NON-INVASIVE HEMOGLOBIN MEASUREMENT SYSTEM

Shruthi B[1], Mohammed Junaid U[2], Parikshith r[3], Subhash Chandra K C[4], Venkat Reddy[5]

[1] *Assistant Professor, Department of Medical Electronics, DSCE Bangalore, India*
[2, 3, 4, 5] *Student, BE, Department of Medical Electronics, DSCE Bangalore, India*

ABSTRACT

Hemoglobin is the most important blood parameter. Conventional methods are mostly used to calculate hemoglobin level which is time consuming and infection risk. This paper presents a non-invasive optical technique for Hb measurement. Oxygenated and deoxygenated hemoglobin absorbs different amounts of light at two wavelengths 660nm and 940nm. Red and IR LEDs are used for these particular wavelengths. Transmitted light through an area of skin on the finger was detected by a trans-impedance amplifier photodiode. The ratio of pulsating to a non-pulsating component of both red and IR signals after normalization is calculated for the determination of Hb. Signal acquisition by this method is totally non-invasive. The sensors assembled in this investigation are fully integrated into wearable finger clip. The process can be viewed remotely and can also store the data in the IoT platform.

Keyword: *Non-invasive hemoglobin detection, oxyhemoglobin, deoxyhemoglobin, Anaemia, Polycythaemia, OLED display, wi-fi module, android app*

---

1. INTRODUCTION

Hemoglobin (Hb) is usually measured as a part of the complete blood count from a blood sample. Hemoglobin is the protein in red blood cells that carry oxygen to the body and can be used to measure physical well-being of an individual. Hemoglobin plays important role for transporting oxygen from the lungs to the other peripheral tissue of body and exchange oxygen for carbon- dioxide and then carry carbon dioxide back to lungs where it is exchange for oxygen. If Hemoglobin level crosses the critical limits then problem occurs such as anemia for low hemoglobin and polycythemia for high hemoglobin level. At different wavelengths absorption coefficient (chart 1) of blood differs, this fact is used to measure the optical characteristics of blood. In this newly developed system, principle of pulse oximetry is used. A non-invasive method allows pain free online patient monitoring with minimum risk of infection and facilitates real time data monitoring allowing immediate clinical reaction to the measured data. The newly developed optical sensor system uses two wavelengths for the measurement of the hemoglobin concentration, oxygen saturation. This non-invasive multi-spectral measurement method is based on radiation of near monochromatic light, emitted by light emitting diodes (LED) in the range of 600nm to 1400nm, through an area of skin on the finger. The sensor assembled in this investigation is fully integrated into a wearable finger clip and allows full wireless operation through on-board miniature IOT enabled microcontroller. The cloud-based storage unit allows to analyze the data with minimal amount of time.

2. METHODOLOGY

2.1 Hardware

In the proposed system we are using pulse oximetry sensor to collect the values from the blood. To collect and process the sensors data we are using Arm cortex processor-based microcontroller. The arm cortex microcontroller supports high speed operation with more Interfacing techniques to communicate with other devices. We are using WIFI module to transfer the data to the cloud server. The cloud server stores the values received from the microcontroller in CSV Format. And displays the received data on the android app in the graphical representation

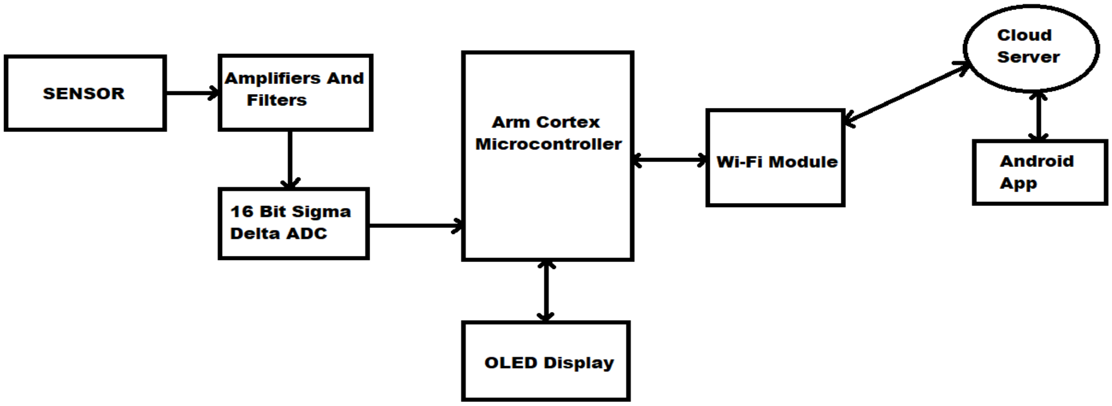

Fig-1 : Block Diagram of the Proposed System

format along with the gauge format. To view the data locally OLED Display is been used. In our proposed system we have adopted Beer's and Lambert's Law (absorbance depends on concentration and path length). Certain amount of radiation is illuminated through the LED's of the pulse oximetry sensor by pre-defining it in the software, the amount of radiation reflected is absorbed by the photodiode. So, the ratio of incidence to that of reflectance is calculated with the following laws

Beer's Law: $I = I_o e^{-k_2 c}$

Lambert's Law: $I = I_o e^{-k_1 l}$

where I is the intensity of emitted radiation, I_o is the intensity of incident radiation, k_1, k_2 are constants, c is the concentration and l is the path length

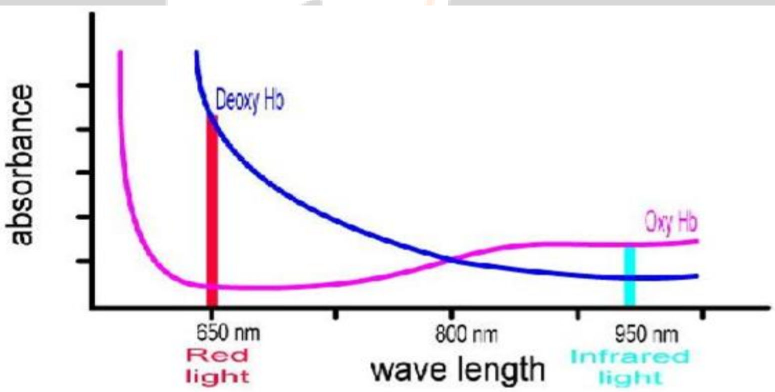

Chart-1: Absorption graph of Oxy and Deoxy Hb

The sensor is interfaced with the microcontroller using I2C communication. This communication method establishes the errorless data transmission between the microcontroller and sensor. The microcontroller collects the data from the sensor and then process the data. After processing the data, it is stored in the internal memory then it is displayed on the OLED display, here the microcontroller uses the I2C communication to transfer the data display. After displaying the data on the OLED display microcontroller sends the data to the Wi-Fi Module using serial communication with using json encryption method. The WIFI module transfers the collected data to the cloud server using internet. In order to establish the communication between the WIFI module and cloud server an authentication code is needed. These authentication codes are generated during the initialization of the android app. Once the communication established the received data is stored in the cloud server virtual memories, these virtual memory addresses are predefined in the source code. We store the received values in the CSV format these helps in the future further studies.

2.2 Software

The algorithm of the system is, First the communication is established with sensor, OLED display and Wi-Fi module. Once the communication is established with the modules verify the address through I2C communication (SDA and SCL). Next, we check the weather finger is inserted in the sensor clip, if it is inserted, we prompt a message on the display stating that press the switch to calculate the Hemoglobin level. If the finger is not inserted, we display another message stating please insert the finger. Once the finger is inserted and switch is pressed, we collect the IR and RED LED absorption ratio and store it in the 10-sample array. Then this data of the array is compared to the ratio of the absorption of the light. Once the comparison is done the details are sent to the Wi-Fi module and store the values on the cloud server so that it could be accessed through a mobile app. Also, the values are displayed on the OLED display. If the Hemoglobin content is lower than a threshold notification is sent to the app.

Arduino complier is used to build the code. Blynk server is used for storing the data on cloud. Blynk app is used to reduce the system complexity to build a mobile application.

3. ADVANTAGES AND DISADVANTAGES

The proposed system for measuring Hemoglobin Non-Invasively consist of the following pros and cons

3.1 Advantages

- Requires no blood sample
- Reduces infection risk
- Patient of any age group can be monitored in real time and immediate clinical reaction to the measured data can be done

3.2 Disadvantages

- Problem of optical shunting and too much ambient light must be taken care while measuring the data
- Problem of electromagnetic interference
- Problem of poor peripheral perfusion

4. RESULTS

Non-invasive system was built for hemoglobin detection. The results of the built system displaying the measured hemoglobin can be visualized in the following figures. The normal range for Hemoglobin in men is 13.5 to 17.5 grams per deciliter and for women is 12.0 to 15.5 grams per deciliter. In the following table results of the subjects tested with the developed system along with gender is presented.

SUBJECT	GENDER	Hb Level (grams/deciliter)
1	Male	13.5
2	Female	12.86
3	Male	13.05
4	Male	14.3
5	Female	12.63

Table-1: Result of Hb level

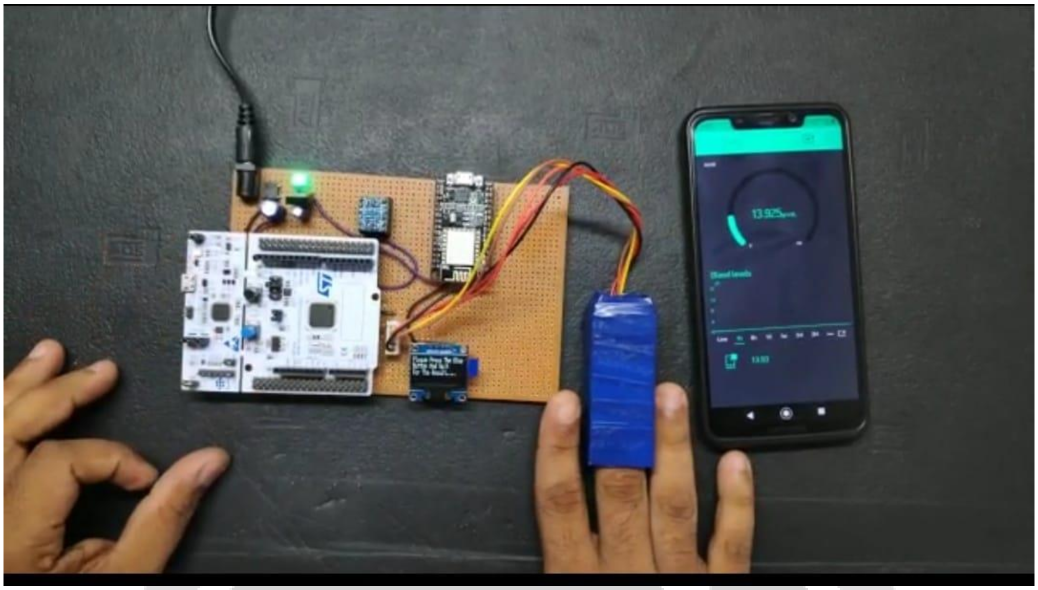

Fig -2 Overview of the System built

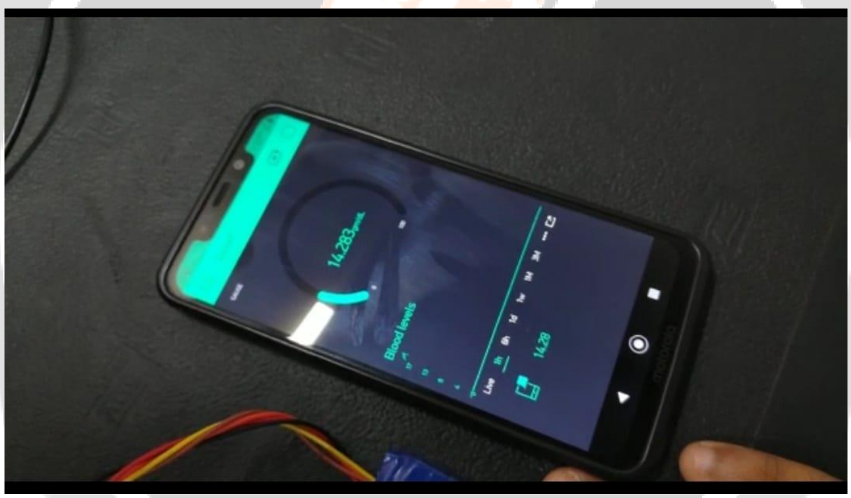

Fig-3 Real time Monitoring on Mobile App

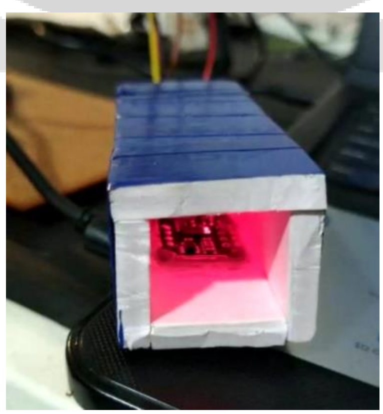

Fig-4 Sensor mounted as a finger clip

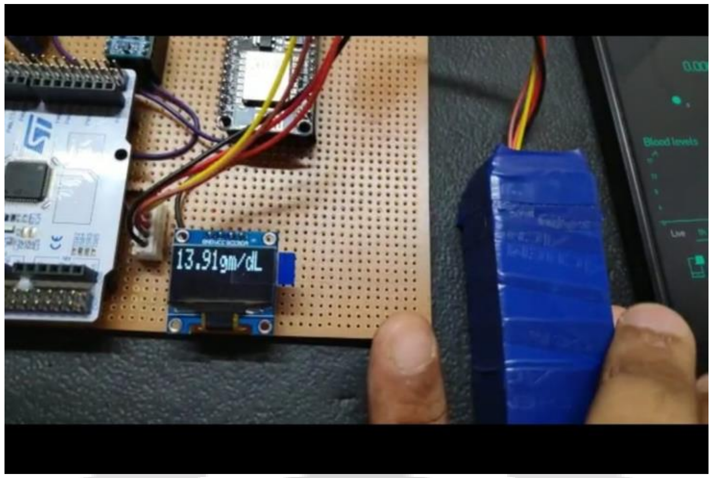

Fig-5 Display of Hemoglobin content

5. CONCLUSION

This paper explains the detection of Hemoglobin Non-invasively through pulse-oximetry sensor. Patient is monitored in real-time with reducing the ease of infection and waiting time for clinical treatment. It is a portable system, user-friendly which could be carried easily anywhere. The sensor, microcontroller and other components considered here for developing the system are reliable for study purpose. Future enhancement could be done by implementing this system with high computational on chip sensor and microcontroller for clinical deployment.

6. ACKNOWLEDGEMENT

Our sincere thanks to our project coordinator Prof. Shruthi B for her continuous support and encouragement throughout our project phase. We would also like to thank Principal Dr.C.P.S Prakash and Head of the department Dr.V.G.Sangam for encouraging us to carry out this project.

7. REFERENCES

[1]. U. Timm, E. Lewis, D. McGrath, J. Kraitl, H. Ewald, “LED Based Sensor System for Non-Invasive Measurement of the Hemoglobin Concentration in Human Blood", IFMBE Proceedings Vol. 23, 82528, 2008.
[2] J. Kraitl, H. Ewald, U.Timm “Non-invasive measurement of blood components” IEEE fifth international Conference on Sensing Technology 2011.
[3] Aldrich TK, Moosikasuwan M, Shah SD, Deshpande KS. “Length-normalized pulse photoplethysmography: a noninvasive method to measure blood haemoglobin”. Ann Biomed Eng 2002; 30:1291– 8.
[4] Jeon KJ, Kim SJ, Park KK, Kim JW, Yoon G. “Noninvasive total hemoglobin measurement Biomed opt 2002;7:45–50
[5] Petrova, Prough, D.S.; Petrov, Brecht, “Optoacoustic technique for continuous, noninvasive measurement of total hemoglobin concentration: an in vivo study” IEMBS Volume: 1, 2004
[6] Jae G. Kim, Mengna Xia, and Hanali Liu “Extinction coefficient of hemoglobin for near-infrared spectroscopy of tissue” IEEEneineering in medicine and biology magazine 2005.
[7] Brecht, H.-P.; Petrov, “Noninvasive continuous optoacoustic monitor of total hemoglobin concentration” Engineering in Medicine and Biology Conference, Volume: 3, 2002
[8] Soumil Chugh, Jaskirat Kaur, “Non-Invasive Hemoglobin Monitoring Device”, 978-1-4673-7349-4/15/$31.00 ©2015 IEEE
[9] Raditya Artha Rochmanto1, Hasballah Zakaria, Ratih Devi Alviana, Nurhalim Shahib, “Non-invasive Hemoglobin Measurement for Anemia Diagnosis”, 978-1-5386-0549-3/17/$31.00 ©2017 IEEE