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TRANSMITTANCE METHOD BASED PULSE OXIMETER DESIGNING FOR THE MEASUREMENT OF HEART RATE, PERCENTAGE OXYGEN IN THE BLOOD AND THE BODY TEMPERETURE

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Abstract

Pandemic since Covid-19 and currently due to Omicron has proven the importance of the health parameters like Heart Rate, Percentage Oxygen in the Blood and the Body Temperature; and is therefore universally known. Varieties of Pulse oximeters are available in the market at cheaper rates and mainly focus on the Heart rate and the percentage of oxygen in the blood while the body temperature is an equally important parameter and needs to be measured in emergencies. The pulse oximeters available in the market are not recommended by the medical doctors in emergencies so far the accuracy is a concern while the highly sophisticated and accurate pulse oximeters are too costly and are available only in ICUs and ICCUs in big hospitals. Here in this paper, an attempt is made to design the transmittance method-based pulse oximeter using a microcontroller which will measure not only the heart rate and the percentage of oxygen in the blood but will also measure the body temperature in ˚C. Care is taken to meet the accuracy requirement with a reasonable cost to be recommended by the medical doctors in emergencies and can be made available even at small places due to low cost.

Keywords: Pandemic, Covid-19, Omicron, Heart Rate, Percentage Oxygen in the Blood, Body Temperature, transmittance method

Introduction:

There are two very popular methods employed in a pulse oximeter in determining the health-related parameters namely percentage oxygen in the blood and the heart rate. These methods are;
1. Reflectance and 2. Transmittance Method of which I have employed the latter one. Also, an attempt is made to measure one more prominent health-related parameter that is Body temperature in ˚C. The reason behind measuring the body temperature in ˚C is; the ˚C scale is universally accepted and if at all one needs to measure it in ˚F the data can be processed through the microcontroller using simple formula as [**˚F =** ***((9*˚C) / 5)) + 32***].
In the design, the efforts are taken to obtain the results considerably accurate with the highly sophisticated biomedical device used in the big hospitals and also to have the reasonable cost. As the cost lowers these pulse oximeters can also be recommended to use at small places and even at PHCs too. Which in the real sense is badly needed in a country like India considering the huge population of around 138 crores as per the census 2020? The concept of pulse oximetry first came to existence during WWII (World War II) in 1942 while in 1972; Pulsoximetry was developed by the Bioengineers Takuo Aoyagi and Michio Kishi who have used the ratio of Red to Infrared light absorption of pulsating components at the measuring site. Medical Surgeon, Susumu Nakajima and his associate first tested the patient with the device at Sapporo Minami National Sanatorium and reported it in 1975[1].

Since then with the technological developments, various changes and upgradations took place in the designing of pulse oximeters and still it's going on.

Development in Pulse Oximetry Parameters Measurement:

While developing any system, to the best of its general understanding there has to be Input, Processing, Mathematical manipulation, and an output. Before the advent of pulse oximetry technology, the Doctors / Medical Technicians use to take 10 ml of blood as a sample and use to diffuse the sample for around 7 days, and then from the hemoglobin, they used it to find the oxygen-rich hemoglobin. The process was called blood gas analysis used to be done by the blood gas analyzer. But the process was time-consuming resulting in the high mortality rate of the patients having Leukemia, patients with acute trauma, and hysteric patients [2].

Hence the challenge was to have some non-invasive technique that could help to measure percentage oxygen in hemoglobin-rich arterial blood which is fresh blood flowing all over the body after being pumped out by the heart.

Every prominent parameter in the blood namely Plasma, RBCs, WBCs, and Hemoglobin exhibits certain permittance for Red and IR light. In the reflectance method for the pulse oximetry, the blood was taken in a tube, and then by introducing a pulse the index of reflection was measured by knowing the amount of light reflected wherefrom the percentage oxygen was calculated following the number of data manipulations and calculations. The procedure was complicated and was very difficult to implement. Also, the major problem associated with this method was if some time elapses after taking out the blood before the test, the oxygen molecules start binding with the free radicals resulting in the increase of opacity due to reduction in intermolecular space due to clotting of blood. Thus the reflectance effects lead to diagnostic error [3].

Hence, it was expected to have a system wherein the percentage oxygen can be made known from the continuously flowing blood and was made possible by passing Red light and IR light through the blood and from the difference of admittances of these lights the percentage oxygen saturation in the blood was calculated. This is how the non-invasive pulse oximeter design started [4].

Transmittance Based Pulse Oximeter Designing:

The proposed pulse oximeter is a transmittance method-based, non-invasive device designed using a microcontroller, keeping in mind the measurement of percentage oxygen in arterial blood, Heart rate in Beats per minute (bpm), and the Body temperature in degree Celsius (°C).
Though so many low-cost pulse oximeters are currently available in the market, they all are facing accuracy constraints so far the emergent situations are concerned. Also, the doctors never consider their readings in emergencies like surgeries and for the patients in ICUs. On the other hand, the pulse oximeters used in emergent situations which are normally available in Multispecialty and Super specialty hospitals are very costly and not affordable at small places. The ultimate aim behind designing the proposed pulse oximeter is to provide the balance between the most important parameters namely accuracy and cost. To design the proposed pulse oximeter the main blocks employed are;

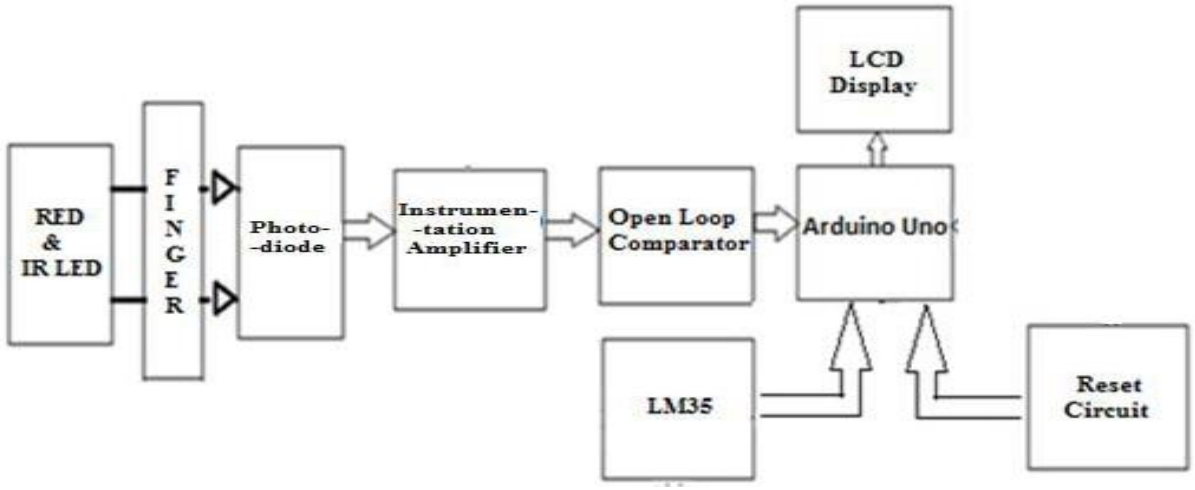
1. Nellcor compatible instrumentation module SpO2 Sensor
2. Node MCU ATmega328P

3. Arduino Uno

4. LM35 (Temperature Sensor IC) and

5. LCD-RG1602A

Block diagram and working of the designed Pulse Oximeter:



Here the input received is in the form of oscillation of blood which is sensed through the change in intensities of RED and IR light passing through it with the optical technology wherein I'm using two LEDs namely Red (660 nm) and an IR or Infrared LED (940 nm) for the purpose along with the photodetector (Photodiode here). As the transmittance method is employed, Red LED and IR LED will be on one side of the finger, and on the other side, a photodiode/photodetector will be there to sense the changes in intensities of these two lights and convert these physical changes into an equivalent electrical voltage. This voltage is then sent to an instrumentation amplifier which digitizes the signal first and the probe is used to calculate the percentage oxygen and converts it into a digital form which is done based on average calculation and finally, from the mean value, the percentage oxygen saturation is calculated. So far the temperature measurement is a concern, there are so many ways like; it can be taken through the Digital Thermometer or IR gun but in this circuit, I'm using IC LM35 which measures the body temperature in °C. This sensor is in contact with the body and it senses the temperature of the body in terms of change in electrical voltage. (Showing 10mV output for 1°C change in temperature). So the output obtained through the transmittance method is applied to the instrumentation amplifier and then to an Arduino while the analog output of IC LM35 is directly applied to an Arduino on separate ports and the complete computational data regarding percentage oxygen in the blood, Heart rate in bpm and the body temperature in °C are then applied to the microcontroller for display which is done through LCD-RG1602A providing the address for the respective parameter on the LCD screen.

Highlights of the Designed Pulse Oximeter:

The Designed Pulse Oximeter is;

1. Lightweight

2. User friendly

3. Portable

4. Simple and contains no complicated circuitry

5. Fault finding is easy

6. Efficient enough

7. Maintaining high accuracy

8. Handled by even a Non-technical person

9. Affordable cost-wise

Conclusion and future scope:

The designed Pulse Oximeter gives very close readings to those taken by the standard costlier Pulse Oximeters used in the hospitals in all emergencies hence it can be easily concluded that the designed Pulse Oximeter is working up to the standards with the most important added feature of measuring the Body temperature. It can also be concluded that the designed Pulse Oximeter can be used in emergencies since its accuracy is very much closer to the standard one. Also, the designed Pulse Oximeter is much cheaper cost-wise than that of the standard one and the cost can be reduced further if the mass production is done and thus very much affordable to be used even at small hospitals and places.

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