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DESING OF A HYPOXIA DEVICE DETECTOR WITH WIRELESS ALERT

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ABSTRACT

In the present work, the development of a non-invasive pulse oximeter is proposed, which will send a warning message in possible case of hypoxia. The oximeter will generate a red light and an infrared light, both lights will be reflected on the skin and captured by a photodiode, that signal will be processed in a microcontroller for calculating the oxygen saturation in the blood (SPO2). That will happen by making a comparative between the light absorbed by oxyhemoglobin and deoxyhemoglobin. In such a way that if SPO2 is below the normal medical parameters, the device will be able to send an alert to another similar device by wireless communication. This device has been proposed to be used by people with cardiopulmonary problems, people who are under anesthesia, as well as people who work in places at high altitudes, such as mountain climbers.

KEYWORDS: SPO2, oxygen saturation, oxyhemoglobin, deoxyhemoglobin, pulse oximeter

I. INTRODUCTION

Hypoxia is a condition characterized by the decrease in the amount of oxygen that supplies the blood to the different organs of the human body Hypoxia is a condition characterized by the decrease in the amount of oxygen that supplies the blood to the different organs of the human body, the oxygen is transported by the hemoglobin in the blood, which travel for all the body through the arteries[1,2].

There are different causes for hypoxia, the most common are; high altitude, anemia, blood diseases, some chronic lung disease and even heart failure, all are possible causes of this disease. Hypoxia is really dangerous for humans, because the organs are very sensitive to the lack of oxygen, such as the brain, where the lack of oxygen could produce a braindead, that´s why if a hypoxia case presents, the SPO2 should be restored urgently [1,4].

Pulse oximetry is the non-invasive way to measure the oxygen transported by hemoglobin in the blood. Through a continuous monitoring, pulse oximetry provides a quick indication of a person's change in oxygenation. The pulse oximetry was developed in 1972 by the Takuo Aoyagi in Japan, working for Nihon Khodes Corporation [1,2].

The oximeters are easy to use and understand as well as helping to reduce the arterial blood analysis processes, which sometimes are very expensive. A pulse oximeter can be placed in some region of the body such as, the finger of a hand, the toe of a foot, nose, the lobe of the ear, in the forehead, in the wrist or in a leg.

With a pulse oximeter we can monitoring the SPO2 in real time and in a non-invasively way to detect hypoxia and also it is possible to know the pulse frequency and detect a tachycardia or bracardia [1-3].

Oxygen saturation (SPO2) is the percentage ratio between the concentration of oxyhemoglobin (HbO2) and deoxyhemoglobin (Hb). This parameter shows the amount of oxygen (O2) transferred from the alveoli to the blood and that subsequently dissolves in the tissues and body fluids.

Currently SPO2, it has been considered as the fifth vital sign along with body temperature, heart pulse, respiratory rate and blood pressure, that´s why it has become a necessity for medical care. In anesthesiology, the use of oximeter is very important for SPO2 monitoring in patients [1,2,4].

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How oximeters work

First, it is important to know that the blood contains a protein called hemoglobin, the one who transports oxygen (O2) from the lungs to tissues and carbon dioxide (CO2) from the tissues to the lungs, so we can find it in two states; oxygenated hemoglobin (oxyhemoglobin) and deoxygenated hemoglobin (deoxyhemoglobin) [4,7].

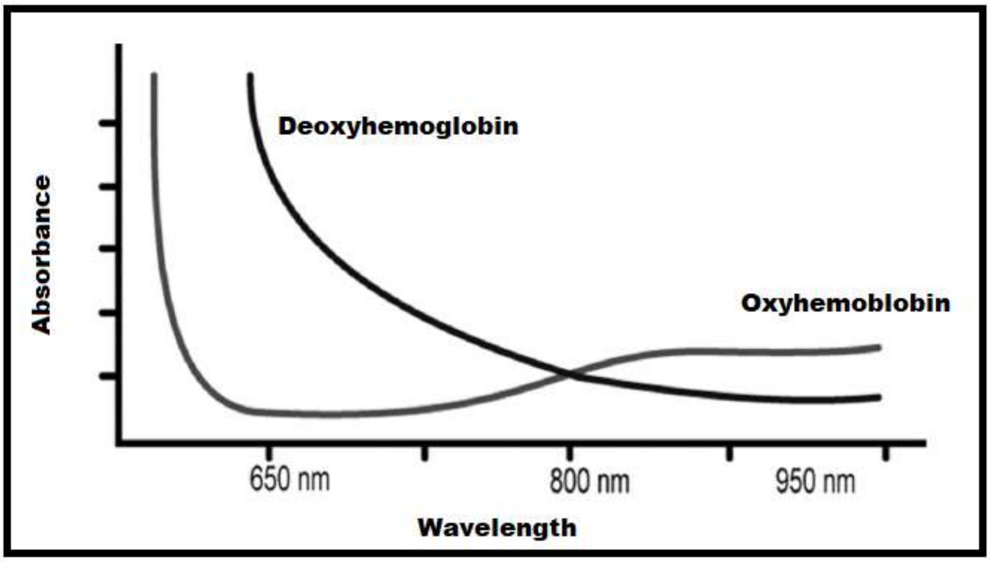

Figure 1. Absorbance of oxyhemoglobin and deoxyhemoglobin to different wavelength.

As we can see in the graph of *Figure 1* between 650 nm and 950 nm, the difference in the behavior between oxyhemoglobin and deoxyhemoglobin is easy to distinguish. Up to 800 nm approximately, deoxyhemoglobin absorbs more light (red) and from that point onwards, oxyhemoglobin starts to absorb more light (infrared) [1-4]. Based on the Beer-Lambert Law and on the behavior of hemoglobin against different wavelengths, the presence or absence of oxygen can be detected [1-6].

Beer-Lambert Law

Spectrophotometry is based on two laws, Beer's Law and Lambert's Law.

Lambert Law

This law stablishes that the amount of light that strikes perpendicularly on a material sample decreases exponentially with the thickness of the material sample traversed. The absorbance is directly proportional to the field traversed.

Beer Law

This law establishes that the amount of light that strikes perpendicularly on a substance decreases exponentially with the amount of concentration of the substance [1-6].

Altogether, Beer-Lambert Law describes the attenuation of the light that travels through a material sample which contains an absorbent substance. The properties of Beer-Lambert Law are valid also if there are more than one absorbent substance in between [1-6].

Taking into account the above, we can analyze hemoglobin in its oxygenated and deoxygenated forms, it will be necessary to use two types of lights in different wavelengths, one beam will be red light with a wavelength of approximately 650nm and the other one will be infrared light with a wavelength close to 900nm.

When an oximeter emits these kinds of light beams into the skin, most of the light is absorbed by the tissue, skin, bone and venous blood, in a constant amount, but with each beat heart, there will be an increase in the arterial blood flow, that is why the presence of an arterial pulse is important and necessary for the device an recognize that signal.

By comparing the light absorbed during the moment of the arterial pulse, the percentage of oxyhemoglobin ican be calculated. The absorption is measured only at the time of a pulse wave is detected, which decreases the influence of tissues, veins bones etc.

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It is important to know that the normal parameters of SPO2 in humans are between 99% and 92%, lowering of this range is very important medical attention immediately, because when you reach 90% there may be irreversible damage brain death [1-4].

II. METHODOLOGY

It is important to mention that we used reflexive method of pulse oximetry because in that way, the device, would be adjusted to the wrist.

For the design of this device, it was contemplated to keep a constant monitoring of the SPO2 and send a wireless alert through a radiofrequency device when the SPO2 decrease less than 92%.

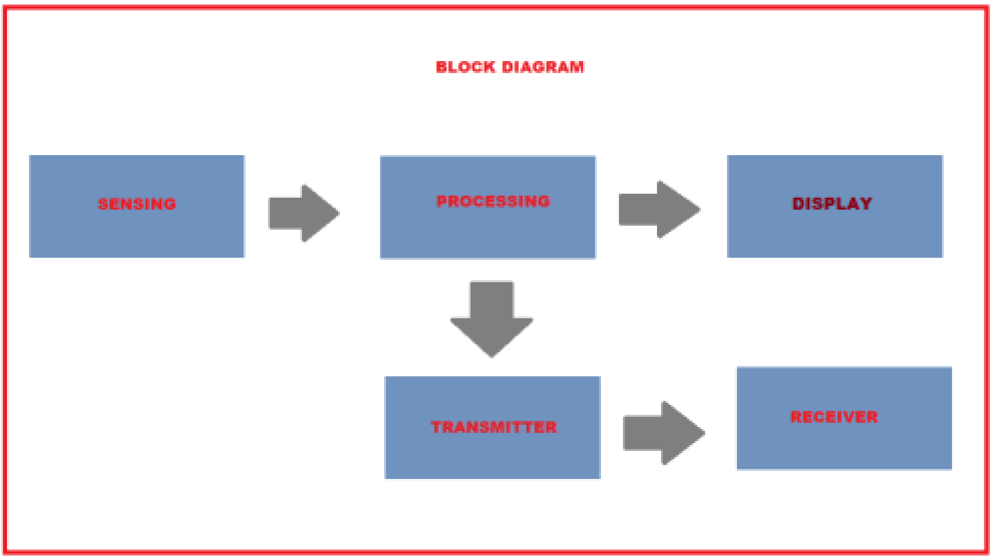

Figure 2. Block diagram of the device.

As we can see in the block diagram of *Figure 2*, firstable the device will start with the sensing of the parameters about absorbance in the hemoglobin, then that information will be sent to the processing unit, where the SPO2 will be calculated, the results will be showed in a display. In the case of SPO2 will be below to the recommended medical parameters (less than 92%), the processing unit will activate an output and a wireless transmitter will send a signal which will be received as an alert in the receiver.

The following components have been selected for the design of the device:

Microcontroller ATMEGA328P

With this microcontroller, we will take place the stage of data acquisition and processing to calculate SPO2. It has been selected because it has enough memory, as well as digital analog converter and I2C communication protocol.

Max30100

This device has an encapsulation in which it has two LEDs, one in red that emits light beams with a wavelength of 660nm and the other one an infrared light beams that with a wavelength of 880nm. In addition, it can be managing a filtering stage, as well as a data transmission through the I2C communication protocol, which will allow the acquisition of data by the before mentioned microcontroller [10].

Mini OLED display 128x32

The selection of this device was basically because it has small size, it has the features to be able about making graphics, as well as write the data obtained in different lines, also it uses I2C communication, so we can share the protocol with the microcontroller and the MAX30100.

RF24L01 Transceiver

Transceiver operates at 2.4GHz, which is a free band and doesn't need a permission to be used anywhere in the world, it manages a rate of up to 2Mbps, low power consumption in stand-by 900nA and up to 70m.

The mechanism that will allow us to obtain the reading of the SPO2 is the pulsation of the arterial blood, because a pulse time, is the moment when the red and infrared light values absorbed by the hemoglobin can be identified.

But on the other hand, there is a static component that absorb light in a constant way and it is conformed by the tissues, bones, skin and the environment light.
The amount of light absorbed, changes according to the amount of blood that is flowing and the presence of Oxyhemoglobin and deoxyhemoglobin, it can be saw in the graph of *Figure 3*.

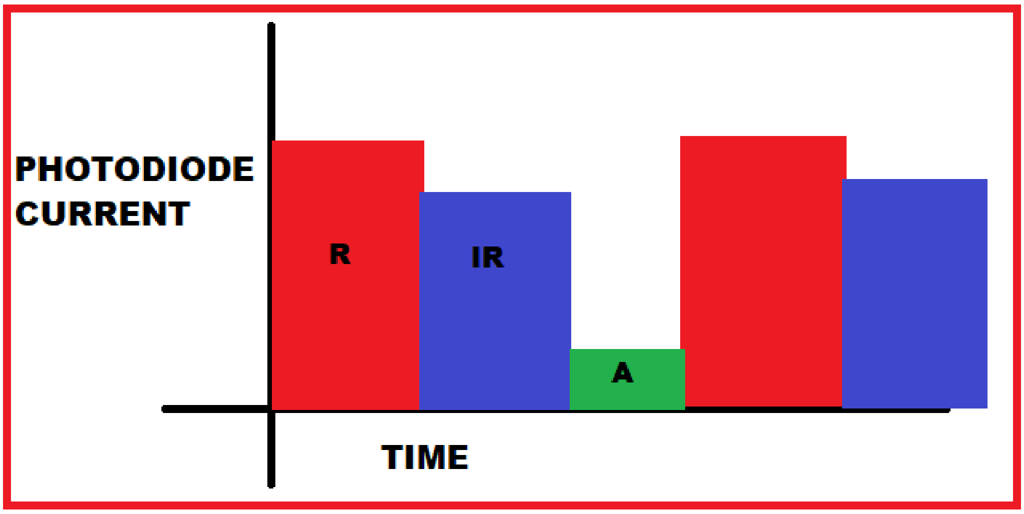

Figure 3. Pulsation of the arterial blood

In some way, the pulsation of arterial blood modulates the light received, while the other fluids and tissues maintain a constant absorption. Therefore, it is assumed at the measurement we have to signals, the arterial component (AC) and another static component (SC) which changes the absorbed light and modifies the HbO2 and Hb portions[1,2,8].
The following formula gives the normalized coefficient with which SPO2 is obtained [4,9]:

$$SPO_2 = \frac{AC\ R\ /\ SC\ R}{AC\ IR\ /\ SC\ IR}$$

When we turn the device on, it will start emitting a red light and a infrared light to the skin and using the reflexive method for pulse oximetry, a photodetector will take the lights and generate a signal depending on the detected light levels, this signal will be amplified, pass through a filtering stage to eliminate the noise generated by ambient light, as well as low frequencies that could disturb the signal. Later it will be digitalized by an analogic to digital converter and it will be stored in a buffer.
The microcontroller will access to the buffer by the I2C BUS and will take the samples of both digitized signals, red and infrared in its arterial component and static component, with these parameters the operation will be performed to calculate the SPO2. If the SPO2 is more than 92% it will write on the display, but in the case that the SPO2 will be 92% or less, the microcontroller will activate an output to send a message of alert by the transceiver.
The idea is to communicate between similar devices, so it can be used, by people that work in high altitude places like climbers, or people that have cardiorespiratory problems, so they can prevent a hypoxia problem.

III. RESULTS

The device was tested, with 7 different people, most of them had average between 97% and 96%. The test was made in different altitudes at altitudes greater than 2000m above the sea level for 3 days. The results are showed in the *Table 1*.

Person 3 and person 4 tested the device in a mountain higher than 3000m above the sea level, person 3 had a minimum SPO2 93%, and person 4 had problems for 2 minutes, the minimum SPO2 registered by person 4 was 90% and the message for alert was received by person 3 correctly.

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PEOPLE	SPO2
PERSON 1	97%
PERSON 2	97%
PERSON 3	96%
PERSON 4	97%
PERSON 5	96%
PERSON 6	96%
PERSON 7	97%
PERSON 8	97%

Table 1

IV. CONCLUSIONS

In this paper a hypoxia detector with a wireless alert system was proposed. A prototype was implemented in a correct way wich has been tested in different situations to reach a final device. With this device we could prevent accidents caused by the decrease of SPO2, as well as helping people to feel more safety about working in high-altitude places or poorly ventilated.

V. REFERENCES

[1] Jaccaud, C. V., Análisis de la oximetría de pulso para su aplicación en la detección de actividad cerebral, master tesis., Centro de Investigaciones en Óptica, México, 2005.
[2] María del Carmen López bautista, Oximetría remota vía fibras ópticas para aplicación en telemedicina, master tesis, UNAM, México 2010.
[3] Bencomo, S, Villazana, S, Salas and B. Diseño, Construcción de un oxímetro de pulso, Revista INGENIERÍA UC, 23(2), 2016, 162-171.
[4] J. G. Webster, Design of pulse Oximeters (Medical Science Series, Taylor & Francis, 1997).
[5] López Herranz, G. Patricia, Oximetría de pulso: A la vanguardia en la monitorización no invasiva de la oxigenación, Revista Médica del Hospital General de México, 66(3), 2003, 160-169
[7] Fernando, C. G., Introducción al mantenimiento biomédico (Instituto Tecnológico Metropolitano, Medellín 2007).
[8] HAAHR R., Duun S, A Novel Photodiode for Reflectance Pulse Oximetry in low-power Applications, Proc. 29th IEEE Conf. EMBS Cité Internationale, Lyon, France, 2007, 2350-2353.
[9] Ed. Joseph D. Bronzino, The Biomedical Engineering HandBook, (Boca Raton: CRC Press LLC, 2000).
[10] "Pulse oximeter and Heart-Rate Sensor IC for Wearable Health", MAX30100, Maxim Integrated Products, 2014.

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