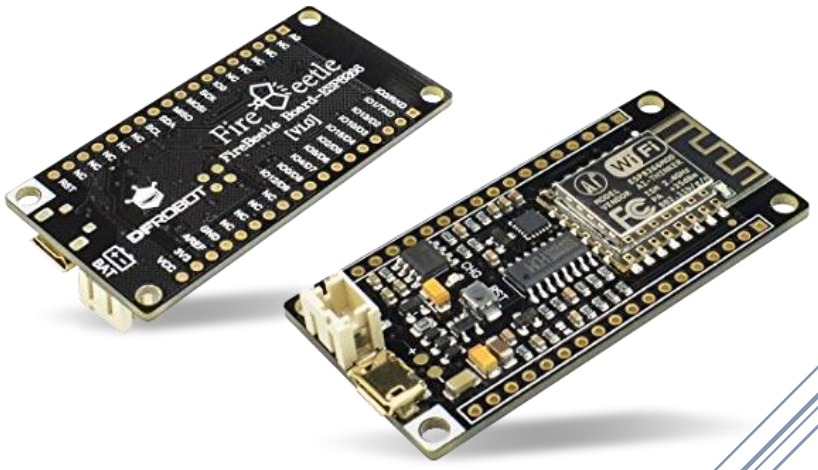
WEARABLE PHOTOPLETHYSMOGRAM (PPG)



Wearable Technology Laboratory (BME/CS 479)

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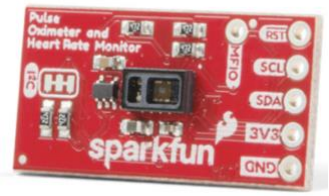
Spring 2022 – Lab 1

Material

- FireBeetle Boards-328P with BLE4.1 x 2
- Micro USB interface cable
- Battery
- Sparkfun Pulse Oximeter and Heart Rate Monitor
- Buzzer
- Velcro & Velcro Band
- Wire and Wire wrapping tool
- Female Headers



Background

Photoplethysmography (PPG) technology is used mainly to develop small, wearable, pulse rate sensors used in smartwatches such as Fitbit and Apple Watch. PPGs consist of a light-emitting diode (LED) and a photodetector (PD) for measuring changes in light absorption (Fig 1.A). In each cardiac cycle, the heart pulses blood to the periphery; when this pulse reaches the skin, the arteries and arterioles can be distinguished in the subcutaneous tissue. The change in volume caused by the pressure pulse is detected by measuring the amount of light reflected back to the photodetector after the skin is illuminated with the LED. The delay between the emission and detection of the light is then used to recreate the pulse signal.

Each cardiac cycle appears as a peak (Fig 1.B). Note that the shape of the PPG waveform varies amongst subjects; it also varies with the location and the way the pulse oximeter is attached to the skin. Recent advances in optical technology have facilitated the use of high-intensity green LEDs for PPG technology which catalyzed the adoption of this measurement technique in wearable technology. In this lab, we are interested in developing a wearable for tracing heartrate through PPG sensors (Fig 1.C).

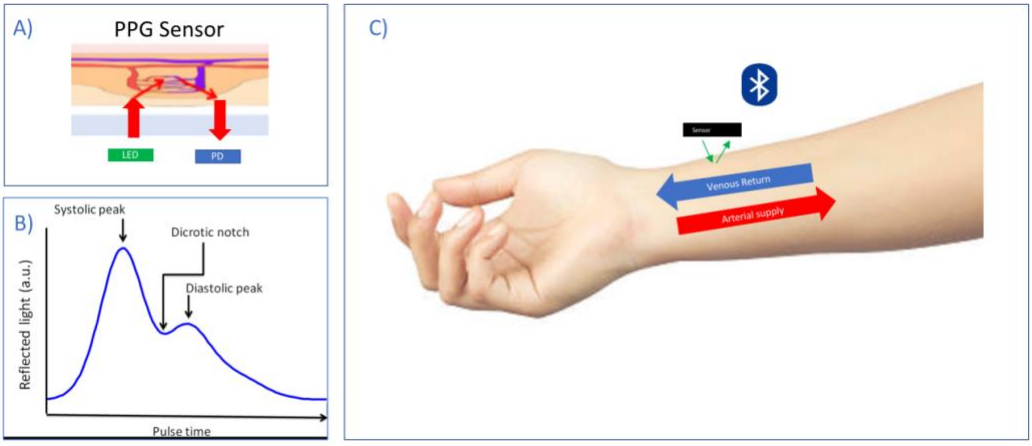


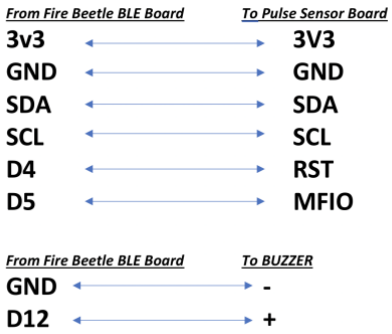
Fig 1: A) Sensor Schematic, B) PPG Signal, C) Fitness Band Design Concept

Arduino PPG Board

The Arduino ecosystem features useful accessories that allows us to mimic the function of various wearables. The PPG sensor you will be using in this lab is a Sparkfun module. You will first need to set up your Sparkfun module by consulting the following tutorial:

https://learn.sparkfun.com/tutorials/sparkfun-pulse-oximeter-and-heart-rate-monitor-hookup-guide?_ga=2.220576152.1212953126.1599321693-1639076062.1599321693

The following is a representation of the wiring diagram; however, you should be able to extract this information from the tutorial and the datasheets.



Device Assembly and Preliminary Setup

After studying the tutorials, compose your wearable by connecting the Pulse Oximeter sensor and the buzzer to the peripheral board. Accomplish the following tasks:

1) Calculate your heartrate in beats per minute, and display it in your user interface
2) Calculate the time between each beat and display in your user interface
3) Calculate your blood oxygen level and report the confidence level in your user interface

Device Evaluation Section I: Fitness Mode

1) Calculate the resting heart rate of the user by collecting a 30 second baseline. The resting heartrate could be used to calculate the cardio zone of the user.
2) For the fitness mode, perform a physical task, like running up and down the stairs, this task should be challenging enough to change your cardio zone. Analyze the collected data and have your User Interface display your activity graph. This activity graph should be color-coded according to the period of the time you were at each cardio zone. **Your user interface should represent all the data outlined in Fig 3 but use your creativity when designing it.**

Fig 3: a) Heart rate zone as a percentage of the user's maximum heart rate (The maximum heart rate for each user is roughly equal to the user's age subtracted from the number 220) b) An example of a possible User Interface.

Device Evaluation Section II: Relaxed vs Stress Mode

1) Play a relaxing music and try to relax, measure your heart rate during the entire duration of the song. Can you conclude if the music actually made you more relaxed? (hint: compare to your resting heart rate)
2) Think of your last difficult exam or 2020 for at least 60 seconds. Measure your heart rate during the entire duration. Can you conclude these thoughts made you anxious?
3) Discuss with your team on how to improve your interface so that it could detect if the user is stressed or calm. Incorporate these steps into your interface so it would be able to automatically detect these two emotional modes.
4) If the user is in stress mode, have the buzzer turn on 2 times in a row in order to make the user cautiously aware of their mental status.

Module Requirements:

You will be graded on:

- A working prototype for each member at the end of the module which your group will present in your video.
- A well organized and scientifically composed report on your user interface.
- Your video presentation should include all the required graphs and visuals with accompanying interpretations of the results.
- All team members should be knowledgeable and able to build and use the circuit and accompanying User Interface.
- Your creativity in representing your data.

Grading Rubric

Hardware:

- *Does the device work?*
- *How compact and easily wearable is the device?*
- *Size constraints consideration*
- *Are the connections and arrangement of the parts efficient and clean?*
- *How user friendly is the device?*

Interface & data processing:

- *User-friendly (effectiveness in data communication/ legibility of the User Interface)*
- *Accuracy of the data*
- *Noise reduction & signal processing algorithms*

Lab specific Calculations: *Parameters and graphs*

- *Heartrate (beats/min)*
- *Blood Oxygen Level & Confidence*
- *Time between the beats*
- *Buzzer in sync*
- *Mode I*
- *Mode II*

Presentation style in the video submission:

- *Each group member presented.*
- *Does everyone understand the concepts and demonstrate knowledge of the design?*
- *Are the figures and graphs logically designed and presented?*
- *Are the parameters clearly calculated?*
- *Is the data presentation clear and concise?*
- *Is the presentation within the 5 minute time limit?*