# Pulse Oximetry

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## Introduction

Every person on Earth uses oxygen as their main fuel source. This is because the cells that make up each person use oxygen to create adenosine triphosphate, otherwise known as ATP, which is the energy source for all of the functions that cells do (Butler). Oxygen is carried to the cells through our bloodstream in a part of the red blood cell called hemoglobin. While carrying oxygen, it is called oxyhemoglobin, and once it has delivered the oxygen it was carrying, it is called deoxyhemoglobin (Lopez). By measuring the ratio of oxyhemoglobin to deoxyhemoglobin, we are able to measure the percentage of oxygen in our blood stream. The most common way that this is done is by using pulse oximetry.

## Description

Pulse oximetry is a non-invasive measurement of blood oxygen level and heart rate which means that the measurement doesn't require a medical instrument to be inserted into the body (Vasan). Blood oxygen is useful to monitor general health and a quick way to assess people with lung and heart disorders at risk for low oxygen levels ("Pulse Oximetry"). By using a red LED, an infrared light LED, and a light sensor opposite the LEDs, we are able to measure how much light is not absorbed by the blood traveling through an artery. This is because deoxyhemoglobin and oxyhemoglobin absorb and reflect different wavelengths (Lopez). Our skin and other tissues absorb light as well, but thanks to the pulsating nature of our blood through our arteries, we are able to differentiate the light not absorbed by our blood pulse (Vasan). The light absorbed by our tissue and other elements is constant, whereas our arteries blood level changes with time, giving pulses of absorption.

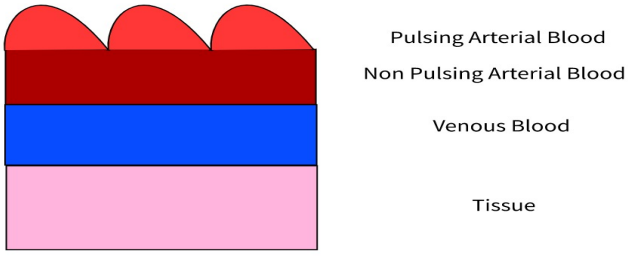


Fig 1: Example of Absorption Through Body Elements (Adapted from Lopez)

### *Mathematical Model*

The blood oxygen percentage is extracted from the measurement of light intensities in several different ways. This extraction can be done by using a ratio of the pulsating magnitude of the signals or by using a ratio of ratios and then using a table with empirically derived formulas and percentages (Lopez). An approximate value can be expressed with the following equations:

$$R = \frac{\frac{AC_{Red}}{DC_{Red}}}{\frac{AC_{IR}}{DC_{IR}}} = \frac{\frac{I_{Redmax} - I_{Redmin}}{I_{Redmin}}}{\frac{I_{IRmax} - I_{IRmin}}{I_{IRmin}}}$$

$$SPO_2(\%) = 110 - 25 * R$$

AC is the pulsating magnitude of the signal, DC is the constant magnitude of the signal from the constant absorption of the tissue, and I is the intensity of the light at different point in times (Vasan). Pulse rate is calculated for "free" by calculating the frequency of peaks from the AC component of red light in a known time interval.

### *Obtaining Measurements*

While the idea is relatively simple in theory, the implementation is rather extensive because we are measuring small fluctuations in light intensity. By alternating the two LEDs on and off opposite one another, each light intensity is measured independently. The light intensities are then amplified, and signal noise is filtered out. The clean and amplified analog signal is the sent into an analog-to-digital converter where the calculation of oxygen levels and heart rate are done with software.

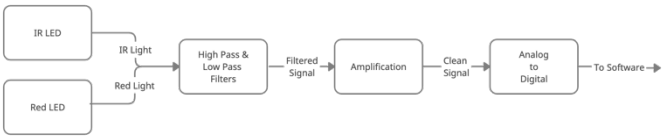


*Figure 2: Pulse Oximeter Block Diagram*

### *Short Comings*

While pulse oximetry poses lots of advantages such as being rather simple to implement and being non-invasive for the patient, there are several disadvantages of using this method, such as precision and accuracy as well as amount of information ( “Pulse Oximetry.”) Pulse oximeters aren’t as precise or accurate as other invasive testing methods. While oximeters might be reliable with an error of ±4%, the given readings can be affected by skin pigmentation, excessive motion, and/or artificial dyes (Pierson). Also, pulse oximetry doesn’t provide information on other gases in the blood stream other than oxygen (“Pulse Oximetry”).

## Conclusion

In conclusion, pulse oximetry is a simple and non-invasive way to measure blood oxygen levels and heart rate. These measurements can be used to help monitor general health and quickly assess people with lung and heart disorders. Our team aimed to correct the drawback of skin pigmentation effect on oxygen measurements.

## References

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