COMPARATIVE ANALYSIS OF PULSE OXIMETER

Arvind Yadav[1], Shahanaz Ayub[2]

[1]*M.Tech Student, B.I.E.T Jhansi, (India)*

[2]*Associate Professor , B.I.E.T Jhansi, (India)*

ABSTRACT

Pulse oximetry is a non-invasive method for monitoring a person's O2 saturation. In its most common (transmissive) application mode, a sensor device is placed on a thin part of the patient's body, usually a fingertip orearlobe, or in the case of an infant, across a foot. The device passes two wavelengths of light through the body part to a photodetector. It measures the changing absorbance at each of the wavelengths, allowing it to determine the absorbances due to the pulsing arterial bloodalone, excluding venous blood, skin, bone, muscle, fat, and (in most cases) nail polish.There are many portable oximeters are available in the market, but they are not so accurate. To make accurate oximeter we are using here ARM based microprocessor/ microcontroller. . in this paper we give the compression between the real time results of haemoglobin(from our designed pulse oximeter) and the results from pathologyof same patient. We find the our designed pulse oximeter gave 94.204 % accurate result.

Keywords:-AVR, Pulse Oximeter, Haemoglobin Measurement.

I. INTRODUCTION

A Pulse Oximeter is essentially a portable, noninvasive monitor of oxygen saturation which enables prompt recognition of hypoxemia. Pulse oximetry basically measures oxygen saturation (SaO2), the percentage of haemoglobin saturated with oxygen. Pulse Oximetry has been recommended as a standard for care of every general anaesthetic[1,2]. The device passes two wavelengths of light through the body part to a photodetector. It measures the changing absorbance at each of the wavelengths, allowing it to determine the absorbances due to the pulsing arterial blood alone, excluding venous blood, skin, bone, muscle, fat, and nail polish. Reflectance pulse oximetry may be used as an alternative to transmissive pulse oximetery described above. This method does not require a thin section of the person's body and is therefore well suited to more universal application such as the feet, forehead and chest, but it also has some limitations.[4,5,6] Vasodilation and pooling of venous blood in the head due to compromised venous return to the heart, as occurs with congenital cyanotic heart disease patients, or in patients in the Trendelenburg position, can cause a combination of arterial and venous pulsations in the forehead region and lead to spurious SpO_2 results.

II. HISTORY

Pulse oximetry was developed in 1972, by Takuo Aoyagi and Michio Kishi, bioengineers, at Nihon Kohden using the ratio of red to infrared light absorption of pulsating components at the measuring site. Susumu Nakajima, a surgeon, and his associates first tested the device in patients, reporting it in 1975[3] It was

commercialized by Biox in 1981 and Nellcorin 1983. Biox was founded in 1979, and introduced the first pulse oximeter to commercial distribution in 1981. Biox initially focused on respiratory care, but when the company discovered that their pulse oximeters were being used in operating rooms to monitor oxygen levels, Biox expanded its marketing resources to focus on operating rooms in late 1982. A competitor, Nellcor (now part of Covidien, Ltd.), began to compete with Biox for the U.S. operating room market in 1983. Prior to the introduction of pulse oximetry, a patient's oxygenation could only be determined by arterial blood gas, a single-point measurement that takes several minutes for sample collection and processing by a laboratory. In the absence of oxygenation, damage to the brain starts within 5 minutes with brain death ensuing within another 10–15 minutes. The worldwide market for pulse oximetry is over a billion dollars. With the introduction of pulse oximetry, a non-invasive, continuous measure of patient's oxygenation was possible, revolutionizing the practice of anesthesia and greatly improving patient safety. Prior to its introduction, studies in anesthesia journals estimated U.S. patient mortality as a consequence of undetected hypoxemia at 2,000 to 10,000 deaths per year, with no known estimate of patient morbidity.

III. PRINCIPLE

The principle of pulse oximetry is based on the red and infrared light absorption characteristics of oxygenated and deoxygenated hemoglobin. Oxygenated hemoglobin absorbs more infrared light and allows more red light to pass through. Deoxygenated (or reduced) hemoglobin absorbs more red light and allows more infrared light to pass through. Red light is in the 600-750 nm wavelength light band. Infrared light is in the 850-1000 nm wavelength light band.

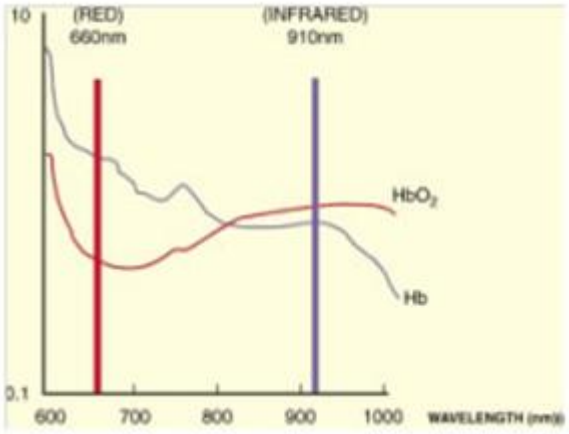

Fig. 1 Absorption of Oxygenated and Non-Oxygenated Haemoglobin at Different Wavelength

Pulse oximetry uses a light emitter with red and infrared LEDs that shines through a reasonably translucent site with good blood flow. Typical adult/pediatric sites are the finger, toe, pinna (top) or lobe of the ear. Infant sites are the foot or palm of the hand and the big toe or thumb. Opposite the emitter is a photodetector that receives the light that passes through the measuring site.[8,9]

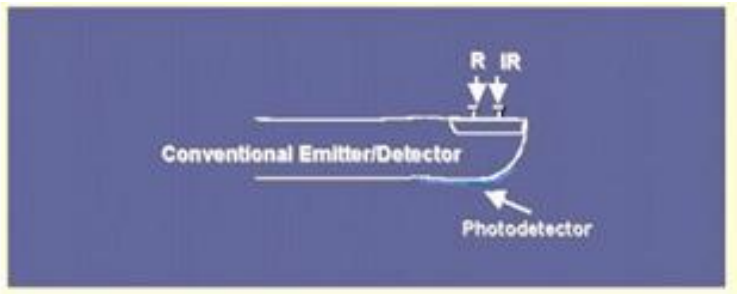

Fig. 2 Conventional Emitter/Detector

There are two methods of sending light through the measuring site: transmission and reflectance.[11,12] In the transmission method, as shown in the figure on the previous page, the emitter and photodetector are opposite of each other with the measuring site in-between. The light can then pass through the site. In the reflectance method, the emitter and photodetector are next to each other on top the measuring site. The light bounces from the emitter to the detector across the site. The transmission method is the most common type used and for this discussion the transmission method will be implied. After the transmitted red (R) and infrared (IR) signals pass through the measuring site and are received at the photodetector, the R/IR ratio is calculated. The R/IR is compared to a "look-up" table (made up of empirical formulas) that convert the ratio to an SpO2 value. [13,14]Most manufacturers have their own look-up tables based on calibration curves derived from healthy subjects at various SpO2 levels. Typically a R/IR ratio of 0.5 equates to approximately 100% SpO2, a ratio of 1.0 to approximately 82% SpO2, while a ratio of 2.0 equates to 0% SpO2.

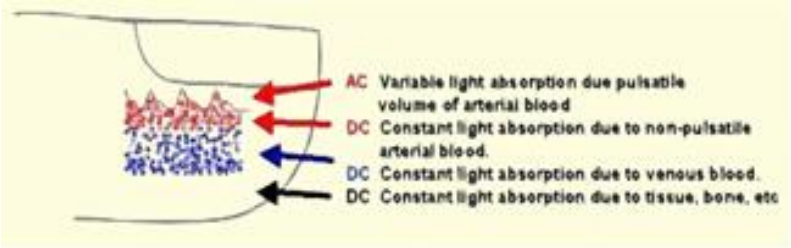

Fig.3 Absorbtion of AC and DC Variavle Light

IV. DEVELOPMENT PROCEDURE

Pulse oximetry has become a standard procedure for the measurement of blood-oxygen saturation in hospitals, clinics, etc. Pulse oximeter can directly detect hypoxemia, deficiency of oxygen saturation in the arterial blood. Early detection of hypoxemia can reduce the gas poisoning by CO2 or CO, tissue damage, etc. Thus, the oxygen saturation of the blood can quickly and accurately be monitored non-invasively using pulse oximeter.

Pulse oximeter works on the principal of absorption and reflectance/transmittance of light by multiple components like skin, muscle and blood vessel.[15,16] Absorption due to tissue, skin or muscle remains fairly constant, whereas absorption due to arterial blood varies. Arteries expand due to the pumping of the heart, expanding the arteries and intern increasing the tissue between the LEDs and the photodiode, thus increasing the light absorption. Using this principle, heart rate can be detected. Absorption of oxyhemoglobin and the deoxygenated haemoglobin form differs significantly with wavelengths (i.e.) oxygen is transported in the blood by haemoglobin, and, depending on the binding of oxygen to the haemoglobin. [8,9,10] Light from two LEDs with different wavelengths i.e. 660 (RED) and 940 nm (IR) are made to fall on the finger. Oxygenated haemoglobin absorbs more infrared light and allows more red light to pass through.blood or Deoxygenated haemoglobin absorbs more red light and allows more infrared light to pass through. The ratio of absorption at

the two wavelengths is used to determine the fraction of saturated haemoglobin. Pulse Oximetry can be done using two methods, reflectance oximetry and transmittance oximetry. In case of reflectance oximetry, the two LEDs and the photodiode are on the same side. Here, the light moves through the skin, muscle and blood vessel, and is reflected back from the bone. Reflectance oximetry has low signal to noise ratio and difficult to set up. In case of transmittance oximetry, the two LEDs and the photodiode are on the opposite side of the finger. Here, the transmitted light is detected by the photo diode, and is found to have higher signal to noise ratio.

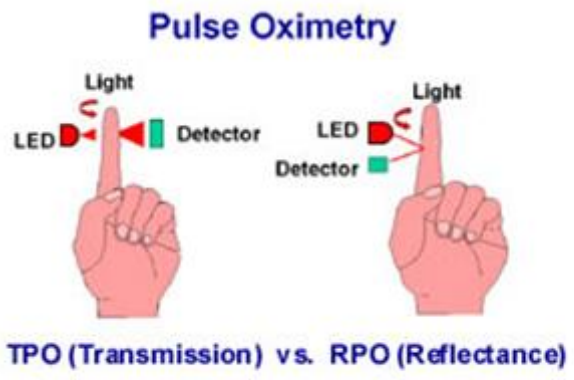

Figure 4: Transmittance Oximetry V/S Reflectance Oximetry

V. BLOCK DIAGRAM

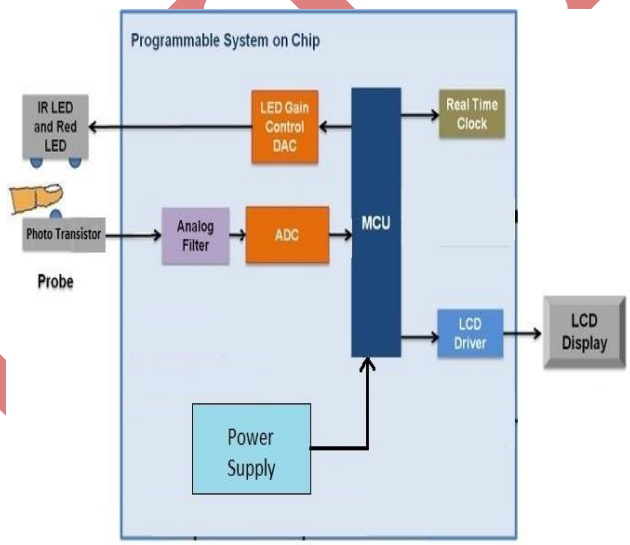

Fig.5 Block Diagram of Pulse Oximeter

Project is divided into three parts.

1- Controller Unit

2- Sensor Unit

3- Display Unit

Sensor consisting of transmitter and receiver, for transmission we used an IR LED and a red LED and for reception we used Phototransistor having capability of receiving signal transmitted from LEDs. IR LED and red LED continuously transmitting signal one by one after a fixed time interval. The received signal passed through the analog filter to remove noise occurred, and this analog output finally detected by controller by passing

through analog to digital converter. According to a set program, controller sends a signal to LCD display. LCD displaying SPO2 percentage, Heart beat and Haemoglobin level.

VI. COMPARATIVE STUDIES

This given table show the comparison between Haemoglobin Reading from our design instrument and Reading from the pathology of the same person.

6.1 Haemoglobin Comparison Studies

Table No.1

Patient Name	Age	Haemo-globin Measuresd by pulse oximeter	Haemo-globin Measures d by pulse oximeter	Accuracy in %
Avadhesh Kumar	22	14	15	93.33
Punam	25	13	12.5	96.15
Shiv Naresh	45	14	14.5	96.55
Vikash	12	12	11	91.66
Nilesh	28	14	15	93.33

6.2 Specifications and Operating Ranges

Range

Oxygen Saturation (%SpO2)	1-100%
Haemoglobin Level (g/dL)	0-17

Accuracy

Oxygen Saturation during Motion and No Motion Conditions

Adults, Pediatrics	70-100% ± 2 digits
	0-69% unspecified
Neonates	70-100% ± 3 digits
	0-69% unspecified
Haemoglobin Level (g/dL)	0-17 ± 1 digits

6.3 Re Resolution

Oxygen Saturation (%SpO2)		1%
Haemoglobin Level	(g/dL)	1%

VII. CONCLUSION

The result of this pulse oximeter is very much approaching the actual value that we find from the Lab. Our percentage of accuracy is 94.406 with respect to result of laboratory. There is column of age of the person in the table. The range of haemoglobin according to The age of person is shown below:

- Newborns: 17 to 22 gm/dL
- One (1) week of age: 15 to 20 gm/dL
- One (1) month of age: 11 to 15gm/dL
- Children: 11 to 13 gm/dL
- Adult males: 14 to 18 gm/dL
- Adult women: 12 to 16 gm/dL
- Men after middle age: 12.4 to 14.9 gm/dL
- Women after middle age: 11.7 to 13.8 gm/dL

From the above data we can observe that haemoglobin of the newborn baby is highest and haemoglobin of woman after middle age is lowest from the table we can observe that reading of haemoglobin lie in range according to their age. We know that low haemoglobin level is referred to as anaemia or low red blood count.
The device was designed efficiently and met all expectations as set earlier. This device is very efficient in compare to the conventional method of haemoglobin measurement. It provide fast reading, there is LCD(Liquid crystal Display) for display the reading, using this device we can measure haemoglobin of hundreds of person in a single day and cost will very less compare to lab test cost. In future a printer can connect with this device, and we can store a huge database accurately.

VIII. ACKNOWLEDGEMENT

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REFERENCES

[1] Brand TM, Brand ME, Jay GD (February 2002). "Enamel nail polish does not interfere with pulse oximetry among normoxic volunteers". J Clin Monit Comput 17 (2): 93–6.doi:10.1023/A:1016385222568. PMID 122129.

[2] Arvind Yadav, Dr Shahnaz ayub " Design and development of pulse oximeter" Progress in Science and engineering Research Journal ISSN2347-6680.

[3] Severinghaus, John W.; Honda, Yoshiyuki (April 1987). "History of Blood Gas Analysis. VII. Pulse Oximetry". Journal of Clinical Monitoring 135138. PMID 3295125

[4] Y. Mendelson, J. C. Kent, B.L. Yocum, and M.J. Birle, "Design and Evaluation of a New Reflectance Pulse Oximeter Sensor," Medical Instrumentation, vol. 22, pp. 167-173, August 1988.

[5] E.B. Merrick and T.J. Hayes, "Continuous, Non-Invasive Measurements of Arterial Blood Oxygen Levels, "Hewlet t-Packard Journal, vol. 2 8, pp. 1-9, 1976.

[6] Y. Yoshiya, Y. Shimada and K. Tanaka, "Spectrophotometric monitoring of arterial oxygen saturation in the fingertip, "Med. &B i o l . Eng. &Comput.vol. 18, pp. 27-32, January, 1980.

[7] Webster JG. Medical Instrumentation: Application and Design, fourth edition. John Wiley and Sons, New York, New York, 2009.

[8] KelvinKT, Steven J.B.(1989) " Pulse Oximetry" Anesthesiology vol70, No. 1, pp 98-108 Jan.

[9] Ploge J.A (1987) "Pulse Oximetry: Technicalaspect of machine design" IntAnesthesiolclin25: pp 147-153

[10] MendeIson Y, Kent J.C (1981) "Variation in optical absorption spectra of adult and fetalhemoglobin and its effect on Pulse Oximetry"IEEE Trans Biomed Eng, .%: pp 844-8413

[11] J.G. Webster, et al., “Design of Pulse Orieters,” MedicolScrenceSm’es, IOP Publishing, p. 178,1997.

[12] Akay, Metin, Biomedical Signal Processing, Academic Press Inc., 1994.

[13] Akselrod, S. et al., “Power spectrum analysis of heart rate fluctuation: Aquantitative probe of beat-to-beat cardiovascular control, “Science, vol.213, pp 220-222, 1981.

[14] Awad, A. et al, “How Does the Plethysmogram Derived from the PulseOximeter Relate to Arterial Blood Pressure in Coronary Artery BypassGraft Patients?” Anesth Anal, vol. 93 pp1466-1471, 2001.

[15] Rusch, T. et al, “Signal Processing Methods for Pulse Oximetry,” Comput.Biol. Med., vol. 26 no. 2, pp 143-159, 1996.

[16] Task Force of the European Society of Cardiology and the North AmericanSociety of Pacing and Electrophysiology, “Heart rate variability: Standardsof measurement, physiological interpretation, and clinical use,”Circulation, vol. 93, pp. 1043-1065, 1996.