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A Survey on Digital Pulse Oximeter

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ABSTRACT: In this paper, we seek to monitor a patient's heart rate and blood-oxygen level using a pulse oximeter. The pulse oximeter is designed using infrared and visible (red) light detection from light that passes through a patient's finger from an emitter. The absorption can tell once blood is moving through the finger and the way a lot of of this is often oxygen-rich. Light generated from two LEDs with totally different wavelengths i.e. 660 (RED) and 940 nm (IR) area unit created to fall on the finger. Ventilated haemoprotein absorbs a lot of infrared light and permits a lot of red light to withstand. Deoxygenated haemoprotein absorbs a lot of red light-weight and permits a lot of infrared emission to withstand. During this paper analysis of calculation of pulse rate and element percent in blood is summarized.

KEYWORDS: Pulse Oximetry, SPO2, Controller, Filter, Finger-tip Sensor.

I. INTRODUCTION

A Pulse Oximeter is essentially a portable, non-invasive monitor of oxygen saturation which enables prompt recognition of hypoxemia [2]. Pulse oximetry basically measures oxygen saturation (SaO2), the percentage of haemoglobin saturated with oxygen. Pulse Oximetry has been suggested as a customary for care of each general anaesthetic.

The Patient Safety Pulse Oximetry project aims to boost the protection of operative rooms worldwide. The Surgical Safety listing has been shown to cut back complications and mortality by over thirty p.c. The listing is straightforward and may be completed in below a pair of minutes, however, there's one element that's not presently realizable in each operating theater within the world: pulse oximetry. United Nations agency Patient Safety has worked with the Harvard college of Public Health, the WFSA, the AAGBI and plenty of different partners round the world to facilitate the event of pulse oximetry technical commonplaces that crystal rectifier to the event of a high standard, affordable pulse measuring device.

The most common cause of preventable disaster in the operating theatre and critical care environments is patient hypoxia. An instrument that would continually and accurately monitor the oxygen saturation of a patient's blood, preferably non-invasively, would facilitate detection of hypoxia before clinical signs are apparent, and enable the physician to initiate corrective actions before it is too late. Until the early 1980s, oxygen saturation was mainly calculated by obtaining arterial blood and examining the profile of the blood gases. However, the disadvantages of this method are that it is in vitro, with the risk of sample contamination, and more importantly is invasive and also not continuous. Although, several other ways of monitoring oxygen saturation optically have been proposed, like the Wood oximeter (Wood, 1948) and the Hewlett-Packard ear oximeter (Saunders, 1976), their success was limited. Since the early 1980s a new technique, namely pulse oximetry, has become widely used [1,3]. Pulse oximeters (Yoshiya, 1980; Taylor, 1986; Griffiths, 1988; Blackwell, 1989) are used in many clinical settings, such as intensive care, surgery and emergency medicine to name just a few, for the continuous, in vivo, non-invasive monitoring of "arterial" oxygen saturation. The current situation regarding pulse oximetry is that of an extremely commercially successful instrument, mainly because of the ease of operation. Although several problems have been reported relating to the use of pulse oximeters, it has to be emphasized that pulse oximeters are very reliable clinical instruments in most cases, and this has been clearly proved over the last few years. Nevertheless it is widely acknowledged that the precise mechanism of their operation is not totally understood.

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In the following sections of the introduction the clinical background of oxygen transport is reviewed along with oxygen saturation monitoring techniques. Also the theory and uses of photoplethysmography, the technique utilized by Pulse Oximetry for monitoring oxygen saturation, are presented.

II. PRINCIPLE OF PULSE OXIMETRY

Pulse oximetry is a non-invasive method for monitoring a patient's O2 saturation.

A sensor is placed on a thin part of the patient's body, usually a fingertip or earlobe, or in the case of an infant, across a foot. Light of two wavelengths is passed through the patient to a photo detector[5,6]. The dynamic absorbance at every of the wavelengths is measured, permitting determination of the absorbance owing to the pulsing blood alone, excluding blood, skin, bone, muscle, fat, and (in most cases) nail enamel. With NIRS it's doable to live each ventilated and deoxygenated Hb on a peripheral scale (possible on each brain and muscle).

A blood-oxygen monitor displays the share of blood vessel Hb within the oxy Hb configuration. Acceptable traditional ranges for patients while not COPD with a hypoxic drive drawback area unit from ninety five to ninety nine %, those with a hypoxic drive drawback would expect values to be between eighty eight to ninety four %, and values of 100% will indicate CO poisoning. For a patient way air, at shortly higher than water level, estimate of blood vessel pO2 will be made up of the blood-oxygen monitor SpO2 reading.

Pulse oximetry may be a significantly convenient non-invasive measuring technique. Generally it utilizes a try of tiny light-emitting diodes (LEDs) facing a photodiode through a clear a part of the patient's body, sometimes a tip or Associate in Nursing ear lobe. One semiconductor diode is red, with wavelength of 660 nm, and also the different is infrared, 905, 910, or 940 nm[10]. Absorption at these wavelengths differs considerably between haemoglobin and its deoxygenated form; thus, the oxy/deoxyhemoglobin magnitude relation will be calculated from the magnitude relation of the absorption of the red and infrared. The absorbance of haemoglobin and deoxyhemoglobin is that the same (isosbestic point) for the wavelengths of 590 and 805 nm; earlier instrumentality used these wavelengths for correction of haemoglobin concentration.

Pulse oximeters operate by assumptive that absorbance measurements area unit performed on blood that flows within the finger.As presented in the theory, pulse oximeters [2,4] use the AC/DC ratio of the photoplethysmographic signal at 660 and 940nm to calculate the oxygen saturation. These instruments are still empirically calibrated and therefore the study of the wavelength dependence of the magnitude of the pulsatile and non-pulsatile components of light scattered from tissue, is of extreme importance in trying to assess and understand the way that pulse oximeters really operate, whether in reflection or transmission mode.

This ties up with a new trend of using transmission pulse oximeters with multi-site sensors which can be used in either transmission or reflection mode. Consequently any observed deviations either from the wavelength dependence predicted by existing pulse oximetry theory or between reflection and transmission mode would suggest that the output from pulse oximeters should perhaps be viewed with caution. The wavelength dependence of the photoplethysmographic signal in both refection and transmission modes from 450nm to 1000nm in studies on the fingertip is therefore investigated. Moreover, the possibilities of using other wavelengths, instead of 660 and 940nm, especially in the visible region is examined with the aim of improving the accuracy and overcoming certain limitations of existing instruments. In addition the possibility of defining a model finger for Monte Carlo simulations of light transport in tissue is investigated. The aim is that simulation results on the wavelength dependence of the photo-plethysmograph are compared with the experimental ones. A successful definition of such a model will allow future simulation prediction of the behaviour of pulse oximeters due to the variation of relevant parameters.

Finally, a new area in which the use of reflection pulse oximetry is currently under investigation is that of fetal monitoring during labour. Preliminary observations reported false low SPO2 readings associated with malposition

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reflectance probes and this new artefact is examined herein detail; the objectives being to both quantify and suggest ways of eliminating it.

III. PARAMETRIC CALCULATION OF SPO2 & HAEMOGLOBIN

Pulse oximetry has become a regular procedure for the measure of blood-oxygen saturation in hospitals, clinics, etc. Pulse measuring instrument will directly sight hypoxemia, deficiency of gas saturation within the blood. Early detection of hypoxemia will cut back the gas poisoning by dioxide or CO, tissue injury, etc. Thus, the gas saturation of the blood will quickly and accurately be monitored non-invasively mistreatment pulse measuring instrument. Pulse measuring instrument works on the principal of absorption and reflectance/transmittance of sunshine by multiple parts like skin, muscle and vas. Absorption as a result of tissue, skin or muscle remains fairly constant, whereas absorption as a result of blood varies. Arteries expand as a result of the pumping of the guts, increasing the arteries and successively increasing the tissue between the LEDs and also the photodiode, therefore increasing the sunshine absorption [7-9]. Mistreatment this principle, pulse rate may be detected. Absorption of haemoglobin and also the deoxygenated Hb kind differs considerably with wavelengths (i.e.) gas is transported within the blood by Hb, and, counting on the binding of gas to the Hb, absorption of sunshine takes place at 2 wavelengths as shown below.

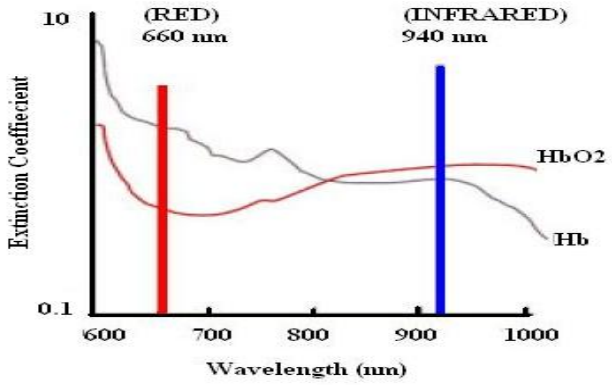

Fig. 1: Absorption of oxygenated and non-oxygenated hemoglobin at different wavelength [1,3]

Light from 2 LEDs with totally different wavelengths i.e. 660 (RED) and 940 nm (IR) square measure created to fall on the finger. Ventilated hemoprotein absorbs a lot of light infraredand permits a lot of red light to suffer. Deoxygenated hemoprotein absorbs a lot of red light-weight and permits a lot of infrared to suffer [4]. The magnitude relation of absorption at the two wavelengths is employed to work out the fraction of saturated hemoprotein. Pulse Oximetry will be done victimisation two strategies, coefficient oximetry and transmission oximetry. Just in case of coefficient oximetry, the two LEDs and also the photodiode square measure on an equivalent facet. Here, the sunshine moves through the skin, muscle and vas, and is mirrored back from the bone. Pulse oximetry has low signal to noise magnitude relation and tough to line up. Just in case of transmission oximetry, the 2 LEDs and also the photodiode square measure on the other facet of the finger. Here, the transmitted light-weight is detected by the image diode, and is found to own higher signal to noise magnitude relation.

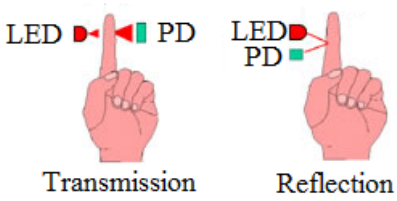

Fig. 2 Transmittance oximetry v/s Reflectance oximetry

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Both the approaches were tried in this project and it was found that the noise in case of reflectance method is higher as compared to the transmittance, also, the amplitude of the waveform is more in case of transmittance method.

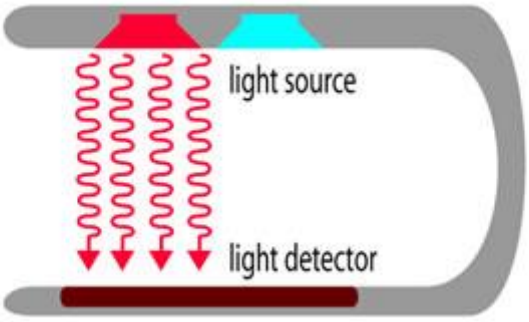

Fig. 3: Emission of Red and Infrared LED on the light detector via the finger/tissue[3]

The output of the photodiode is very less in amplitude, and also very noisy. Before giving to the microcontroller, high amplification and filtering is required to get the desired signal. Two band pass filters are used for the signal processing. The microcontroller is required to perform the analog to digital conversion of the signal, and calculate the peak amplitudes of the signal to generate the heart rate and SpO2.

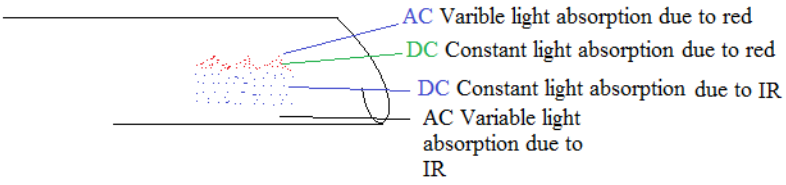

Fig. 4 Absorption of light due to multiple components in finger

The values are displayed on a Graphic LCD. Background Math: The ratio of the absorbance due to red led to that of infrared led can be formulated as

$$R = \frac{\frac{(V_{max}\ (Red\ ) - V_{min}\ (Red\ ))}{V_{min}\ (Red\ )}}{\frac{(V_{max}\ (IR) - V_{min}\ (IR))}{V_{min}\ (IR)}} \quad (1)$$

And oxygen saturation of blood can be formulated as

$$SPO_2 = \frac{HbO_2\ (Vmax\ )}{HbO_2 (Vmax\ ) + Hb} \quad (2)$$

or

$$SPO_2 = (10.0002 \times R^3) - (52.887 \times R^2) + (26.81 \times R) + 98.283 \quad (3)$$

Using these parameters we are able to live hemoglobin in body.

Haemoglobin is sometimes measured as a section of the entire blood count (CBC) from a blood sample. Many ways exist for mensuration hemoglobin, most of that area unit done presently by automatic machines designed to perform many totally different tests on blood. At intervals the machine, the red blood cells area unit softened to urge the hemoglobin into an answer. The free hemoglobin is exposed to chemical containing cyanide that binds tightly with the hemoglobin molecule to make cyanomethemoglobin. By transmittinglight through the finger and mensuration what proportion light is absorbed (specifically at a wavelength of 540 nano-meters), the quantity of hemoglobin are often determined.

Using same concept in my project, I used an LED emitting light of wavelength 540nm. And we directly get the different values of Hb by absorption of light into the blood. And finally on the basis of values of Hb and SPO2, we can measure the Haemoblobin:

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$$Haemoblobin = \frac{av(Hb)\times SPO_2}{100} \qquad (4)$$

IV. ALGORITHM OF PROJECT

Signal processing might contain any or all of the following functions:

- remove DC component
- remove out-of-band noise signals with bandpass filter
- amplify signal to well above oscilloscope minimum levels
- provide a suitable trigger threshold for a trigger indicator, midway between peak and valley points
- disable processing during artifacts caused by movement

Algorithm of project is described as below
(a) Initialize Parameters
(b) Turn on and off Red and IR LEDs
(c) Calculate maximum and minimum values of voltages due to red & IR LEDs.
(d) Turn on timer
(e) Calculate time between two peaks. Now heart rate can be calculated as frequency=1/t beats/sec = 60/t beats/minute.
(f) SPO2 can be calculated using equations (1 & 3).
(g) Haemoglobin can be calculated using equation (4).

V. CONCLUSION

The project was successful. The Heart rate, Haemoglobin and SpO2 for me was on an average 80 beats per minute, 12.8-16.9gm/dL and 98.54% respectively. The heart rate for normal person is about 72 beats per minute and a normal range is about 65-92 beats per minute. The SPO2 for normal person who is helthy lies between 95.3-99.99%. SpO2 below 94% may be fatal and may cause unconsciousness. The normal ranges for hemoglobin depend on the age and, beginning in adolescence, the gender of the person. The normal ranges are:

- 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

A low hemoglobin level is referred to as anemia or low red blood count.More advanced formula are often written to vary the brightness of the LEDs with variation within the skin thickness. Smaller solar battery couldn't be bought, and its inclusion can create the project very sturdy and prepared to use in any setting. As mentioned earlier, the device incorporates a capability of running for over forty hours, which is able to very revolutionize the health care in beneath developed and developing nations that has several electricity issues. With higher charge capability batteries, time length for its usage are often created longer. Finally, we tend to became ready to show haemoprotein level and SPO2 count.

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