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# Non-Invasive Sensor Technology for Hemoglobin Measurement in Blood

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**Abstract -***In the human body's blood cells, haemoglobin (Hb) is the most vital parameter. Hemoglobin is the protein in red blood cells that carry oxygen to the body. There are number of invasive methods available for estimating Hb value in blood. These methods are considered as accurate and reliable which involve pricking of needle stick to draw the blood sample. Further sent to laboratory for analysis, with results back later after few hours or after a day which results in treatment delay and increase chances of infection. But they are expensive, not real time, high infection risk, and need special techniques. There is a requirement for simple method which will be easy, fast, painless and non-infectious. Hemoglobin demonstrate some properties like absorption, transmission and reflection of photons in different proportions based on photons wavelength. Here, in non-invasive measurement technology photons at appropriate wave lengths (650nm and 850nm) are send into the fingertip. The transmitted photons from the Hb content are then received at a photodetector which convert them to electrical signal which further shows calibrated signal strength in terms g/dL. The system uses microcontroller which will control the operation of the hardware and for calculation of haemoglobin concentration.*

***Keywords:*** Haemoglobin, Anaemia, Polycythaemia, non-invasive method, photodetector

## 1. INTRODUCTION

Taking out blood through needle is a painful process. so, our main motivation here is to calculate the concentration of haemoglobin in the blood through non-invasive technology [3]. Measuring Hemoglobin (Hb) is one of the frequently ordered laboratory tests. Hemoglobin (Hb) in the red blood cells that transport the oxygen from lungs to body tissues and returns carbon dioxide from tissues back to lungs.

The normal range of Hb concentration in blood is from 13.5 to 17 g/dl for males while it is 12 to 15 g/dl for females [4,5]. Hb values can be lower or higher than the normal range differs in different types of diseases [8]. If Hemoglobin is lower than normal levels then it is termed as anemia and it could be as a result of iron deficiency, thalassemia, bleeding, kidney, and liver diseases [1,8]. Whereas high Hb levels is termed as polycythemia and caused due to factors such as lung diseases like respiratory diseases or circulatory disorder or even cancer. Patients suffering from anemia, polycythemia, trauma and related diseases require regular monitoring of hemoglobin content in blood, which is not feasible under the current methodology [5,8].

The standard way of measuring Hb concentration is to prick one's finger/arm to collect the blood sample and this sample is later analyzed by professionals using one of the different chemical methods available [1]. When blood is drawn from the finger/arm using a syringe, extra care needs to be taken to prevent infections [2,3,5]. Also, the results are not obtained instantaneously but it takes a few hours for the analysis of the blood sample by a pathologist to verify the results obtained. Although Invasive measurement is accurate but it is also time-consuming, costly, painful for the patient, and may have potential risk for exposure to biohazards [1]. It significantly delays patient care because of the time required for the analysis, validation, and reporting of the results back to physician [1,2,3,5].

In non-invasive method pain free continuous monitoring is done through photodiodes with no risk of infection and we get the

calibrated value in seconds [1,2]. Non-invasive measurement is a compact and handy device which provides results instantly and is easily portable which do not require any services of experienced doctors [2]. This device will be more useful for calibrating the value of haemoglobin and hence reduces the use of expensive machines and laboratories for testing. Previously, similar devices are tested but were not in use as they were costly and not accurate. Fig. A shows the block diagram of the system.

The main objective of this discussion is to give instant and reliable reading of hemoglobin count of the blood over the conventional pathology lab testing which are costly and takes time.

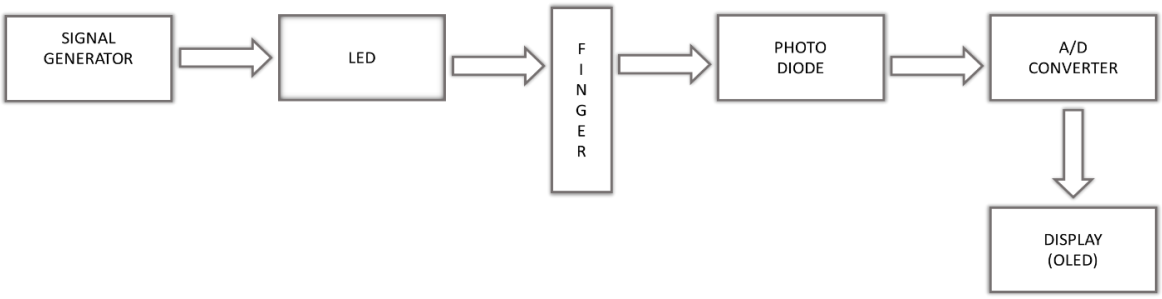



Figure. A: Block diagram of the proposed system

## 2. LITERATURE SURVEY

### 2.1 Non-invasive hemoglobin screening

Non-invasive hemoglobin screening was pioneered in Europe, but it is now available in a wide range of countries. The common thing in all this method is that they do not require a blood sample to determine an individual's hemoglobin. Non-invasive method allows pain free continuous monitoring with extreme low risk of infection [7]. Within 30 seconds, the results are available, allowing for immediate clinical evaluation. The non-invasive sensor technology for Hemoglobin in blood is that, which doesn't involve pricking of the skin. Continuous hemoglobin measurements can assist prevent the extremes of excess or under transfusion. Hemoglobin screening is an essential test used to evaluate if a donor is eligible to give blood products during the donation process. The major use of the non-invasive technology is for trauma patients such as non-operative and undergo surgical intervention only for ongoing bleeding or hemodynamic instability [7]. Close monitoring in the Intensive Care Unit (ICU) and repeated phlebotomy for hemoglobin measurement to test for continuous hemorrhage are required with this method. Non-invasive hemoglobin monitoring, whether continuous or spot-checked, allows these patients to be monitored in real time and respond to changes in hemoglobin levels [1,3,7].

### 2.2 Occlusion spectroscopy

Occlusion spectroscopy technology is composed of a non-invasive optical measurement platform combined with a ring-shaped sensor probe attached to the finger. Most of the major approaches for estimation of hemoglobin is measured by means of a spectrophotometric sensor [2]. For hemoglobin measurement, there are two devices that use spectrophotometry. The type of sensor used makes a difference. Occlusion spectroscopy, which uses an annular, ring-shaped, multi-wavelength probe with pneumatically operated cuffs, is one method [7]. Other method involves placing a multi-wavelength pulse co-oximetry sensor on a person's fingertip. The current approach for non-invasive hemoglobin measurement device rely on spectrophotometry [3,5]. Depending on their biochemical variables, wave propagates through or is reflected from tissues and blood in different ways. This difference in the degree of reflection allows for estimation of the hemoglobin [4].

### 2.3 Hemoglobin pulse Co-oximeter technology

The system developed is a Pulse co-oximeter capable of measuring hemoglobin concentration using a noninvasive,

multi-wavelength sensor for spot check and continuous measurement [5]. The system uses multiple wavelengths of light to calculate hemoglobin concentration based on light adsorption in the blood. The device uses a fingertip probe similar to a standard pulse oximeter sensor and determines the hemoglobin noninvasively. In trauma patients, this new technology allows for quick and precise Hb measurements [7].

When light is made to pass through the fingertip of a person, the output signal obtained contains a low amplitude pulsatile portion corresponding to the flow of blood in arteries while the rest of the signal is the dc portion resulting due to the bones and tissues present in the path of light [3].

### 2.4 Evaluating accuracy and sensitivity

Noninvasive hemoglobin methods have been compared to standard practice in a number of studies. These studies' main goal was to determine the accuracy, bias, and precision of noninvasive point-of-care methods. The patient must stay still while the device calculates hemoglobin values when using non-invasive hemoglobin monitoring. This could necessitate multiple attempts at measuring hemoglobin with the non-invasive hemoglobin monitor, limiting its use in agitated or intoxicated patients. The presence of tar, soot, or nail polish on fingers may interfere with accurate hemoglobin measurement because this device uses a spectrophotometer to do so [7]. Despite these disadvantages, non-invasive hemoglobin technology holds promise, especially in the treatment of trauma patients. This could not only help speed up patient care, but it could also improve patient satisfaction by reducing the number of needle sticks required for invasive hemoglobin measurement, as well as lower hospital costs. These methods determine the Hb content using calibration [1,2]. Invasive blood testing on a group of volunteers is used to determine their hemoglobin levels using chemical methods, while the non-invasive sensor measures absorbance levels at the same time.

Following that, real patients in clinical settings were used to test the accuracy and utility of continuous non-invasive hemoglobin measurement. This is worth debating because the device's accuracy can vary depending on the clinical environment [7]. Non-invasive hemoglobin monitoring found excellent correlation and accuracy, expressed as ARMS value between 0.5 and 1.4 g/dL between the measures of non-invasive and invasive methods of hemoglobin measurement. The bias and agreement limits were also within the traditionally accepted ranges of 0.0 ± 1.0 g/dL [7].

## 3. PROPOSED WORK

In this project we developed an optical sensor for measurement of hemoglobin non-invasively using two wavelengths i.e. 650 nm & 850 nm [1]. Which based on a pulse photometric measurement method & allows pain free continuous on-line patient monitoring with minimum risk of infection and facilities real time data monitoring allowing immediate clinical reaction to the measured data [3].

Our proposed work deals with utilizing the noninvasive technique like photoplethysmography (PPG), simple, painless, low cost, and easy to operate device to determine hemoglobin in real-time [1].

The principle application started with keeping finger on sensor or photodiode to measure blood parameter which capture the signal and give it to the microcontroller which converts the received signals value by photodiode into voltage. Finally, after computation, achieved value will be displayed on the LED screen.

### 3.1 FLOW OF THE SYSTEM

1. Firstly, the finger will be put on Red LED (650 nm), IR LED (850 nm).
2. Red infrared light is emitted sequentially through the body tissue.
3. Transmitted light reflected from tissue cells and sensed by the photodiode. Output voltage of the photodiode increases linearly with light intensity.
4. Signals received by the photodiode is given to the Microcontroller (ATMEGA328P) which converts the signal from analog to digital.
5. Each sample measured is stored in the system which compared with the received signal from photodiode to calibrate the system for better accuracy.
6. The level of Hemoglobin is shown as XX.X g/dL on LED screen.

Fig. B shows the flow chart, all the process is withinside the microcontroller code. If, in the process the microcontroller unable to detect the converted value from ADC it will again try to convert the value of output voltage and try to send to microcontroller. Else, microcontroller easily execute and continuous the process.

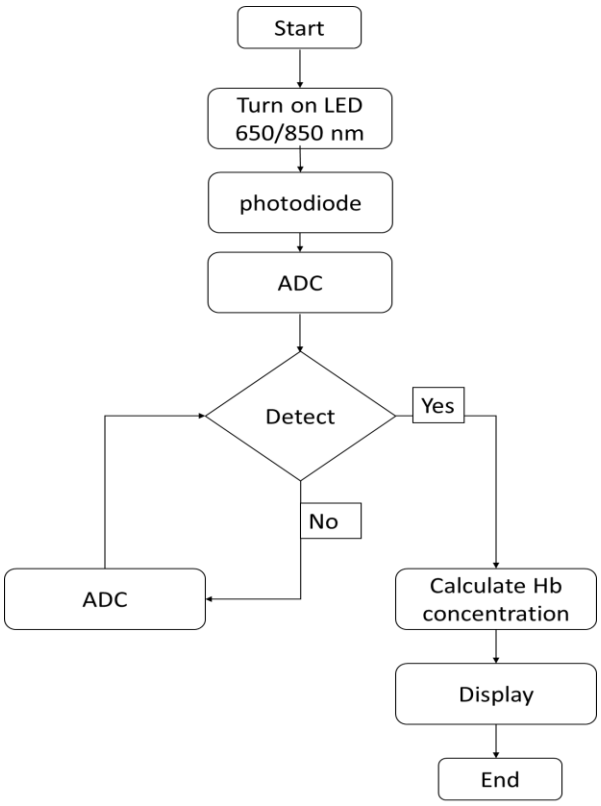
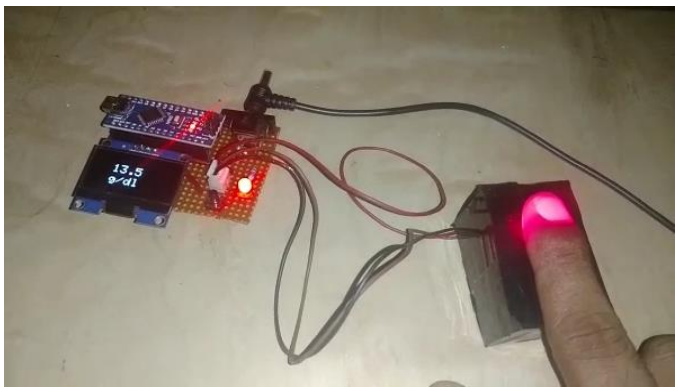



Fig. B: Flow chart of the system

## 4. OUTCOME

Non-invasive hemoglobin measurement gives accurate level of Hb in blood. It gives result in short duration time (preferably in seconds). The kit become portable and cost efficient. Prevent pricking the skin and possibility of infection through needle.



## 5. CONCLUSION

Presently, trained professionals do measurement of Hemoglobin concentration via chemical methods in clinical laboratories, which involves pricking one's finger or arm to obtain a sample of blood. In this project, we have developed a device which would measure the content of blood non-invasively which allows pain free and continuous monitoring with risk of infection extremely low and also the results are available in less than 30 seconds, allowing for immediate clinical evaluation. Basically, when we put our finger on the device, two sources of LEDs with a wavelength of 650nm and 850nm will pass through the tip of the finger. Photodiodes that have a sensitivity range of 400-1000nm are used as sensor to detect the transmitted light through the finger. In this system, Microcontroller are used to control the operation of LEDs, process the data from the sensor and calculate haemoglobin concentration. The Analog-to-Digital Converter (ADC) in Microcontroller was used to convert the analog sensor data from the Photodiode in voltage value to a digital data so that it can be further processed by the microcontroller. Further, Calibration is done which involves invasive blood testing on a set of people to determine their haemoglobin levels through chemical methods and the non-invasive designed measures the absorbance levels at the same instance. This will increase the accuracy of the device. Also, this method is simple, easily portable, easily operable and does not require services of experienced and skilled technicians.

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