ISSN - 2250-1991

Research Paper

Medical Science

A Noninvasive Portable Measurement System for Quantification of Hemoglobin

Dr. Raid Saleem Al-Baradie

College of Applied Medical Sciences Majmaah University Kingdom of Saudi Arabia

ABSTRACT

Analysis of blood substances such as hemoglobin, glucose, protein, cholesterol, etc. are important parameters for health condition monitoring. Traditionally, blood sample is taken using a needle. Some chemical process such as enzyme reaction is required before the final value for concentration is read. Reagents involved in such processes are expensive for both the hospital and patient. Non-invasive measurement is much more attractive by its evident advantages such as real time monitoring and infection-free operation. The Hemoglobin (Hb) in human blood is measured and analyzed using Advanced RISC (Reduced Instruction set computing) Machine processor Non-invasively. This investigation helps in ruling out the diseases like anemia (a low hemoglobin level) and polycythemia vera (a high hemoglobin level). At present, the procedures used to measure the Hb concentration in blood are invasive. For this purpose blood is taken and analyzed. The hindrance of this method is the delay between the blood collection and its analysis. The portable smart non-invasive measurement system, discussed in this paper, gives a detailed idea about the hemoglobin concentration in the blood.

KEYWORDS

hemoglobin, Non-invasive, ARM processor, anemia, polycythemia.

I. Introduction

. The non-invasive medical diagnostic techniques including X-rays, ultrasound, thermography, and magnetic resonance imaging (MRI) has greatly reduced risk to the patients and has increased the understanding of how the body works. The benefits of non-invasive techniques are no incisions, no scars, low risk of infection, low risk of bleeding and blood transfusion and shorter recovery time and faster return to normal work. Therefore it is mandatory to evaluate the composition of the blood using non-invasive techniques. The absorption of whole blood in the visible and near infrared range is dominated by the different hemoglobin derivatives and the blood plasma that consists mainly of water. The blood volume changes in tissue can be observed by measuring the transmission or reflection of light through the blood volume. This diagnostic method is known as photoplethysmography (PPG) [1]. This non-invasive Hb measurement is based on radiation of near monochromatic light, emitted by Light Emitting Diodes (LED) of 670nm and 810nm, through an area of skin on the finger. The Hb sensor developed for this research is fully integrated into a wearable finger clip. An area of skin on the finger is trans-illuminated by monochromatic light which is emitted by LED of 670nm and 810nm. It is well known that arteries contain more blood during systolic phase of the cardiac cycle than they do during the diastolic phase. This phenomenon is due to the increased diameter of the arteries during the systolic phase and occurs only in arteries but not in veins [1]. As a result the absorption of light in tissues, during systolic phase, is greater due to a greater quantity of hemoglobin (absorber) being present. Additionally light passes through a longer optical path length in the arteries during the systolic phase which further increases absorption. These changes in the absorption of light are the so called PPG-waves. PPG waves may be described as containing a DC component, which is time independent variable and due to venous blood, and an AC component, which is time dependent variable and due to the pulsation of blood flow in the arteries. In such developed system light transmitted through the tissue is detected non-invasively by photo diodes. The Beer-Lambert law, (equation 1), describes the reduction in intensity for light which is travelling through a homogeneous medium containing an absorbing substance. In equation 1, Io and I are the intensities of the incident and received light, ε (λ) is the extinction coefficient of the absorbing substance at a specific wavelength, *c* is the concentration of the absorbing substance and *d* the optical path length along the medium.

$$I = I_0 e^{-\epsilon(\lambda)cd} \qquad \text{-------(1)}$$

II. Basic Principle of single wavelength spectrophotometry

The principle of Hb concentration measurement of the system is using single wavelength spectrophotometry (Oppenheimer, 1997). Figure 1 illustrates the relationship between wavelength of light from 400 – 1800 nm and Absorption coefficient in deoxygenated hemoglobin (HHb), oxygenated hemoglobin (HbO_2) and water (Timm et al., 2009). It is clear from figure 1 that the absorption coefficient of HHb and HbO_2 is indistinguishable near the wavelength of 670 nm and 810nm. Consequently, the accuracy of measurement is higher than that at other wavelengths.

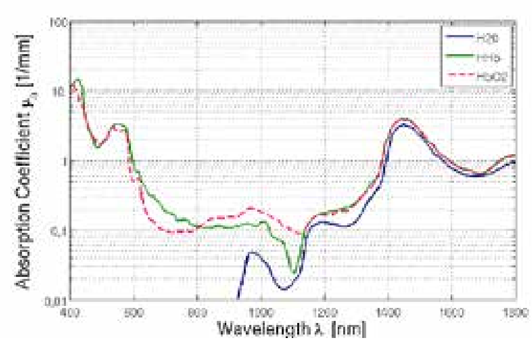


Fig.1. Absorption Spectra of Water and Hemoglobin

III. Hemoglobin Measurement system based on ARM Processor

The portable hemoglobin Sensor System developed consists of a number of hardware modules, which include: light source; receiver; ARM processor LPC 2148 and LCD display. The mean value of the receiver current, when the emitter is on, is calculated and dark current, when the emitter is off, is subtracted from the on current in software to generate an accurate value for the intensity of the received wavelength. The LED is installed in the upper part of a finger clip, while the photodiode is installed in the lower section of the finger clip. The on/off time of the LED currents is controlled by the timer circuit, which effectively controls the intensity of the wavelength source. To detect the intensity of the transmitted signals, a phototransistor is used. Figure 2 shows the block diagram of the system.

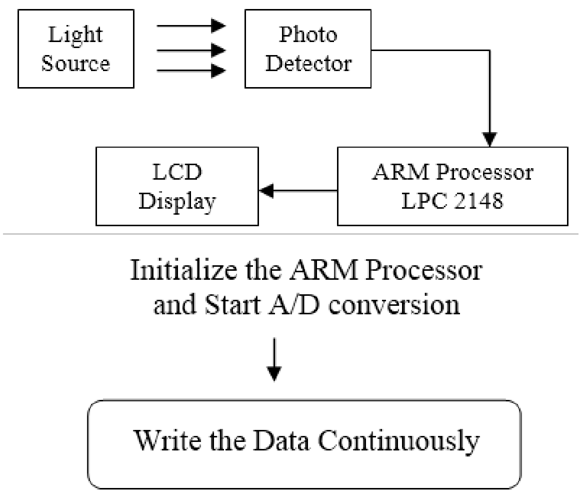


Fig.2. Block diagram of the system

IV. Methodology

The Hemoglobin Sensor System developed consists of an ARM processor that continuously reads the data from the Detector when the input key is pressed and displays the value in the LCD display. The read data is stored in a register for further analysis. The processing and display software is written in Keil µVision3 software and the Hex code is downloaded to the processor LPC 2148. The LED is installed in the upper part of a finger clip, while the photodiode is installed in the lower section of the finger clip. The on/off time of the LED currents is controlled by the timer circuit, which effectively controls the intensity of the wavelength source. To detect the intensity of the transmitted signals, a Photo transistor is used.

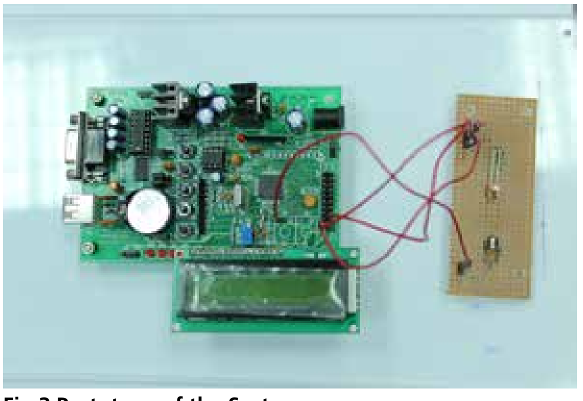
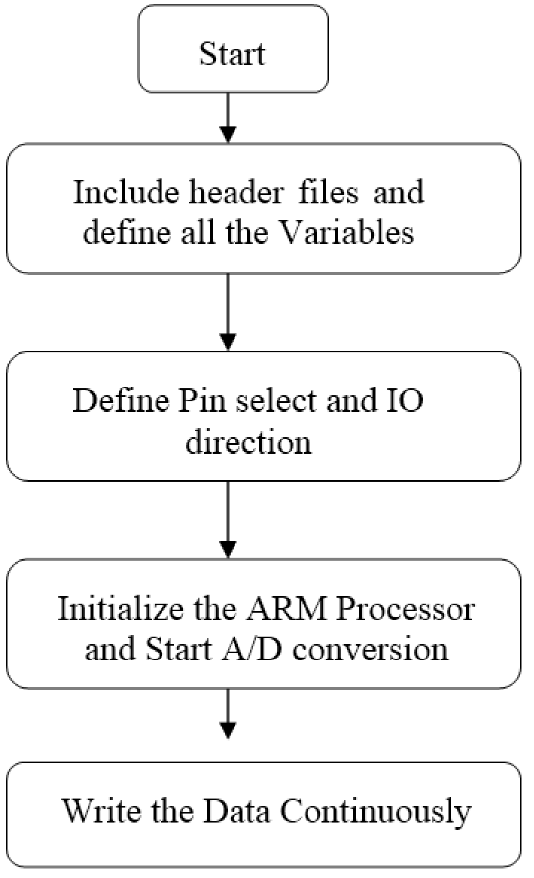
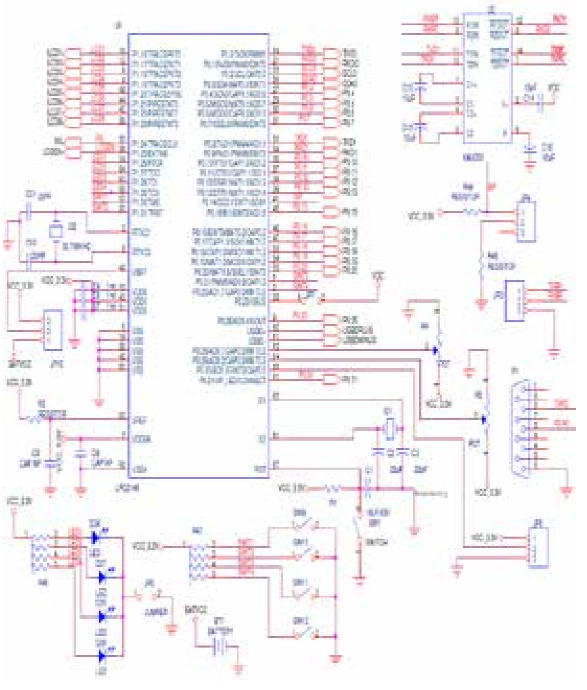


Fig.3 Prototype of the System

V. System Flowchart



VI. Circuit Diagram



VII. Results

All the non-invasive measurements were compared with blood samples which were analyzed using the Instrument Hemo Cue.

By comparing the invasively determined concentration of Hb with the non-invasively measured concentration it was found that there is a linear relationship between the hemoglobin concentration of blood and the calculated Hb coefficients measured with the sensor device.

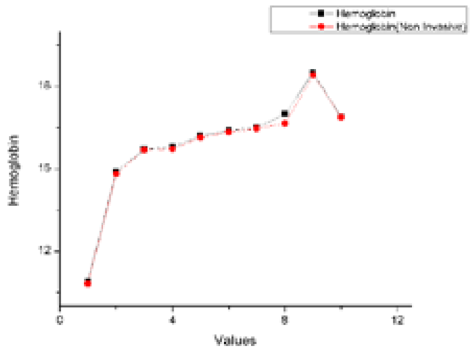


Fig. Comparison curve of Hb Values invasive and Non-invasive.

TABLE I. **Hemoglobin samples**

SL.No.	Age	Hemoglobin (Hemo Cue)	Hemoglobin (Non Invasive)
1.	20	16.4	16.34
2.	20	18.5	18.41
3.	21	15.7	15.68
4.	20	15.8	15.72
5.	20	17.0	16.65
6.	20	10.9	10.81
7.	21	16.2	16.14
8.	37	14.9	14.82
9.	19	16.5	16.47
10.	21	16.9	16.88

VIII. conclusion

A novel LED based Hemoglobin sensor system has been developed that is able to measure PPG-signals continuously at the wavelength of 670 nm and 810nm. The system is mainly built up with ARM processor. The Hemo Cue instrument used to measure the Hemoglobin content of the blood, to calibrate the sensor system. The sensor developed may be suitable for non-invasive and continuous online monitoring of Hemoglobin in human subjects.

The developed sensor is under trials. After taking reading from many samples the sensor was calibrated to know the Hemoglobin concentration in the blood.

IX. Future scope

The work described here can be extended to measure some other parameters in the blood non-invasively. The developed algorithm can be used to measure the blood glucose level non-invasively, but the concept of changes in the glucose in the blood with respect to different input signals has to be studied.

Acknowledgment

Apart from the efforts of me, the success of this project depends largely on the encouragement and guidelines of many others. I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this project.

I would like to show my greatest appreciation to Dr. Guesmi Hedi (HOD, Medical Equipments Technology, Majmaah University). Without his encouragement and guidance this project would not have materialized.

I would also like to express my profound gratitude to Dr. Mottar Rizvi (Assistant Professor, College of Applied Medical Sciences, Majmaah University) for his constant and valuable suggestions while doing the project work.

Last but not least, I express my heartiest gratitude to Almighty Allah, my parents, my wife and children for their love and blessings to complete this work successfully.

REFERENCES

[1]U.Timm, E.Lewis, G.Leen,J. Krait and H. Ewald, Non-Invasive continuous online Hemoglobin monitoring system, IEEE, 2009. [2] S. J. Matcher, M. Cope, and D. T. Delpy. Use of the water absorption spectrum to quantifies tissue chromospheres concentration changes in near-infrared spectroscopy. Phys. Med. Biol., 38:177–196, September 1993. [3] Kamal AAR, Hatness JB, Irving G, Means AJ, 1989 Skin photoplethysmography – a review, Comp. Meth.Progr. Biomed., 28, pp 257-69 [4] N. Kollias. Tabulated molar extinction coeffcient for hemoglobin in water. Wellman Laboratories, Harvard Medical School, Boston, 1999. [5] Oppenheimer, L., 1997 Spectrophotometric blood analysis, United states patent US5601080. [6] T. Ahrens and K.Rutherford. Essentials of Oxygenation: Implication for Clinical Practice. Jones & Bartlett Pub, 1993. [7] J G Webster. Design of Pulse Oximeters. Taylor & Francis, 1997. [8] Schmitt Joseph M, Zhou X., Miller J.: Measurement of blood hematrocrit by dual-wavelength near-IR photopleythysmography, 1992 SPIE Vol 1641 p.150-161 [9] Kratil, J., Ewald H., Results of hemoglobin concentration measurements in whole blood with an optical non-invasive methodƐ, Photon08, Optics and Photonics, IOP Conference, p 77, Edinburgh UK, 2008 . Dr. Raid Al-Baradie Received the Bachelors degree in Clinical Laboratory Sciences from King Saud University, Riyadh, Kingdom of Saudi Arabia in 1993 and High Diploma in Molecular experimental Techniques from Duke University Medical school, U.S.A in 1999 and completed hid Ph.D Degree from Manchester University, U.K in 2008 and Post post doctoral fellowship also from Manchester University, UK in 2010. Currently he is working as Vice Dean (Research), College of Applied Medical Sciences, Majmaah University, Kingdom of Saudi Arabia. His fields of interest are oncology, angiogenesis and Stroke.