Wireless Blood Oxygenation Sensor

W + stryker®

Students: Yifei Li, Yifei Zou, Brandon Chen, Josh Liu

20

Problem Statement

Patient blood oxygen level measurement devices used in healthcare require wire connections that take up space and hinder the movement of healthcare workers. **Our team aims to create a blood oxygenation sensor that uses a bluetooth connection to reduce the inconvenience to healthcare personnel.**

Background

- A pulse oximeter measures the oxygen concentration (SpO2) in the blood.
- A person's SpO2 level can warn healthcare professionals of potential dangers to the person's health.
- Our pulse oximeter detects SpO2 levels by utilizing the fact that molecules in the blood have different absorptivity for different lightwaves (Figure 1).

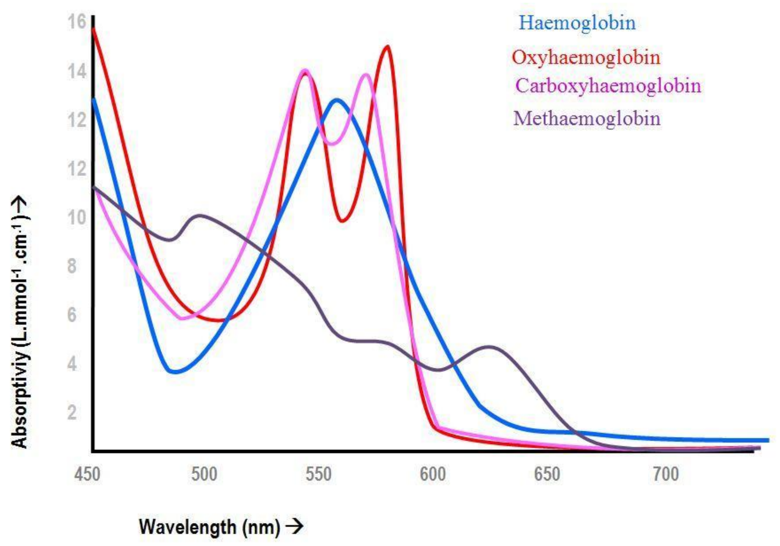

Fig. 1 shows the cell absorptivity of different light waves.

Project Overview

Our overall goal is to design a wireless pulse oximeter. To do this, we need parts working on detecting human finger oxygen signals and the device sending these signals out, and a device to receive this signal and convert it into readable results. To detect human finger oxygen signals, we can use Texas Instrument's AFE4403. To send the signals, we could use Gecko board's EFR32 to send via Bluetooth. To receive signals, we use a laptop via Bluetooth. To convert the data into results and display it, we use a web page with a python script. Since we need the hardware works as a whole, we need the EFR32 read data in AFE4403, we need to design a PCB to do that. Therefore, our overall workflow and design will look like the following chart:

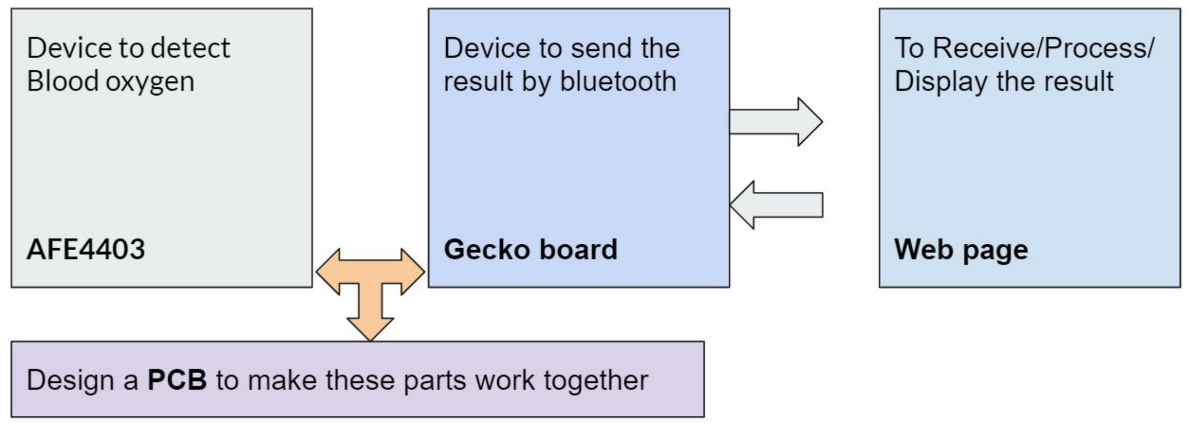

Fig. 2 the overall design and workflow

Python Script Receiver/Displayer

When connecting from our bluetooth board to desktop, we need a tool to receive the bluetooth data, The most easy and convenient way to do this is via a python script. There are a lot of open sources on the internet we can use. We also use another python script to filter the signal data and display them by pyplot.

PCB Design

- Our team troubleshooted the previous PCB design using EAGLE CAD and prototyped a PCBA that houses the AFE4430 chip, LED sensor, and Gecko Bluetooth board.
- This PCB board contains an AFE4403 board and a connector used to plug in the wireless Gecko board. The AFE4403 is a fully-integrated analog front-end and is used for Medical Pulse Oximeter Applications. This board will receive the raw data from the figure detector and send the processed data to the wireless Gecko board by SPI communication.
- The left part is a connector to connect with the finger detector. The middle-bottom one connected by lots of wires is the AFE4403. The right part is the connector and a BRD4183 could plug in those pins and receive processed from the AFE4403.

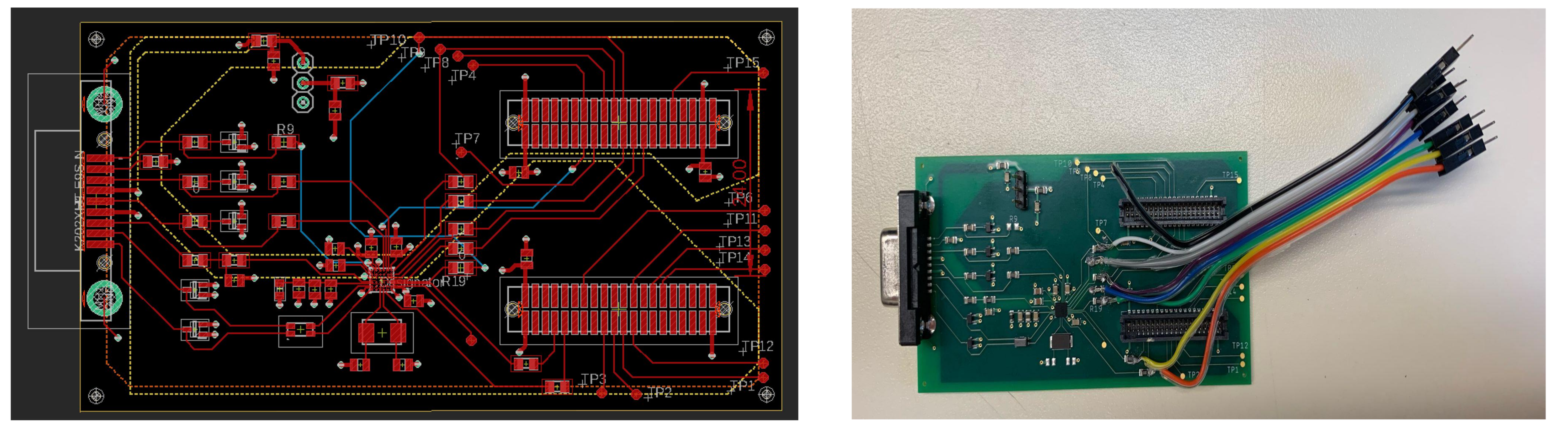

Fig. 3 shows the PCB layout on EAGLE CAD and the PCBA prototype with connector wires to AFE 4430 for testing.

Bluetooth Implementation (Signal Transmission)

- We programmed the BRD4182A (a bluetooth chip) on the Geck board named EFR32.
- We firstly used the bluetooth empty example on Silicon Lab to check the connection with cellphone and laptop.
- We modified the bluetooth code on Silicon Lab based on the previous code to ensure the sample with data could be transmitted between cellphone and laptop.
- We used the pin tools on Silicon Lab to fit the pin change on the PCB design. We followed the pin configuration and changed the functions on the ports.

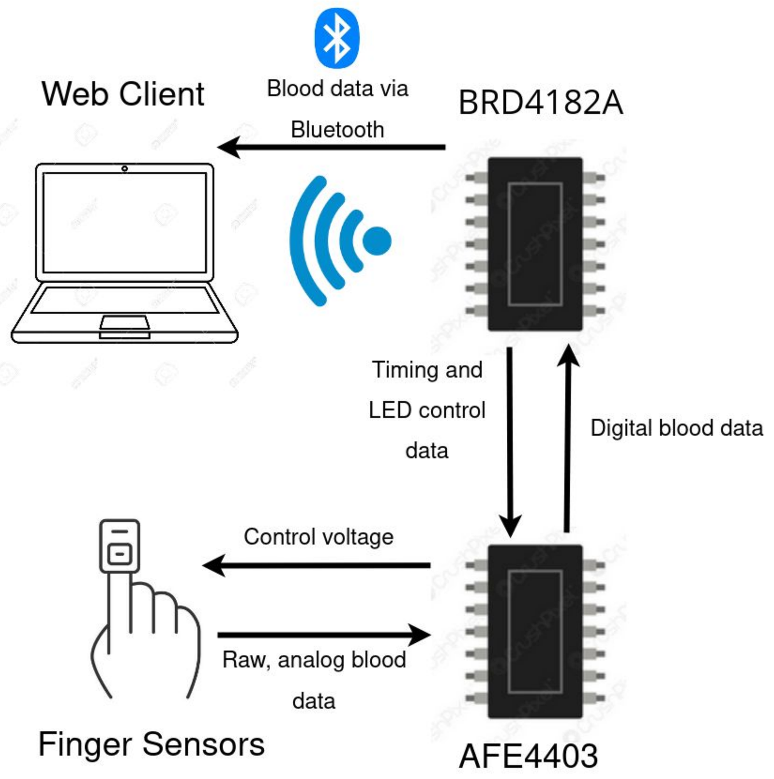

Fig. 4 workflow of Bluetooth system

Test & Conclusion

- We connected the PCB board with the Arduino Atmega 2560 board and use the Arduino board to setup the AFE4403. Also, the Arduino board will provide power to the PCB. Then we connected the SPI pins (MISO, MOSI, SCK, SpiSte) to the digital logic analyzer form DigiView to analyze the output from each pin.
- We could detect the corresponding SPI signals from the AFE4403 by using the digital logic analyzer. But, we need a way to translate the signals to the real SpO2 number after the bluetooth part can functionally work.

Fig. 5 Using logic analyser to read from pins on PCB board

- After we installed EFR32 gecko board on our PCB, we could detect the Bluetooth signal and build a stable connection with a cellphone to our PCB Board. We also tested the connection on a laptop which could run the python script to receive the data.
- We also used a python script to analyze these datas as a plot that displays the SPO2 rates in a statistic chart changing with time.

Fig. 6 Building stable Bluetooth connection with cellphone and our device

Future Work and Acknowledgements

- Set up the AFE4403 without using Arduino. Find another way to set up the AFE4403 without connect other board.
- Translate the signal received from the AFE4403 to the SpO2 concentration.
- Continue working on Bluetooth connection between Gecko board and the web client to transfer the data.
- Continue working on a web client that can receive, analyze and display data at the same time

References:
https://derangedphysiology.com/cicm-primary-exam/required-reading/respiratory-system/Chapter%20121/absorption-spectroscopy-hemoglobin-species

We hereby thank our sponsoring company, Stryker, the 2021 Wireless Blood Oxygenation Sensor capstone team, and our mentors Rob Greenewald and Professor Eli Shlizerman.

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

Mentors: Rob Greenewald, Prof. Eli Shlizerman

Sponsor: Stryker