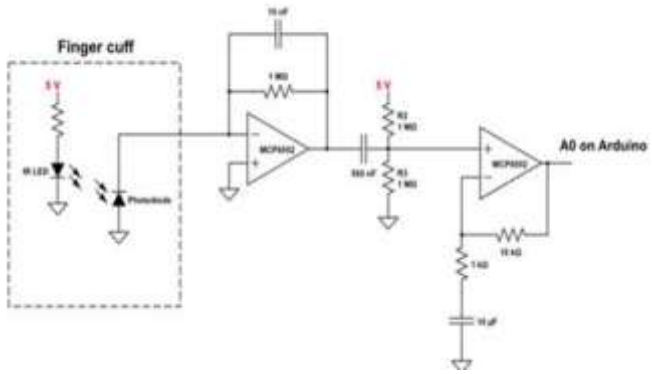

Figure 2 Electrical circuit diagram for the detection of pulse rate

As blood is pumped through the body, the volume of blood in extremities such as fingers increases and decreases with the pumping of the heart. The change in blood volume in the finger tips can be detected by shining a light through the finger and detecting the amount of light that passes through the finger using a photodiode. A photodiode is semiconductor that produces a current proportional to the amount of light that hits it. So when the blood volume in the fingers increases, less light is getting through the finger and hitting the photodiode. The current produced by the photodiode is converted to a voltage by an amplifier and read by the Arduino. The finger cuff has a photodiode and IR LED integrated into it. Both components have wires that connect them to the Arduino.

The next portion of circuit is known as a transimpedance amplifier or current-to-voltage converter. A transimpedance amplifier is an amplifier configuration that allows to convert a current to a voltage. In this case, the current produced by the photodiode flows through the resistor in the op amp's feedback loop. A voltage at the output of the op amp with accordance to Ohm's Law, V = I*R. The current produced by a photodiode can be small (micro-amps), this is why we are using such a large resistor (1 M Ohm) as the gain-setting resistor. A high gain-resistor such as this is typical for transimpedance amplifiers. The capacitor in the feedback loop helps reduce high-frequency noise.

Next stage is a high-pass filter. A high-pass filter allow us to remove low-frequency signals. In this case, we are removing signals that are slower than a normal pulse signal. Specifically, we are removing the DC bias from our signal. When the IR LED shines light through the finger, most of the light is absorbed by the tissue. Our circuit will in turn produce a voltage that corresponds to the absorbance of light by the tissue, not the pulsatile of the artery (which is what we really want). For this reason, we use a high pass filter to get only the absorbance due to the pulsatile of the blood in the arteries (our pulse).

The final portion of our circuit is an AC gain stage using a non-inverting op amp. A non-inverting op amp amplifies and input voltage in accordance to the equation 1+R2/R1 where R2 is the resistor in the feedback loop and R1 is the resistor that is connected to ground. Notice the capacitor in the non-inverting op amp. A capacitor blocks DC signals and only allows AC signals to pass. This means that only the AC signal which corresponds to our pulse gets amplified, not the voltage that we applied in the previous stage.

V. Factors For An Irregular Pulse Rate And Oxygen Level During Pregnancy

1. Increased Load during Pregnancy:-During pregnancy heartsaccommodate to the changes in body. Because heart is working harder. Due to that "skipped beat" or a "fluttering" in neck or chestoccur. Additional symptoms like fatigue, lightheadedness, dizziness, chest pain, shortness of breath, and a rapid or pounding heart point to an irregularity in the rhythm of heart that's impacting its functioning[12].

2. Lifestyle or Health Factors**:-**Some factors are related to lifestyle, health, and state of mind that may also cause irregular pulse Rate. As pregnancy hormones tussle with system, it feel the impact on the body and mind quite intensely. Deal these through some simple lifestyle changes or quick remedies, without medical intervention

These factors include:

- Anxiety or stress: Ease pregnancy pangs with relaxation or breathing exercises.
- Dehydration: Take in plenty of fluids or have an oral rehydration solution.
- Low blood sugar: Deal with it by having juice, biscuits, or even a tablespoon of sugar or honey [13].
- Too much chocolate or caffeine. Cut down on these or avoid them as much as possible.

3. Medical Conditions**:-**Sometimes, an irregular heart rate can be indicative of a problem like a heart disorder or thyroid imbalance.

- Heart Disorder: Additional symptoms like chest pain, dizziness, shortness of breath, or fainting along with palpitations could point to heart disease [14].
- Hyperthyroidism: Symptoms like fatigue, hair loss, difficulty concentrating, hand tremors, frequent bowel movements, increased sweating and appetite, problems with your weight or sleep, and heat intolerance may be indicative of hyperthyroidism.

VI. Factors For A Regular Pulse Rate And Oxygen Level During Pregnancy.

1. Adopt Healthy Habits:-Eat regular meals, and get plenty of fluids as well as sufficient sleep. These habits can good for general health and wellbeing during pregnancy.
2. Cut out the Stress:-Anxiety and stress can make your heart rate irregular. Practicing relaxing techniques like meditation, tai chi, or yoga can help you deal with stress.
3. Take A Breath:-Try deep breathing when you get palpitations. Breathe in deeply and slowly through your nose so that you feel your abdomen move.
4. Splash Water:-Splashing some cold water on face can be helpful for palpitations.

VII. Factors Affects Pulse Oximetry Reading

Several factors can interfere with the correct function of pulse oximeter including:

- Light – bright light (such as the operating theatre light or sunlight) directly on the probe may affect the reading. Shield the probe from direct light.
- Shivering – movement may make it difficult for the probe to pick up a signal.
- Pulse volume – the oximeter only detects pulsatile flow.When the blood pressure is low due to Hypovolemic shock or the cardiac output is low, or the patient has an arrhythmia, the pulse maybe very weak and the oximeter may not be able to detect a signal
- Vasoconstriction: - reduces blood flow to the peripheries. The oximeter may fail to detect a signal if the patient is very cold and peripherally vasoconstrictor.
- Carbon monoxide poisoning: - may give a falsely high saturation reading. Carbon monoxide Binds very well to hemoglobin and displaces oxygen to form a bright red compound called Car boxy hemoglobin. This is only an issue in patients following smoke inhalation from a fire.

VIII. Source Of Error

- Environmental interference: vibration at 0.5-3.5 Hz, excessive movement and perhaps high level of ambient light, including infrared heat lamps. [15]
- Cold hands - warm extremity if local poor perfusion
- Nail polish should be removed, as it may cause false readings. [16]
- Intravascular dyes, such as methylthioninium chloride, may also temporarily falsely reduce saturation readings.

IX. Hardware And Software Requirement

The pulse oximeter uses the ARDUINO as microcontroller, which has ultra-low power capability so the system power consumption is low [11].One Arduino, One general Purpose Op Amp (MCP6002 or similar) .Arduino Uno is a microcontroller. It has 14 digital inputs/out pins. Three Capacitors (1 x 10 nF 1 x470 nF and 100 nF).One Photodiode. One IRLED. (Figure no 3).Matlab for automation of experiments, data visualization Arduino UNO

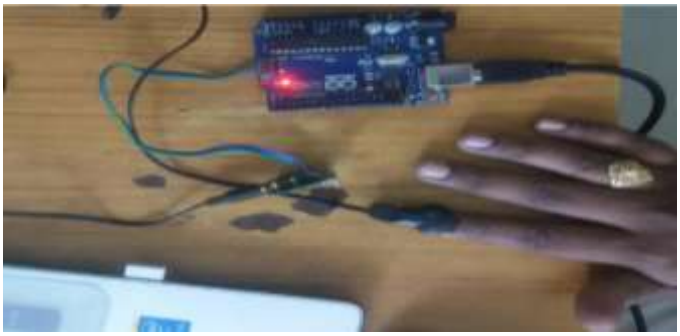

Figure 3 Device interface with Arduino

X. Results And Discussion

A Program is developed in Matlab which allow viewing and stored the signals for further analysis with algorithms in order to minimize the noise and to make the peak detection to determine the pulse rate and oxygen level in the blood and store the patient detail in the database for further used like patient name, age, weight, pulse rate and oxygen level and due date of patient(Figure 4)

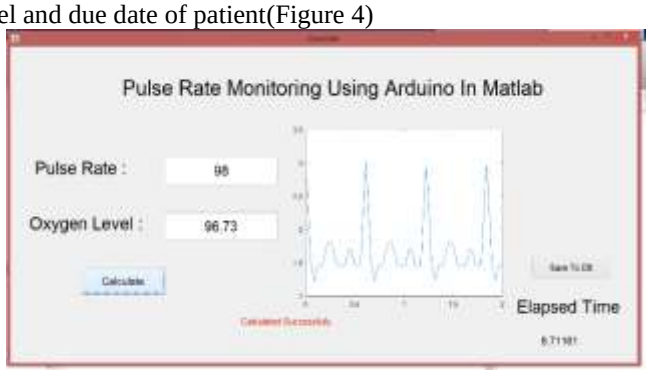

Figure 4 Representing data after Matlab processing

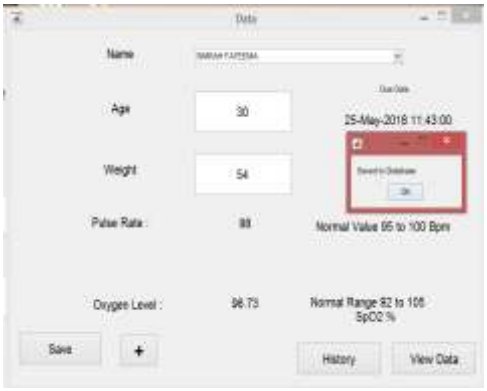

Figure 5 Storing of the data after Matlab processing

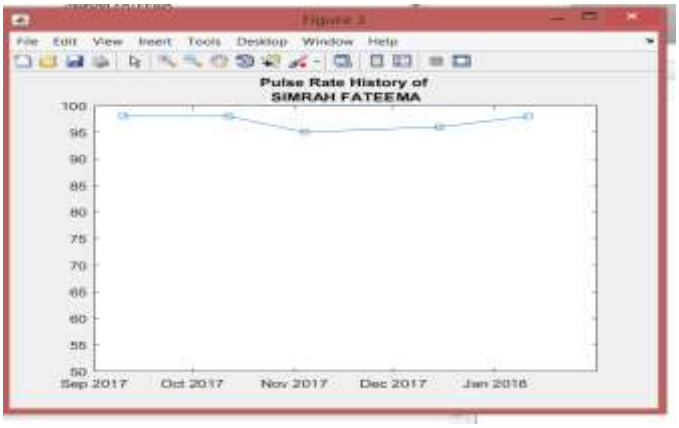

Figure 6 Graphical Representation for History of Pulse Rate

Figure 7 Graphical Representation for History of Oxygen Level

The above Figure no 6and 7 describes the Pulse Rate and Oxygen Level of a Patient. It helps to view the history of the patient throughout the nine month for the patient and doctors.
In order to verify the accuracy of the device. The device was compared with stethoscope. The authenticity of the device was tested using stethoscope present in the market. The comparison is tabulated in table no 1.

Sr.no	Subject Name	Pulse rate By Device	Stethoscope Reading	Month
1.	Simrah	98	98	Sep 2017
2.	Simrah	98	99	Oct 2017
3.	Simrah	96	98	Nov2017
4.	Simrah	97	97	Dec2017
5.	Simrah	99	98	Jan 2017

Table no 1 Performance testing of Pulse oximetry

Table no 1 shows that the Stethoscope result is higher or same. Inaccuracy could rise from human error where by mistake in counting of pulse might have occurred. The error percentage is not very large.

XI. Conclusion

The main aim of this paper to developed a portable pulse oximeter unit that receives data and process in order to return the values of pulse rate and oxygen level in the blood. The need for the development of pulse oximeter was emerged to enhance the technical competency of India and to provide the cost effective products for the hospital requirements both in urban and rural areas. The data is acquired by Arduino module, which communicate with a platform that would have implemented in order to perform the signal processing.

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