Project Deliverable G:
Prototype II and Customer Feedback

GNG 1103
Group C6

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1. Introduction

The objective of this deliverable is to devise a test plan, develop our second prototype, get customer feedback on your prototype. In the following report, we will be discussing our prototype along with our gathered feedback. To start, we will outline our design concept and prototype test plan. This plan will include the concept we are testing along with the purpose and method of testing. We will then discuss our progress in our design and sensor prototype. We will also discuss future objectives we have set for each prototype. We will also summarize the customer feedback we received from our most recent client meeting/presentation. This document will contain the project's second prototype, the experimental prototype, along with its test plan and feedback.

2. Design Concept

In our last deliverable, we planned out that we would create our prototype II for this deliverable, which is our experimental prototype. We continued to stick with the schedule that we made in our previous deliverables to ensure we will deliver good quality work and to stay on track. In our last meeting, we created a design plan for our wiring of the sensor. Below is Figure 1, the drawing of the wiring.

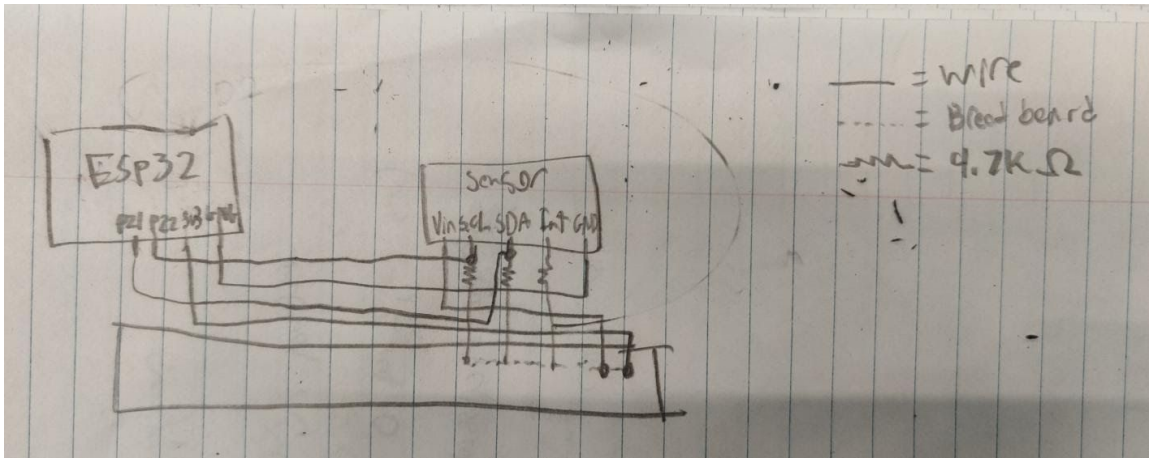

Figure 1: Plan for the Wiring of ESP32S (microprocessor) and MAX30100 (sensor)

For our prototype II, that will be further discussed under the Prototyping Test Plan, we are testing out our sensor, the MAX30100, so that actual aesthetic of the sensor and device is not yet finished. However, we plan to clean up the wirings by putting it in the box that we will soon laser cut which we designed in the last deliverable.

3. Prototyping Test Plan

3.1 Purpose of Test

For prototype II, we will have an experimental prototype. This prototype will concentrate on the MAX30100 that measures the blood oxygen saturation. It will be attached to the ESP32S and it will measure the heart rate and blood oxygen saturation in real time. The main objective of the test is to determine that the oximeter works and that it is accurate compared to a commercial oximeter.

3.2 Test Objectives Description

The following list below are the things we want to test.

- If the sensor accurately gathers data
- If the sensor can produce a consistent set of results that don't deviate too much from an average person's resting oxygen levels

3.3 Possible Types of Results

The possible types of results from the experimental prototype are:

- The prototype results matches the results obtained from the actual pulse oximeter
- The prototype results do not match the results obtained from the actual pulse oximeter
- The sensor works and properly reads data
- The sensor fails to read the data
- The sensor only works for a certain amount of time and then stops collecting data

3.4 Criteria for Test Success or Failure

Certain criteria were used in order to determine if our second prototype would be able to have a working sensor.

1) Success for our second prototype includes:

- When testing with an actual pulse oximeter, the sensor was used to compare whether the data received was comparable with data received from the actual pulse oximeter.
- The sensor works properly and is able to collect heart rate and blood oxygen saturation

2) Failure for our second prototype includes:

- Incorrect wiring and resistor placement which leads to the sensor not being able to collect data properly during the testing phase.
- Failure to make the sensor be able to fit properly into the box design.
- Failure to get the proper code to collect data from the sensor and display it.

During the testing phase, this criteria was used in order to see if the experimental prototype would be able to go through testing. The sensor was placed on the index finger which then collected data of the test users heart rate and blood oxygen saturation.

3.5 Testing Process

The following is our testing process of the sensor:

- Assemble the sensor
- Have one finger on a stand-alone pulse oximeter and another finger on our sensor
- Compare the pO2 data from the pulse oximeter and sensor and see the accuracy

3.6 Cost of Prototype II

In this prototype, we need to use parts that will actually be used in our final product. This will cause the price of the prototype to be higher than usual. The following parts were used:

- ESP32S - $13.99
- Headphones - $5
- Sensor - $13
- Cables - $0 (Given from Makerspace)

3.7 Work to be done

After the completion of the first prototype, there are still things our team must work on in order to improve our prototype. Below is a list of work which must be done by our group in order to create a working model. Our progress will be updated into our Trello cards and gantt chart and tasks will be assigned to team members.

- We need to do self-learning on the microprocessor that we are using so that we can properly integrate it into our design.
- The box must be designed using Solidworks and used for 3-D printing
- The proper dimensions of the box must be established in order for it to be able to properly store all the components and be able to be held in pockets.
- Further research needs to be done on establishing a way to connect the sensor to the ear.
- Add the SD card reader and earphone jack and test it
- Tubing the wires together to create an aesthetically pleasing design

4. Analysis of Prototype Test Plan

The Prototype II is an experimental prototype created so that the group could test whether or not the sensor of the device works and accurately conveys data to the Arduino board. The second prototype is experimental because the group decided that there was a need to have a functioning sensor that could be tested for accuracy.

Completion of the first prototype offered no proof about if the product was functional. However, the second prototype will provide proof regarding the functionality of the sensor on the device. This prototype was validated by the functionality of the sensor through the tests conducted. By having an experimental prototype, we were able to receive accurate data about how well the sensor in our device works, and how it connects to the Arduino board.

The sensor of the second prototype is fully functional so that the group could see how well it works when a user is interacting with the device. The purpose of this prototype is to purely test if the sensor on the device works or not. No non-ear part of the final product will be included in this prototype due to a lack of time and a focus on the sensor.

5. Analysis of Prototype

5.1 Sensor

We have made a sensor that measures the blood oxygen saturation of the user. This sensor is currently at its very basic stage as it is currently attached to the breadboard. In the future, we would like it to be attached to the microprocessor via the wires instead of it being attached to the breadboard. To have the MAX30100 work, we had to remove the built-in

resistors on the chip using a soldering iron, and we soldered the chip to its 7-pin header. On the breadboard, we connected the following:

Table 3: Connected Pins on Breadboard

ESP32S	MAX30100	Used Resistor
3v3	Vin	N/A
Gnd	Gnd	N/A
SDA – 21	SDA	4.7 KΩ
SCl – 22	SCl	4.7 KΩ

With these actions we made the sensor work using the example code from the MAX30100 header. It records blood oxygen saturation (PO2) and the heart beat, but we only recorded the PO2 down. The following is the data we received when doing the test:

Table 2: Blood Oxygen Saturation, PO2, Readings (in %) - Comparison of Data Received from Commercial Oximeter and MAX30100

Oximeter	MAX30100 Sensor
95	96
97	97
97	97
98	97
99	97
99	97
99	97
99	97

99	97
99	97
99	97
99	97
99	97
99	97
99	97
98	97
99	97
97	96
96	97
95	96
95	96
94	96
92	96
90	96

As seen in Table 2, the sensor produced a consistent set of results that don't deviate too much from an average person's resting oxygen levels, and the two sets of data are very close. This means that our prototyping is successful and that our sensor works. The pairs of data that had a larger range is due to human errors.

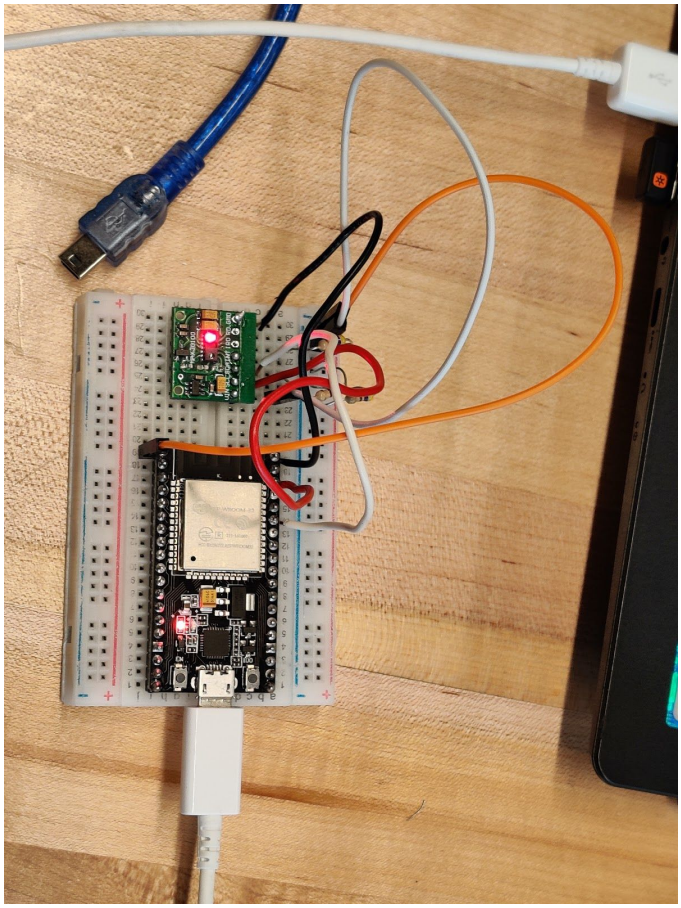

Figure 2: Prototype II Experimental

Figure 2 shows the wiring of the microprocessor and sensor for our experimental prototype.

6. Feedback

6.1 Feedback for the sensor

- Group c7: “The sensor would sometimes turn off (Due to unstable connection of wires)”
- Group c7: “The sensor less accurate than we hoped”

6.2 Feedback From Client Presentation

- It's Very neat, unique, discreet device
- She worries about the device falling off the ear

- Make sure the box placement is somewhere so that the user can still have full motion without the earbuds falling out
- Make sure the headphones do not unplug from the box

As we analyzed these given feedback to us, we hope to improve our sensor by obtaining better wires and soldering parts together for accuracy. We also plan to research on how to create ear-clamps that will not easily fall out for our final prototype.

7. Lifelong Learning

From our previous deliverables, we learned that it is important to continue to plan out our procedures and assign specific roles to each member. Our planning in Deliverable E and F was used in this deliverable to ensure what each team member were doing and when to complete it by. As this part of the process has taken longer than we expected, we learned that sometimes our estimated time will not always match our expectations and that we should work on the next tasks as soon as possible. The tentative plan and tasks have been modified as we received new ideas and feedback from people and learned that these upcoming tasks will take longer than expected to complete if we want good quality work. Therefore, with the submission of this deliverable, our Trello and Gantt chart will be updated to show a more accurate division of tasks as our upcoming prototypes will be harder to develop than our initial conceptual prototype.

8. Conclusion

In this deliverable, we presented our prototype II, which was a prototype experimenting with the sensor. This prototype was the most difficult for our group thus far as we had to do a lot of research on the wiring and pins of the microprocessor and sensor. However, we were successful in figuring out how to get our sensor to work properly even though it took longer than we expected. In this deliverable we also talked about the testing of the prototype and the feedback from the client and from another group. We plan on using these feedback to improve our prototype.

Now that we know how to set up the wirings for the sensors correctly, configuring it into the ear-clamp format will be a possible plan that will be done in the future. After this prototype II, we plan to work on our prototype III which will be the final and conceptual prototype. Along with that will be the testing of the SD card reader and earphone jack part. With our final prototype, we also need to ensure to tube all the wires in place to make our final prototype look polish.