GNG1103[D] – Engineering Design
Course Project
Group C7

Project Deliverable G:

Prototype II and Customer Feedback

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Introduction

This week's deliverable consists of detailing the procedures regarding the second prototype of our climate sensor add-on for the JAMZ team's drone. Our team was lucky enough to meet again with the team to showcase our progress thus far to get some feedback on our work. With this, we have been able to iterate on our last prototype with the ideas explained in this document in hopes of achieving our goals come design day.

Client Feedback

The JAMZ team provided us with important feedback from our pitch presentation on Friday, March 12. Originally, we were unsure of the dimensions of the box that held the parcel; the CAD model provided by the client was unclear in this regard. We were informed that the box was 1 cubic-foot, and was a styrofoam container. The material the box would be made from was a necessary piece of information, as it will influence our temperature recording methods and temperature dissipation statistics. Additionally, we finally received a concrete and definitive response with respect to the raspberry pi/arduino board integration. They affirmed that we would be able to use the onboard raspberry pi, or the arduino; however, we would need to consider the fact that the raspberry pi only has digital pins, and would require a digital to analog converter if we so chose. Fortunately, our sensor of choice provides digital outputs that can be sent to the raspberry pi or arduino on their drone. Concerning the length of the wires running through the device, reaching a length of 1 foot. After concluding our presentation, the client mentioned that we should be sure to bear in mind the method of sending out and receiving information.

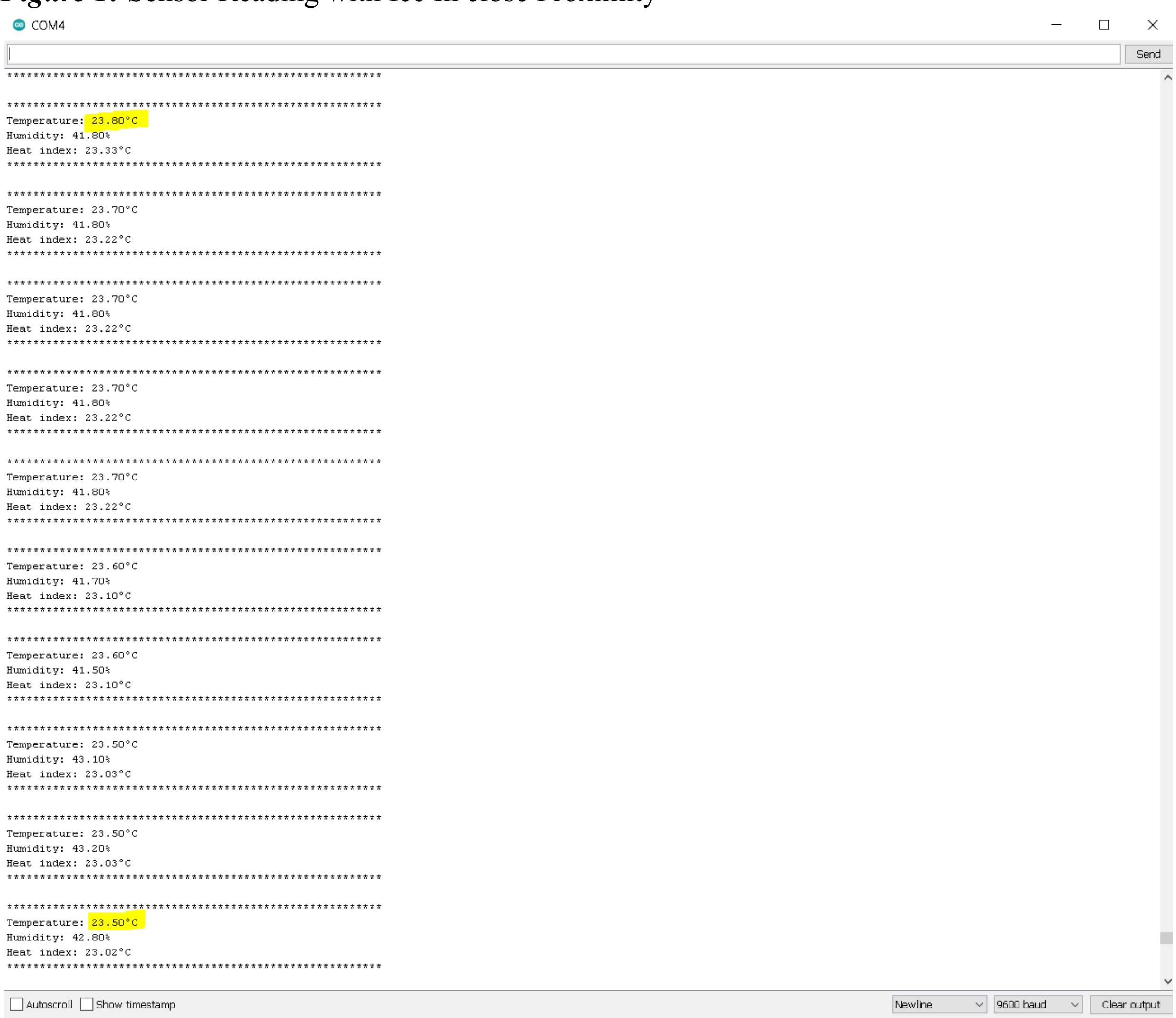
Prototype II Description

Our second prototype will be focused on testing how our separate subsystems will work when put together in a manner similar to our final product. This means that the demonstration box from the last deliverable has been delivered to the team member who will be constructing the arduino system, William, and has been fashioned with the two sensors attached to the underside of the lid of the container that should be the most efficient way to measure the climate inside the box. This comprehensive model will be used throughout the next week to both refine the code framework and the sensor placement.

Single-Sensor Cold/Recovery Test

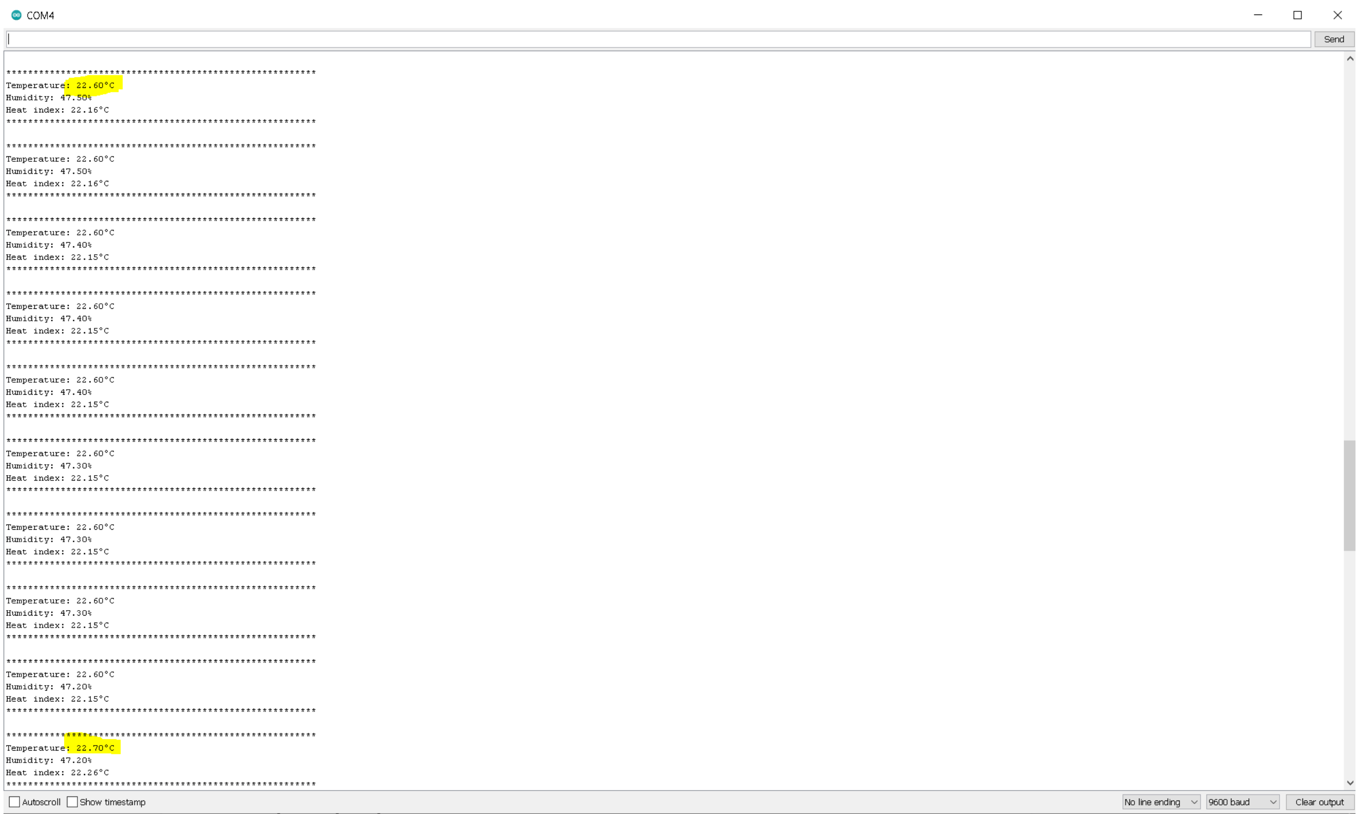
In our testing so far, we verified that the temperature sensor is able to quickly respond to a positive change in temperature induced by a heat source. It later became apparent that the sensor's ability to respond to negative change in temperature may behave differently and must be independently tested. In this test, a bag of ice will be placed in close proximity to the sensor and the sensor reading will be recorded. Additionally, the temperature sensor will be continuously monitored after the ice is removed to check the recovery time for the temperature reading to go back to pre-ice levels. Given that the sensor has been proven to have a fast response time to change, a recovery test will provide information on how long it takes for the ambient temperature to return to normal after removing the exposure to heat/ice element. In theory, the recovery period should be longer than the period of initial change. This theory will be experimentally verified using the sensor results. The results will be displayed in the figures below.

Figure 1: Sensor Reading with Ice In close Proximity



Before any cold element is placed beside the sensor, the ambient room temperature was recorded to be around 24 °C. In testing the responsiveness of the sensor to a negative change in temperature, it was observed that the temperature change was less abrupt, and took about 3-4 readings for each 0.1 degree change. This took a bit longer to register on the sensor compared to the heat test. This may indicate two things, either the sensor responds slightly slower for negative changes in temperature, or the thermal change induced by the ice was less significant than the hot cup of water. In either case, this test has verified the sensors ability to detect a decrease in temperature. In practice though, this sensor would mainly be used to detect the change in climate induced by hot foods.

Figure 2: Sensor Reading Recovery After Ice Is Removed



The above figure shows the sensor reading after the ice element was moved away from the sensor. At the time of removal, the sensor reading was lowered from ambient (24 °C) to 22.5 °C. Based on the collected results, it can be seen that it took almost 10 readings before a 0.1 degree change was detected. Thus it can be concluded that the recovery period for the sensor to read the same ambient temperature (24 °C) again is longer than the period of time it took for the sensor to reach the lowered temperature. These results are in agreement with the fact that placing any sort of heat source will cause a faster change in temperature than letting the heat naturally reach an equilibrium with the ambient surrounding. This verifies the sensor's ability to detect various temperature changes correctly.

Multi-sensor Equilibrium Test

The purpose of this test is to determine how fast the sensor will be able to detect a change in temperature. Additionally, it will determine how long it takes for the sensor to reach an equilibrium and for the data to settle. For testing, a cup of boiling water is placed into the box with the lid closed; the sensors are then initialized to take temperature and humidity readings. There isn't a primary reference as the tester does not own a thermometer and humidity meter; however the main purpose of this experiment is not to see the precision yet, it is trying to quantify the behaviour of the sensor at this stage. The sensor was turned on and powered to sit for ~1 minute, in order to eliminate any potential error that was linked to sudden change of environment and allow the sensing input to settle to the environment; At ground state, the sensor has settled around 25.00 C, and although relative humidity from 2 individual sensors did not agree with each other, they can be averaged to and the mean can be used.

The setup for the test can be seen below; and the test proceeds by measuring how long does the sensor respond to the change and how long does the temperature inside settle. The criteria for responding to change is to have a difference greater than 5 degree celsius from starting point, and the time to reach equilibrium is counted from the moment water was placed inside the box and 2 sensor has datapoint within 0.2 from each other, and have consistent data for past few data point.

`00:39-->02:07 temperature changed, about 1 and half minute to detect significant change, from 24.3 to 29.4`
`00:39-->01:22 Humidity sensor maxed out over this period`
`00:39-->05:02 Reached equilibrium`

Figure 3: Initial settling period

COM3

```
22:17:45.522 -> DHT22_2  25.40Degree Celsius 22.40%RH
22:17:46.511 -> DHT22_1  25.50Degree Celsius 15.60%RH
22:17:47.546 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:17:48.538 -> DHT22_1  25.40Degree Celsius 15.50%RH
22:17:49.575 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:17:50.561 -> DHT22_1  25.50Degree Celsius 15.50%RH
22:17:51.553 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:17:52.589 -> DHT22_1  25.40Degree Celsius 15.50%RH
22:17:53.580 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:17:54.625 -> DHT22_1  25.50Degree Celsius 15.50%RH
22:17:55.618 -> DHT22_2  25.30Degree Celsius 22.30%RH
22:17:56.609 -> DHT22_1  25.40Degree Celsius 15.50%RH
22:17:57.649 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:17:58.647 -> DHT22_1  25.40Degree Celsius 15.40%RH
22:17:59.641 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:18:00.637 -> DHT22_1  25.40Degree Celsius 15.40%RH
22:18:01.679 -> DHT22_2  25.30Degree Celsius 22.30%RH
22:18:02.669 -> DHT22_1  25.40Degree Celsius 15.40%RH
22:18:03.661 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:18:04.703 -> DHT22_1  25.40Degree Celsius 15.40%RH
22:18:05.691 -> DHT22_2  25.30Degree Celsius 22.40%RH
22:18:06.728 -> DHT22_1  25.40Degree Celsius 15.40%RH
22:18:07.717 -> DHT22_2  25.30Degree Celsius 22.30%RH
22:18:08.707 -> DHT22_1  25.40Degree Celsius 15.30%RH
22:18:09.737 -> DHT22_2  25.30Degree Celsius 22.30%RH
22:18:10.764 -> DHT22_1  25.40Degree Celsius 15.30%RH
22:18:11.755 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:12.780 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:13.767 -> DHT22_2  25.30Degree Celsius 22.30%RH
22:18:14.799 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:15.788 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:16.821 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:17.810 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:18.807 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:19.850 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:20.835 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:21.859 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:22.848 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:23.884 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:24.877 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:25.863 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:26.894 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:27.878 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:28.917 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:29.906 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:30.936 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:31.918 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:32.952 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:33.947 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:34.974 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:35.961 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:36.996 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:37.985 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:38.977 -> DHT22_1  25.30Degree Celsius 15.20%RH
22:18:40.004 -> DHT22_2  25.20Degree Celsius 22.30%RH
22:18:40.992 -> DHT22_1  25.30Degree Celsius 15.10%RH
22:18:42.028 -> DHT22_2  25.20Degree Celsius 22.30%RH
```

Figure 4: Significant change of humidity and temperature from second test

```
22:35:39.282 -> DHT22_1  24.30Degree Celsius 20.90%RH
22:35:40.277 -> DHT22_2  24.30Degree Celsius 28.80%RH
22:35:41.260 -> DHT22_1  24.30Degree Celsius 27.00%RH
22:35:42.293 -> DHT22_2  24.30Degree Celsius 46.00%RH
22:35:43.278 -> DHT22_1  24.40Degree Celsius 33.60%RH
22:35:44.312 -> DHT22_2  24.30Degree Celsius 60.90%RH
22:35:45.302 -> DHT22_1  24.40Degree Celsius 39.60%RH
22:35:46.338 -> DHT22_2  24.30Degree Celsius 67.50%RH
22:35:47.328 -> DHT22_1  24.40Degree Celsius 45.00%RH
22:35:48.361 -> DHT22_2  24.40Degree Celsius 75.20%RH
22:35:49.346 -> DHT22_1  24.40Degree Celsius 50.60%RH
22:35:50.381 -> DHT22_2  24.40Degree Celsius 82.80%RH
22:35:51.367 -> DHT22_1  24.50Degree Celsius 55.50%RH
22:35:52.399 -> DHT22_2  24.50Degree Celsius 88.70%RH
22:35:53.381 -> DHT22_1  24.60Degree Celsius 61.60%RH
22:35:54.411 -> DHT22_2  24.60Degree Celsius 91.10%RH
22:35:55.393 -> DHT22_1  24.60Degree Celsius 66.30%RH
22:35:56.435 -> DHT22_2  24.70Degree Celsius 93.00%RH
22:35:57.423 -> DHT22_1  24.70Degree Celsius 70.80%RH
22:35:58.454 -> DHT22_2  24.80Degree Celsius 94.90%RH
22:35:59.440 -> DHT22_1  24.80Degree Celsius 75.80%RH
22:36:00.470 -> DHT22_2  24.80Degree Celsius 96.20%RH
22:36:01.447 -> DHT22_1  25.00Degree Celsius 80.80%RH
22:36:02.471 -> DHT22_2  24.90Degree Celsius 97.10%RH
22:36:03.458 -> DHT22_1  25.10Degree Celsius 85.30%RH
22:36:04.492 -> DHT22_2  25.00Degree Celsius 98.10%RH
22:36:05.477 -> DHT22_1  25.20Degree Celsius 88.90%RH
22:36:06.512 -> DHT22_2  25.10Degree Celsius 99.20%RH
22:36:07.504 -> DHT22_1  25.30Degree Celsius 91.10%RH
22:36:08.544 -> DHT22_2  25.20Degree Celsius 99.90%RH
22:36:09.539 -> DHT22_1  25.50Degree Celsius 92.50%RH
22:36:10.528 -> DHT22_2  25.30Degree Celsius 99.90%RH
22:36:11.560 -> DHT22_1  25.60Degree Celsius 93.80%RH
22:36:12.549 -> DHT22_2  25.40Degree Celsius 99.90%RH
22:36:13.582 -> DHT22_1  25.70Degree Celsius 95.10%RH
22:36:14.569 -> DHT22_2  25.60Degree Celsius 99.90%RH
22:36:15.607 -> DHT22_1  25.90Degree Celsius 96.30%RH
22:36:16.595 -> DHT22_2  25.70Degree Celsius 99.90%RH
22:36:17.628 -> DHT22_1  26.00Degree Celsius 97.40%RH
22:36:18.614 -> DHT22_2  25.90Degree Celsius 99.90%RH
22:36:19.603 -> DHT22_1  26.20Degree Celsius 98.40%RH
22:36:20.638 -> DHT22_2  26.00Degree Celsius 99.90%RH
22:36:21.632 -> DHT22_1  26.30Degree Celsius 99.60%RH
22:36:22.663 -> DHT22_2  26.10Degree Celsius 99.90%RH
22:36:23.647 -> DHT22_1  26.40Degree Celsius 99.90%RH
22:36:24.676 -> DHT22_2  26.20Degree Celsius 99.90%RH
22:36:25.661 -> DHT22_1  26.60Degree Celsius 99.90%RH
22:36:26.694 -> DHT22_2  26.40Degree Celsius 99.90%RH
22:36:27.678 -> DHT22_1  26.80Degree Celsius 99.90%RH
22:36:28.709 -> DHT22_2  26.50Degree Celsius 99.90%RH
22:36:29.697 -> DHT22_1  26.90Degree Celsius 99.90%RH
22:36:30.732 -> DHT22_2  26.70Degree Celsius 99.90%RH
22:36:31.718 -> DHT22_1  27.00Degree Celsius 99.90%RH
22:36:32.750 -> DHT22_2  26.80Degree Celsius 99.90%RH
22:36:33.737 -> DHT22_1  27.20Degree Celsius 99.90%RH
22:36:34.770 -> DHT22_2  26.90Degree Celsius 99.90%RH
22:36:35.755 -> DHT22_1  27.30Degree Celsius 99.90%RH
22:36:36.786 -> DHT22_2  27.10Degree Celsius 99.90%RH
22:36:37.772 -> DHT22_1  27.50Degree Celsius 99.90%RH
22:36:38.803 -> DHT22_2  27.20Degree Celsius 99.90%RH
22:36:39.794 -> DHT22_1  27.60Degree Celsius 99.90%RH
22:36:40.831 -> DHT22_2  27.40Degree Celsius 99.90%RH
22:36:41.813 -> DHT22_1  27.80Degree Celsius 99.90%RH
22:36:42.849 -> DHT22_2  27.50Degree Celsius 99.90%RH
22:36:43.841 -> DHT22_1  28.00Degree Celsius 99.90%RH
22:36:44.831 -> DHT22_2  27.70Degree Celsius 99.90%RH
22:36:45.866 -> DHT22_1  28.10Degree Celsius 99.90%RH
22:36:46.854 -> DHT22_2  27.80Degree Celsius 99.90%RH
22:36:47.885 -> DHT22_1  28.30Degree Celsius 99.90%RH
22:36:48.868 -> DHT22_2  28.00Degree Celsius 99.90%RH
22:36:49.908 -> DHT22_1  28.40Degree Celsius 99.90%RH
22:36:50.891 -> DHT22_2  28.10Degree Celsius 99.90%RH
22:36:51.926 -> DHT22_1  28.50Degree Celsius 99.90%RH
22:36:52.906 -> DHT22_2  28.30Degree Celsius 99.90%RH
22:36:53.936 -> DHT22_1  28.70Degree Celsius 99.90%RH
22:36:54.919 -> DHT22_2  28.50Degree Celsius 99.90%RH
22:36:55.951 -> DHT22_1  28.80Degree Celsius 99.90%RH
22:36:56.937 -> DHT22_2  28.60Degree Celsius 99.90%RH
22:36:57.973 -> DHT22_1  29.00Degree Celsius 99.90%RH
22:36:58.961 -> DHT22_2  28.80Degree Celsius 99.90%RH
22:36:59.994 -> DHT22_1  29.10Degree Celsius 99.90%RH
22:37:00.984 -> DHT22_2  28.90Degree Celsius 99.90%RH
22:37:02.013 -> DHT22_1  29.30Degree Celsius 99.90%RH
22:37:02.998 -> DHT22_2  29.10Degree Celsius 99.90%RH
22:37:04.030 -> DHT22_1  29.40Degree Celsius 99.90%RH
22:37:05.014 -> DHT22_2  29.20Degree Celsius 99.90%RH
22:37:06.044 -> DHT22_1  29.50Degree Celsius 99.90%RH
```

Figure 5: Testing Environment for Equilibrium Test

Figure 5 shows the testing set-up. The image on the left shows the inside of the testing box while the image on the right displays the arduino connection.

Demo-box Prototype

In this second prototype our group had the opportunity to merge both parts of our first prototype to form a more comprehensive model. By placing a bowl of water inside the box at varying temperatures, we were able to extract measurable results. Despite the inaccurate dimensions and materials used for the mock compartment, the closed environment allowed for the sensors to function with relatively high fidelity. As seen in figure 1 below, this iteration of prototyping is also a physical model. The tangible approximation of the prototype was great when presenting to the clients because it offered a visual representation of the climate sensor add-on.

Figure 6: Comprehensive model (Likely to be replaced by styrofoam box in final demo)

Project Direction and Planned Changes

As for the direction of our project going forward, we are looking to transition into our design having an emphasis on ease of use of our system. We want to be able to have a system that is “plug and play” that can be reliable and simple to utilize. With this, we are also most likely going to be able to focus on increasing the variety of our sensors, in turn making the extrapolated data more accurate. This alongside making a more accurate testing environment using a styrofoam box that is one cubic foot in volume will make for our project being more accurate and reliable to add to the JAMZ drone.

Conclusion

Our second prototype begins to display the more refined qualities of a finished product. The combination and integration of all individual subsystems into a single cohesive design confirms the compatibility of our preliminary concepts. Although the slight variation and errors caused by the relatively unpolished connections between the components. The satisfying results from our second prototype assure that we will be able to address and improve any shortcomings or gaps in the achievements of Prototype I. With further feedback from the invaluable JAMZ team, and a dedicated effort from our group, we can remain optimistic that our final prototype will be the ideal design.