WIRELESS BLOOD OXYGENATION SENSOR: REFACTORING PRIOR WORK

STUDENTS: KEVIN LIANG, TANNER POLING, ZACK LYNCH

OBJECTIVES

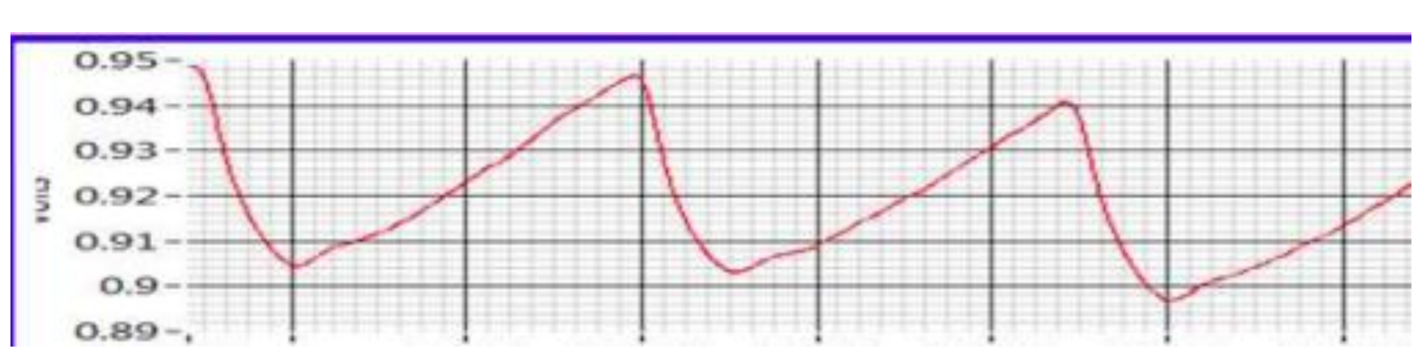
- Display pulse oximetry data such as SpO2, SpCO, and SpMET values over Bluetooth to reduce the number of wires used in medical settings (e.g., ambulances and hospital beds).

Previous Stryker Wireless Blood Oxygenation Project

- Replace last year's project (shown left) modules with more compact chips to assemble on a PCB.
- Issues with last year's design:
  - Unnecessarily powerful boards, such as the EVM development board for the AFE4403 and an Arduino Mega
  - Many wires and breadboard used in design

TERMINOLOGY

- **Sp02**: a measure of the amount of oxygen-carrying hemoglobin in the blood relative to the amount hemoglobin not carrying oxygen. Also called Oxygen Saturation, this metric is usually between 95 - 100 % in healthy individuals.
- **SpCO**: a measure of the amount of carbon monoxide in the blood. This metric is usually between 0 – 5% in healthy individuals.
- **SpMET**: a measure of methemoglobin in the blood. This metric is usually between 0 – 3% in healthy individuals.



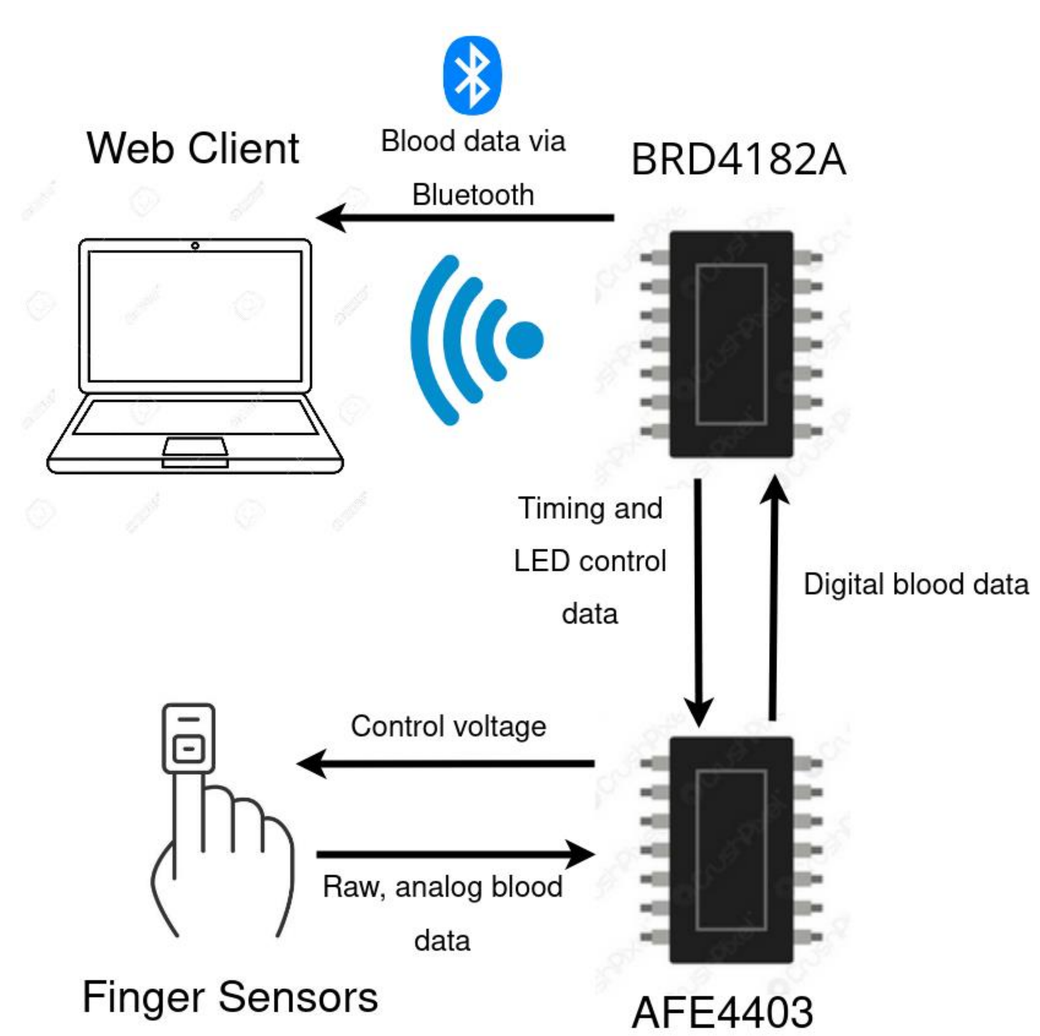
Above: Graph of typical Sp02 (Source: Texas Instruments)
Left: Blood Oxygenation Sensor Enclosure (Source: Stryker)

DESIGN DECISIONS

- Main issues facing last year's design:
  - End product was too bulky / cumbersome to be made into a consumer product.
  - Selected microcontroller (Arduino Mega) had an unnecessary amount of computing power, making the system overly expensive.
  - The system is intended to be battery operated: an Arduino Mega is too power-intensive for this purpose.
- To address this, we:
  - Chose the Silicon Labs EFR32MG22 as our microcontroller. Specs:
    - 32-bit ARM Cortex-M33 core
    - 76.8 MHz maximum operating frequency
    - 512 kB of flash and 32 kB of RAM
    - Bluetooth Low Energy (BLE) capability

OVERVIEW

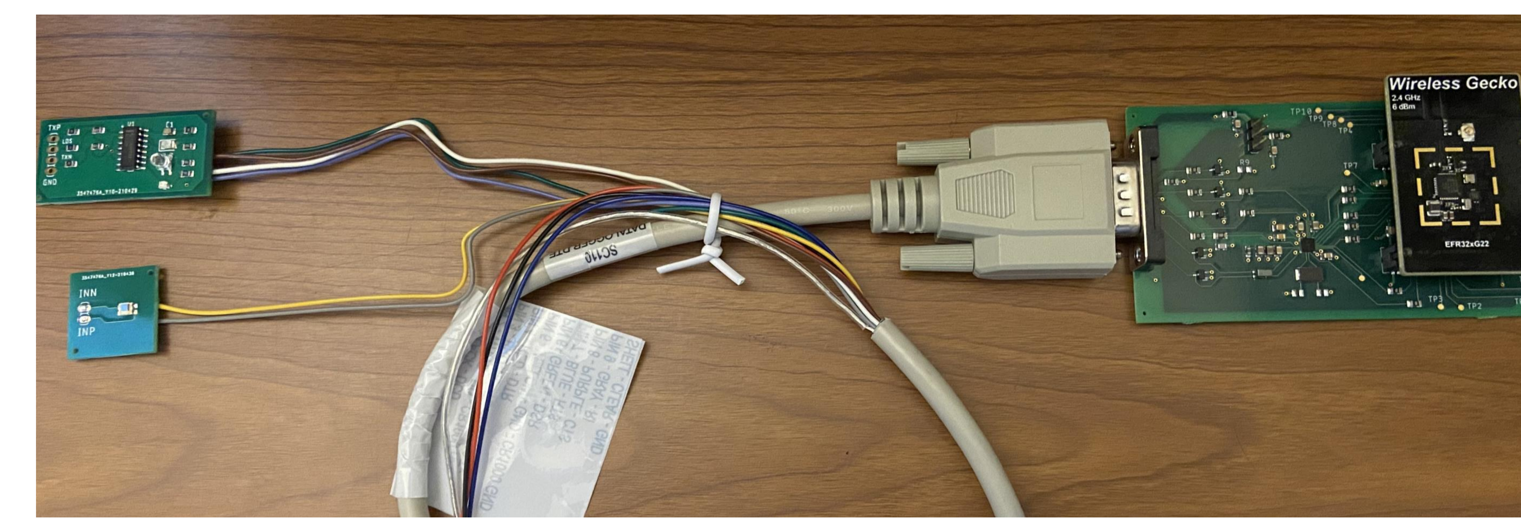
- **AFE4403**: analog front end designed by Texas Instruments to take pulse oximetry readings. We send timing and LED data to the AFE to control the sensor's LEDs and then read the values out of an ADC register.
- **BRD4182A Radio Board**: Silicon Labs development board with built-in Bluetooth capabilities and EFR32MG22 system on a chip. We attached it to their Wireless Starter Kit to program it and then connect it to our main PCB via connector headers. Used for communicating to the AFE4403 via SPI and sending data to the web client via Bluetooth.
- **Finger Sensors:** comprised of two custom designed PCBs (LED board and photodiode board). The LED board receives driving signals from the AFE and the photodiode returns the generated current back.
- **Web Client**: software running on a laptop that connects to the BRD4182A via Bluetooth and displays the given blood data



System Diagram of our work

CURRENT PROGRESS

- We currently have all the parts to our system and are working on developing the SPI communication on our board that will control pulling in our sensor readings from the fingerboards.
- We are finished with our python script to read in values received on the computer and are developing our Web App to display the processed data.
- We have powered up our main PCB and have hooked up to power with our BRD4182A Radio board attached to its connectors and are able to transmit test data over Bluetooth to our phone.



Top left board: LED Controller PCB (Finger Sensor 1)
Bottom left board: Photodiode PCB (Finger Sensor 2)
Middle cable: DB-9 Connector
Right board (green): Main PCB to support AFE4403 and BRD4182A
Right board (black): BRD4182A

CONCLUSIONS

- Designed a custom PCB to replace last year's AFE4403 development kit and Arduino Mega with just the AFE4403 chip and BRD4182A (and supporting components). [2]
- Refactor last year's embedded code, written in C++ for Arduino, to align with this year's modules, BRD4182A written in C.
- Configured BRD4182A to transmit data over Bluetooth to our laptop to display dummy data so far
- We have gained a much better perspective on the effort that goes into creating a PCBs from scratch and then incorporating them into a greater system.

FUTURE WORK AND ACKNOLEDGEMENTS

- Design a PCB antenna along with the EFR32MG22 on the main PCB to avoid using the entire BRD4182A board
- Continue testing and calibration to increase accuracy of pulse oximetry readings
- Optimize PCB design for size and power, as well as using battery for power instead of a power supply

Industry Mentors: Rob Greenwald, Gwynn St. John
Faculty Mentor: Tai-Chang Chen

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

ADVISOR: TAI-CHANG CHEN
INDUSTRY MENTORS: ROB GREENWALD, GWYNN ST. JOHN
SPONSOR: STRYKER