# REFLECTANCE-BASED PULSE OXIMETER FOR THE CHEST AND WRIST

A Major Qualifying Project Report:

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By


_______________________________
Alexandra Fontaine

_______________________________
Arben Koshi

_______________________________
Danielle Morabito

_______________________________
Nicolas Rodriguez


Submitted on:

Approved by:

_______________________________
Professor Yitzhak Mendelson, Advisor, Dept. of Biomedical Engineering

# Authorship

| Section | Author |
|---|---|
| **Introduction** | Nicolas Rodriguez, Danielle Morabito, Alex Fontaine, Arben Koshi |
| **Literature Review** | Nicolas Rodriguez, Danielle Morabito, Alex Fontaine, Arben Koshi |
| **Design Approach** | Alex Fontaine, Danielle Morabito |
| **Device Development** | Nicolas Rodriguez, Danielle Morabito |
| **Methods** | Nicolas Rodriguez, Danielle Morabito |
| **Final Design** | Arben Koshi, Nicolas Rodriguez, Danielle Morabito |
| **Results** | Alex Fontaine, Arben Koshi |
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| **Appendix A** | Danielle Morabito |
| **Appendix B** | Arben Koshi |
| **Appendix C** | Alex Fontaine |
| **Appendix D** | Arben Koshi |

# Abstract

Reflectance-based pulse oximetry is a technique used for noninvasively monitoring the oxygen saturation ($SpO_2$) and pulse rate (PR). However, there is little supporting evidence that it can accurately collect measurements from the chest and wrist. In this project, a reflectance-based pulse oximeter was built and used to collect measurements while sitting, standing, during self-induced hypoxia, and during self-induced hyperventilation then compared to the measurements taken by a HOMEDIC Deluxe Pulse Oximeter. The prototype was able to accurately measure within an error of $\pm$ 1% and $\pm$3% for $SpO_2$ and PR respectively from the wrist while an error of $\pm$1% and $\pm$4% for $SpO_2$ and PR respectively from the chest.

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# Executive Summary

Oxygen saturation ($SpO_2$) is the measurement of oxyhemoglobin ($HbO_2$) in arterial blood. $SpO_2$ is an important vital measurement because it shows the levels of blood oxygenation. Traditionally, $SpO_2$ is measured by invasively drawing blood samples. This method, however, is not ideal and it is unable to provide clinicians with real-time measurements. With the need for a noninvasive way to measure $SpO_2$, pulse oximetry was developed. The use of this technology allows clinicians to determine $SpO_2$ in patients that are sedated, anesthetized, unconscious, or unable to regulate their own oxygen supply.

Reflectance-based pulse oximetry allows measurements to be taken from areas of the body in which transmittance based pulse oximetry cannot be applied. In reflectance-based pulse oximetry, the incident light is passed through the skin and is reflected off the subcutaneous tissue and bone. To this day, being able to measure signals from the chest and wrist with one single device has not been successfully achieved. Such a device would allow patients to measure $SpO_2$ and pulse rate (PR) without hindering their normal day-to-day activities.

The prototype pulse oximeter constructed during this project consists of two hardware components and a programmed LabVIEW Virtual Instrument (VI). The hardware components consist of the sensor and a circuit which produces, collects, and processes photoplethysmographic (PPG) signals. The VI collects the PPG signals produced by the hardware and process them in order to produce numerical results for PR and $SpO_2$ . The optical sensor is made up of two Light Emitting Diodes (LEDs), a red LED, with a peak emission wavelength of 660 nm, and an infrared emitter with a peak emission wavelength of 940 nm. These LEDs are positioned next to each other in the center of a circular Printed Circuit Board (PCB) and surrounded by 8 photodiodes (PD). The circuitry for the sensor consists of an Arduino Duo Microprocessor which is programmed to light up the red and infrared LEDs intermittently at a frequency of 100Hz. The PDs are connected in photovoltaic mode in order to produce a voltage output. Operational amplifiers are utilized to amplify the photodiode output. Once amplified, the red and infrared PPG signals obtained from the photodetectors are sent through two Sample-and-Hold circuits to separate the signals into their respective alternating current (AC) and direct current (DC) components for further filtering and amplification.

The four input signals sent to the LabVIEW software : AC red, AC infrared, DC red and DC infrared access the VI via a National Instruments (NI) Data Acquisition (DAQ) system. The AC components of the red and infrared PPGs are measured using a peak-to-peak detection algorithm, while the DC components are measured by finding their respective averages. Once the signals are processed, $SpO_2$ is calculated by obtaining the ratio of the AC and DC components of the red PPG and dividing that by the ratio of the AC and DC components of the infrared PPG. To calculate PR, the frequency of the infrared AC signal is measured using frequency measurement parameters in LabVIEW and then

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