Project Deliverable G: Prototype II and Customer Feedback

Team #7
GNG 1103C
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Abdel Baig (300121134)
Bilal Ahmad (300125852)
Ali Al-Zaidi (300082526)
David Onoruvwe (300144303)
Yazan Elmasry (300136709)

1. Introduction:

This deliverable will document the development and assessment of team 7’s Prototype II test plan and includes the results obtained from testing of the prototype as well as customer feedback. Through the progression of prototype II, our team is responsible for testing the different components purchased, mentioned in project “Deliverable E”. More specifically, we will be prototyping and testing what we believe is the most important subsystem, the measurement of heart rate and blood oxygen saturation levels by the purchased pulse oximeter part, MAX30100**.** The vital components that are being tested and put together will ensure that our team is aware of the potential risk factors and uncertainties that can negatively affect the test plan.

2. Prototyping Test Plan:

In prototype I, we created the outline of a watch which contained metal casing with rubber straps that surrounded the casing. During class presentations, the client had stated that it would be better if the casing for the watch was more of a rounded shape because if it were to be kept as a square, the user might not wear it, since watches aren’t normally box shaped and it will stand out. This is more concerned with the aesthetics of the device rather than the actual functionality. The client also stated that the watch should not call a control centre service as that would raise the price of the watch too much, and may require a subscription model. However due to time constraints, when creating the mobile app, we will only program it to call one number to keep the device simple. This will allow us to successfully test our device’s capabilities and if there is additional time afterwards, we will be able to add more functionality to the content of the app. All of these features will be implemented in prototype III.

This section will describe the team’s developed test plan with regards to the second prototype.

2.1. Test Objectives Description:

For prototype II, our team has decided to test and analyze the most important subsystem of our device, and that is the heart rate and pulse oximeter sensor. We have decided this to be the most important feature of our device since the device will be using this information to decide whether the user is having an overdose or not, and it is critical that it functions flawlessly.

The main objectives of this test are to analyse the identified subsystem and to get feedback for our ideas. The second prototype is composed of a physical model which is used to test the heart rate and oxygen saturation measurement equipment. We will utilise the Arduino software in which our team will take already-existing source code and run this program. First we will construct a circuit diagram of the materials to be used, including an Arduino breadboard, Arduino ESP32 microcontroller, resistors, jumper wires, and a Sensor MAX30100. Testing will give us an idea of how uniform the results are, the values that appear should be constant or changing gradually, not jumping around. We will also hear from testers to gain general feedback. After this prototype is completed, we will work on sending the numerical values to the GPS tracker app which will be created in prototype III.

The possible types of results are on a yes/no basis. The first result is that when one places his or her finger on the heart rate sensor for a given interval of time, the heart rate and oxygen saturation values are displayed on the Arduino serial monitor and remain the same or change gradually over that interval of time. This would indicate that the measurements are as we want them to be, and the setup is successful, to which then we can proceed to creating the GPS tracking app. The second result is that the values aren't uniform and fluctuate or don't make sense (aren't consistent with normal human behaviour). This indicates that the test is a failure, since the system is not working as we want it to. In the event that this occurs, we will ask for assistance from the TA's and if that is of little to no avail, we will reconstruct the Arduino circuit diagram to ensure that every part is in its proper location (i.e. attached to the proper pins) on the Arduino breadboard. We will also consider using different pieces if ours are malfunctioning.

2.2. What is going on and how is it being done?

The prototype that we have decided to create is a focused prototype which as mentioned, is to test the heart rate and oxygen saturation measuring equipment. If we start with testing simple functionality, this will allow us to fix whatever issues we may have instead of jumping ahead to creating a comprehensive prototype at this stage. The prototype was built using source data from an electronics website (Alam, M, 2019). Testing was done by having different individuals place their finger on the oximeter for an interval of one minute, and observing the recorded data. The testers were then asked to give any feedback they may have about the user experience. The information being measured is the values for heart rate and oxygen saturation levels throughout the span of that one minute interval.

2.2.1 Arduino Subsystem Test

The testing process is very simple, however there are multiple steps that must be taken before the subsystem can be tested. Firstly, for the MAX30100, the three ohmic resistors that are mounted onto the part must be desoldered, and specific pins on it must be soldered. The reason for desoldering is because the default resistors are not powerful enough to withstand high-powered microcontrollers such as the ESP32, which also has built-in bluetooth functionality. The pins that must be soldered are VIN, SCL, SDA, INT and GND. Once these tasks have been completed, the sensor can be placed onto the breadboard, alongside the ESP32. Then, one must attach 4.7K ohmic resistors to the SCL, SDA and INT pins (see **Appendix 4).** The information that is being measured and observed is the heart rate and oxygen saturation levels. These values are clearly recorded and displayed on the Arduino serial monitor. Most of the materials required for prototype II were given to our team from the Makerlab, so it did not go towards our total budget. The only parts our team purchased were the Sensor MAX30100 and Arduino ESP32 microcontroller, giving an approximate total of $25.49.

2.3. When is it happening?

The subsystem testing will take place over the course of a couple hours, where different individuals will be invited to test the prototype and give feedback. In order for this prototype to go according to plan, our team will be respectful to the timeline outlined in the Gantt chart that was created in “Deliverable E”, which allows us to gather the data in time for the submission of this deliverable. Sticking to the agreed upon schedule will ensure that all team members are aware of the timeline for this prototype to be successful and will reduce the possibility of failure. The dependencies of testing include the manufacturing of the prototype, which is expected to take 2 days of work. The testing will stop after we have had five people test the device for one minute.

3. Prototype and Analysis:

The heart rate and SpO2 subsystem testing was completed in accordance with the procedures detailed in the prototype test plan.

3.1 Prototyping Test Results:

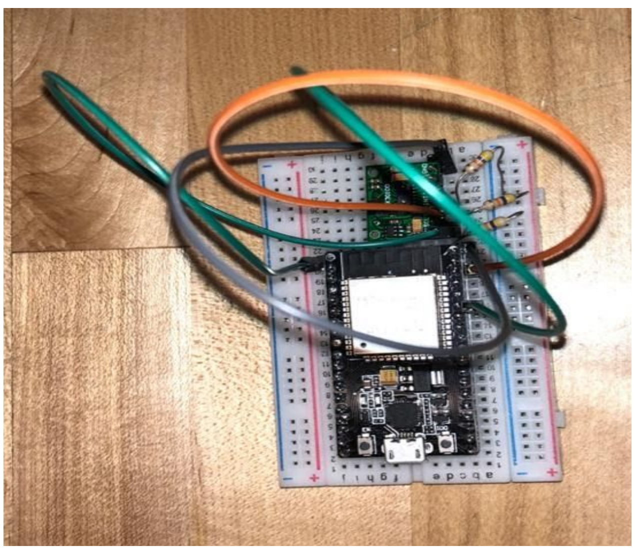


Figure 1: Top View of Circuit Diagram

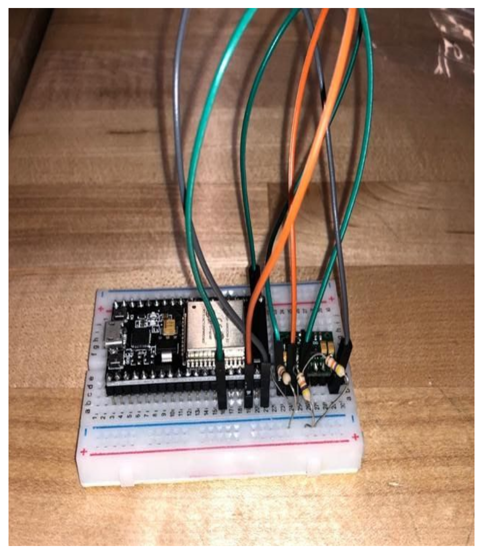


Figure 2: Front View of Circuit Diagram

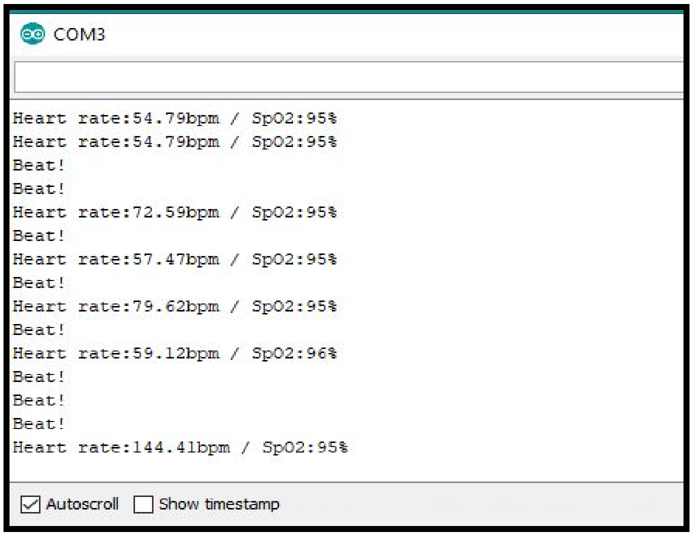


Figure 3: Serial monitor displaying fluctuation in heart rate.

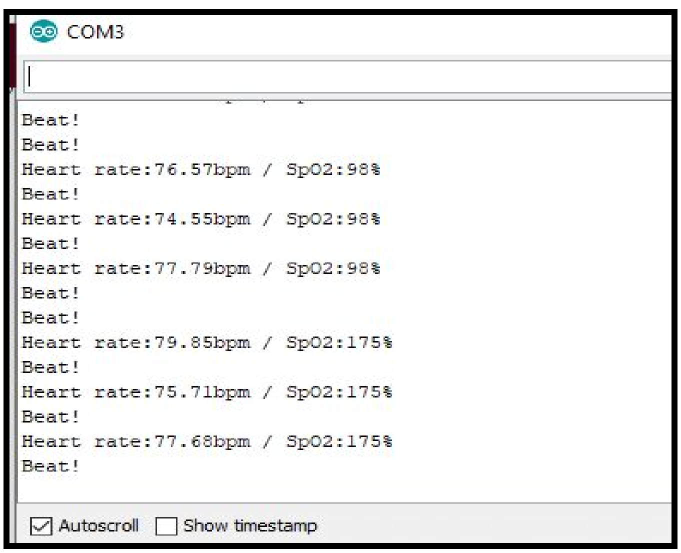


Figure 4: Serial monitor displaying fluctuation in oxygen saturation levels

3.2 Customer Feedback:

After our testers interacted with the protype, we asked them to share their thoughts on the user interface and to give any feedback that they had. It is important to note that they were shown the data collected in live time. We received the following feedback:

- The values don't seem stable and are jumping around. The tester would not feel comfortable using this device since false alarms could easily occur.
- The oximeter (which was on and sending infrared waves over the course of the minute it was being tested) was getting very warm. The user said that he would feel uncomfortable wearing it all day, especially if it gets hotter.
- A user mentioned that they would have concerns over the health effects caused by a constant infrared light being directed towards the skin and blood stream

4. Analysis:

The implementation of the plan developed in previous sections was done with success. The results, however, were not as we had hoped. While both the oxygen saturation levels and heart rate were usually uniform, there were common instances of fluctuation, as can be seen in **Figure 3 and Figure 4.** The former of which show an instance of where the measured heart rate value was very unstable and jumping up and down. The latter shows a similar instance, but with the SpO2 levels, which is our main method of recognizing an overdose. Unfortunately there is a big possibility that these fluctuations are a result of the quality of the parts used to measure the values, but we will nonetheless make an effort to remedy them, since the data we have shows that the device would be unreliable. We will do this by ensuring that there is no faulty wiring and that everything is secure, and by looking at if we can improve the code to fix the issue.

Some assumptions were made, including the place where the SpO2 and heart rate are measured. The test subjects were asked to place their finger on the sensor, but our design idea involves taking measurements from the wrist. Due to the setup of the prototype we were unable to take measurements from the wrist, but we assumed that the sensor would behave the same and that the results would be the same. We also assumed that the measurement values would behave the same regardless of what activity the user is doing, but in reality the sensor may behave differently in different situations (eg. the person is writing, running, laying down, wearing it tight or loose, etc). Due to the nature of this focused prototype, however, we had to assume that it will always behave the same. A more comprehensive prototype can be made in the future to test its behaviour in different situations. With these assumptions and limitations taken into account, the team has rated the fidelity of this prototype as medium.

The testing method could have been improved by comparing the results to that of a reliable oximeter. The user could have been made to wear both the prototype and a reliable, established oximeter at the same time, so that the results could be compared. This would give us insight to the accuracy of the device, in addition to the insight on the precision (or uniformity) of the device which we have gained from the results.

Many testers had concerns about the heat caused by the sensor and the health effects of the infrared waves constantly aimed at the skin when the prototype is being used. In order to deal with the issue of the sensor heating up, we will look into making it turn on at specific intervals to measure values, rather than always being on. This should reduce the heat released, and lessen the concerns some may have about the health effects. We will also research what studies say about infrared light being directed towards the skin repeatedly, to determine if this is a safe method to identify opioid overdoses.

5. Design Refinement:

The first refinement that our group will undertake is to alter the shape of the metal casing of our watch, after the feedback received during the short presentations. Based on the analysis of the results from the seconds prototype, the team will be working on having the infrared sensor turn on periodically to measure values, rather than being constantly on. This will reduce the heat produced and make people more comfortable using the device. We will also be looking at ways to improve the uniformity of the results to stop them from jumping around, since at the moment the readings are not reliable. These include reassembling the prototype to ensure there's no faulty wiring or circuit problems and looking at optimizing the code.

6. Conclusion:

Throughout this report, our team has displayed the entire prototyping test plan for prototype II, as well as the results, feedback, and analysis. The test results from this prototype indicate that the functional subsystem operates successfully, but with questionable precision and accuracy. This is because the values sometimes jump around, so they are not precise, and this puts the accuracy into question. The team wishes to further test the heart rate and SpO2 measurements with the objectives of determining whether or not they are accurate by comparing it to another device, as described in the analysis. We will utilise the client’s feedback to refine the design prior to the assembly of Prototype III, which will be done in the next deliverable, entitled, “Project Deliverable H - Prototype III and Customer Feedback.”

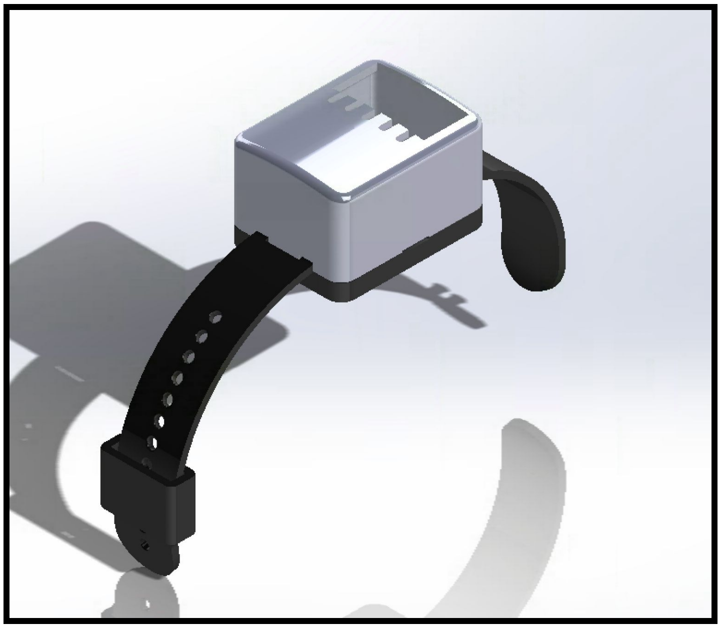
References

[1] Alam, M. (2019, December 18). Interfacing MAX30100 Pulse Oximeter Sensor with Arduino. Retrieved March 6, 2020, from https://how2electronics.com/interfacing-max30100-pulse-oximeter-sensor-arduino/

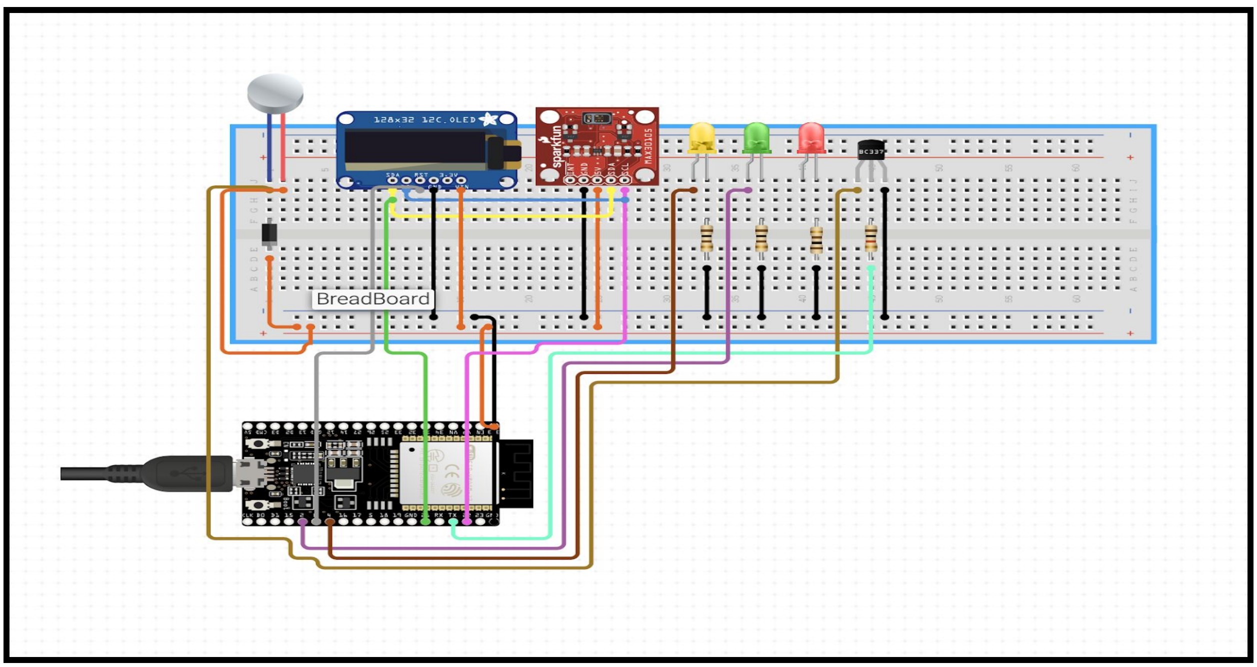
[2] Koyanagi, F. (2018, March 12). ESP32: Internal Details and Pinout. Retrieved March 6, 2020, from https://www.instructables.com/id/ESP32-Internal-Details-and-Pinout/

[3] oxullo/Arduino-MAX30100. (2018, March 10). Retrieved March 6, 2020, from https://github.com/oxullo/Arduino-MAX30100

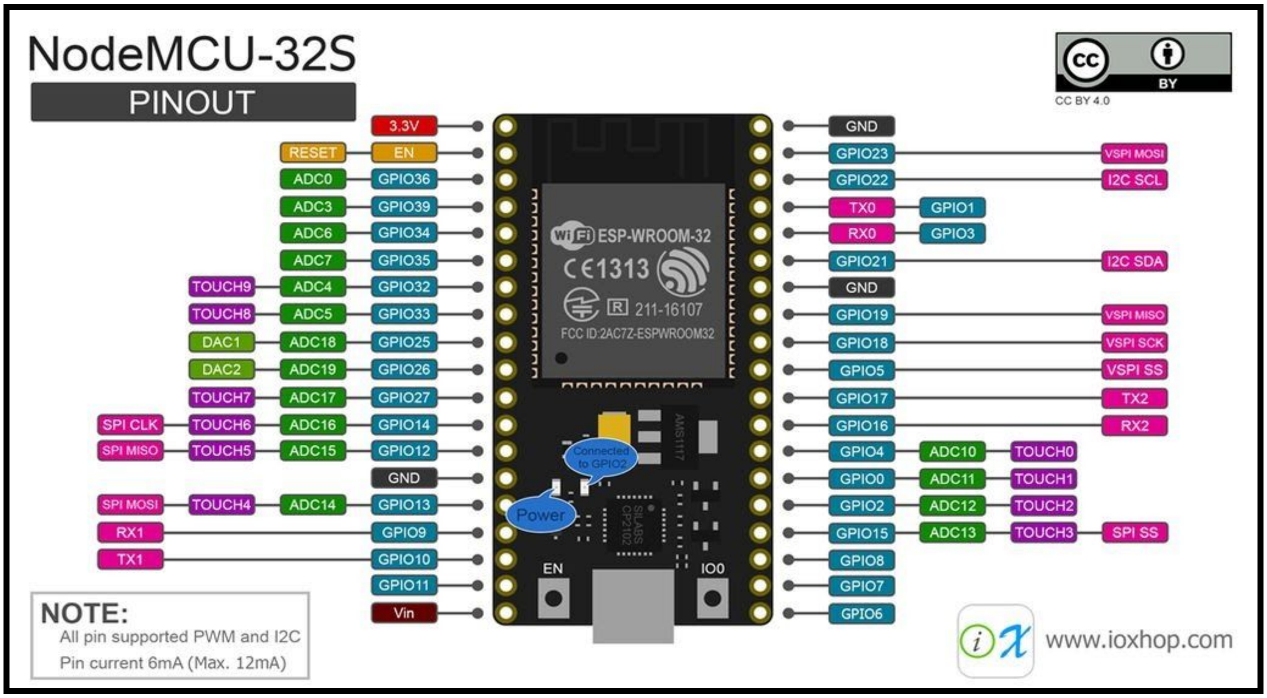
Appendix:



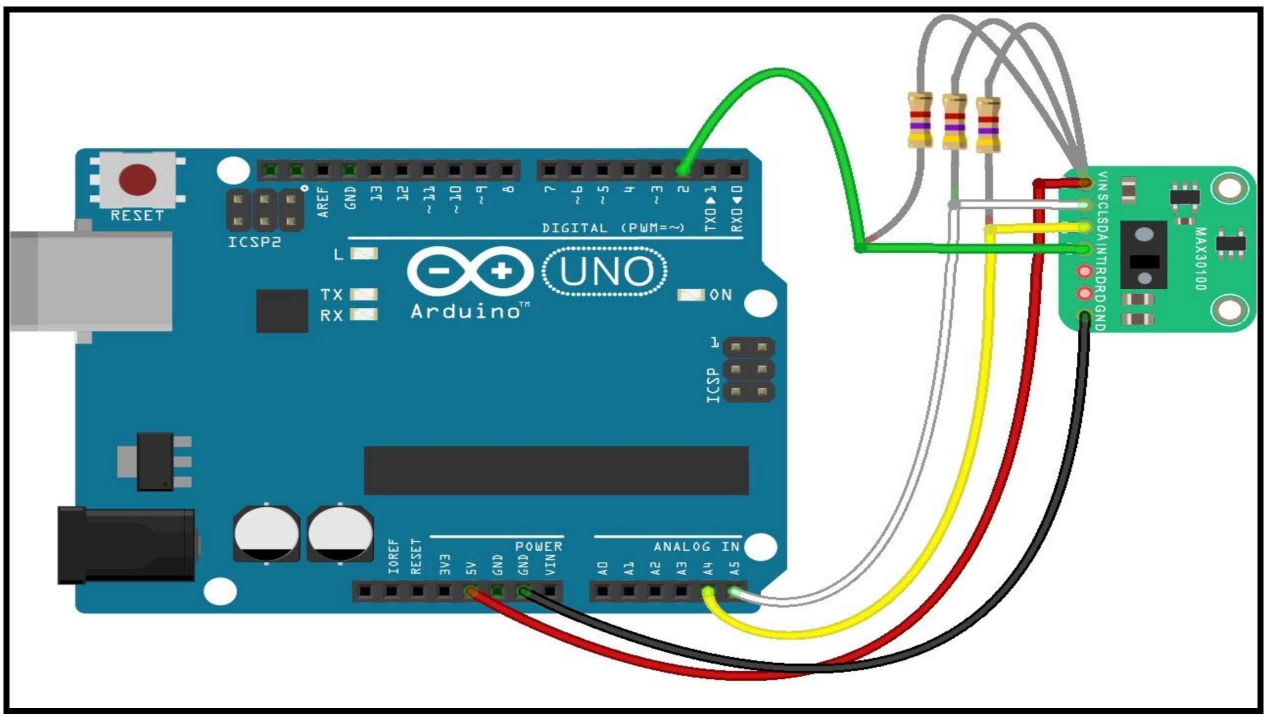
Appendix 1: Analytical model of Prototype III



Appendix 2: Electric Circuit Diagram of all Components Needed for Prototype III (Note: the heart rate sensor used in this diagram is different than the one our group used)



Appendix 3: Development Board of Arduino ESP32-S Microcontroller



Appendix 4: Circuit Diagram of Arduino Uno with Sensor MAX30100