# Non Invasive Measurement of Heart Rate and Hemoglobin Concentration Level through Fingertip

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***Abstract—***
*Modern medicine and healthcare rely heavily on engineering to deliver improved prevention, diagnosis and treatment of illness. The proposed system uses a photo-plethysmography (PPG) technique. PPG sensors optically detects the blood volume changes in the microvascular bed of the tissue. The data which is obtained non-invasively through fingertip is first processed via analog filters and the output is sent to the microcontroller to estimate Heart Rate. The output from the filter is also sent to the computer through a microcontroller interface to be processed using MATLAB to estimate the Hemoglobin concentration Level. The estimated parameters are sent to the concerned person or to the doctor through GSM for real-time monitoring of the patient in critical situations.*

**Index Terms—** *Heart Rate, Hemoglobin concentration, Photoplethysmography, real-time monitoring.*

## I. INTRODUCTION

A lot of invasive methods or blood parameter estimation have been invented and are still in use. In this invasive method, blood is ejected from the patient and subsequently analyzed. Apart from the discomfort of ejecting blood samples, an added disadvantage of this method is the delay between the blood collection and its analysis, which does not allow real time patient monitoring in critical situations.

A non-invasive method allows pain free continuous on-line patient monitoring with minimum risk of infection and facilitates real time data monitoring allowing immediate clinical reaction to the measured data.

In order to measure blood parameters non-invasively, changes in blood volume with time need to be measured using plethysmographs. PPG is a simple, low cost reliable optical technique that can be used to detect blood parameters by passing electromagnetic light rays through the skin. The information about blood parameters is obtained non-invasively in contrast to the painful and inconvenient invasive methods, with measurements generally made at the skin surface where upon it is easy to record data.

During the process, changes in volume of blood caused due to blood pressure, pulses are detected by illuminating the light through the skin using a light emitting diode (LED) and measuring the amount of light either transmitted or reflected through a light detector.

A PPG sensor can be used in reflection mode or in transmission mode. PPG sensor in transmitting mode have led and photo detector arranged opposite to each other. When light produced by the led falls on the finger some of the light is absorbed and the remaining light is transmitted and falls on the photodiode.

In case of reflecting mode the led and photodiode are arranged on the same side of the finger. When the light produced by the led falls on the finger some of the light is absorbed by various components and some light is reflected back. The reflected light is detected by the photo detector. Transmission mode is used in this paper.

IR LED is used to estimate Heart Rate. IR LED and Red LED both are used to estimate the Hemoglobin concentration level.

## II. LITERATURE SURVEY

In 1991, Y. Iyriboz et al. [7] published a comprehensive study of the accuracy of pulse oximetry for the non-invasive measurement of heart rate, and concluded that the results obtained accurately estimate the heart rate at rest and during sub-maximal exercise. However, during heavy exercise when the heart rate rose above 155 bpm, this method reported an error margin of 9%.

Hemoglobin level in person's blood can be estimated by analyzing the color of the blood. H Ranganathan proposed a technique in which the photograph of the blood samples were taken for analyses and the samples were color coded to get some values. By using artificial neural network computational models the strong relationship between blood color and the hemoglobin was found

by taking color coded values of samples as input and hemoglobin value determined by conventional method as output. In this method blood sample was needed for color analyses. It required skilled technicians and risk of infection.

Kumar, Dr. Ranganathan worked on reduction for the complications due to anemia, for which the hemoglobin level needs to be measured. In this discussion photons at appropriate wave lengths are pumped into the skin on the finger. The transmitted photons from the hemoglobin content of the blood are received at a photo detector which converts them into electrical signal. The received signal strength can be calibrated in terms of hemoglobin content in blood. In this method the error rate was more.

Absorption of light by oxygenated and deoxygenated hemoglobin is measured at two wavelength 660 nm and 940 nm. These wavelengths of light are obtained from red and infrared LED. Constant current circuit is designed to drive the LEDs. Photodiode is used to detect transmitted light through an area of skin on finger. Ratio of red to IR signal after normalization is calculated for determination of Hb. This was developed by Rajashree Doshi and Anagha Panditrao . In this research no transmission of data is done and only the hemoglobin is detected.

By analyzing the drawbacks of the above works, a new device is proposed which has two applications: estimation of Heart rate and Hemoglobin concentration using PPG. The estimated parameters are then sent to the concerned person or to the doctor via GSM for monitoring of the patient.

## III. PROPOSED SYSTEM

### A. *Hardware Requirements*

The hardware part consists of PPG signal acquisition circuit. An infrared (IR) LED is used for the estimation of Heart Rate and both IR and Red LED are used for the estimation of Hemoglobin. The LED illuminates the finger and the tissues underneath the epidermis. Due to changes in the blood volume in the finger, the absorption of radiation changes, which leads to variation in the amount of radiation being transmitted. The change is detected by the photo detector, which varies the amount of current through the same. A signal conditioning circuit is used for removing the noise and to amplify the obtained signal in order to make it readable by the microcontroller.

### B. *Software Requirements*

The software part consists of the microcontroller coding in Embedded C to estimate Heart rate and MATLAB code to estimate the Hemoglobin level.

### C. *System Description*

#### 1) *Heart Rate Estimation*

The obtained PPG signals are weak which is in micro volts range and are not readable by the ADC in the microcontroller. Hence the signal conditioning is required which includes filtering followed by the amplification of the obtained signal.

On an average the frequency of the heart rate of a human being is around 1-2Hz. So, the low pass filter at the input side is designed with the cut off frequency 2.5Hz which removes the high frequency noise signals. Filtered signals are given to the non-inverting Operational-amplifier with the gain of 101 as shown in the Figure 1. The capacitor in the feedback circuit is to eliminate the noise that might come from the ground and from the output side.

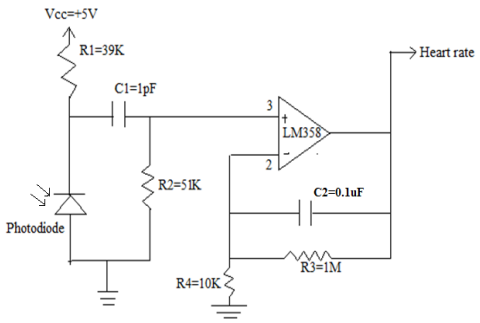


**Figure 1. Signal Conditioning Circuit**

The output from the signal conditioning circuit is converted into digital by the ADC in the microcontroller and is further processed in the controller to estimate the Heart rate.

#### 2) *Haemoglobin Level Estimation:*

Absorption of light by oxygenated and deoxygenated hemoglobin is measured at two wavelengths 660 nm and 940 nm. These wavelengths of light are obtained from red and IR LED. Constant current circuit is designed to drive the LEDs. Photodiode is used to detect transmitted light through an area of skin on finger. Ratio of red to IR signal after normalization is calculated in MATLAB for determination of Hb.

#### 3) *Results*

The measured heart rate (in bpm) is the frequency of the comparator output times 60, since the frequency is calculated in terms of 'per second'. Haemoglobin rate is measured using the relation between the absorption of light and the properties of the material through which light is getting transmitted, is used to estimate haemoglobin level in this work. By taking the ratio of IR LED and Red LED voltage signal haemoglobin is measured. In this paper, the input voltage to the sensor and output voltage from the collector of sensor phototransistor are used.

## IV. CONCLUSION

Conventional methods of estimating the blood parameters are all invasive i.e., the blood is ejected from the patient's body and it is then subjected to chemical analysis to find out the required blood parameters. But the use of invasive methods comes with many disadvantages like

1. The risk of infection is more due to the use of needles to extract the blood.
2. Since it takes few hours to analyse the blood samples and to estimate the required parameters, the process is time consuming.
3. Invasive methods require a skilled or trained staff to carry out the process.
4. Blood samples must be maintained at some particular temperature.

The non-invasive measurement of haemoglobin is based on radiation of Red and IR light emitted by LEDS at 660nm and 940nm respectively. Transmitted light through the finger was detected by a photodiode. The ratio of voltage levels of red and of IR LEDs is calculated in MATLAB for the estimation of Haemoglobin concentration level. In order to estimate the heart rate IR LED is used which acts as IR emitter illuminates the finger and the tissues underneath the epidermis. Due to the changes in the blood volume in the finger, the amount of radiation being transmitted is varied. The change is detected by the photo detector. Since the obtained signals are bio signals which are very weak and are not readable by the microcontroller, conditioning of the signals needs to be done which includes filtering and amplification. And then the signals are sent to the microcontroller to calculate the number of pulse counts per minute.

Temperature sensor is also interfaced with the microcontroller which gives the temperature of the object which comes in contact with it.

After calculating all the three parameters, the message which contains these parameters is sent to the concerned person or to the concerned doctor through GSM to allow real time monitoring of the patient.

Future augmentation to the work can also be done in the direction of estimating other parameters like blood pressure and blood glucose level.

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