GNG1103

Design Project User and Product Manual

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	**Definition**
BOM	Bill of Materials
I2C	Pronounced I-Squared-C, a serial communication method used for sensors and other devices. Uses a slave and master device synchronized to the same clock for sampling and transmitting.
DHT22	Digital temperature and humidity sensor. This device uses a capacitive humidity sensor and thermistor to measure the surrounding air and sends out digital signals on the data pin.

PLA	Polylactic Acid
M3 Bolts	‘M3’ gives a radius dimension to bolts.

Table 2. Glossary

Term	Acronym	Definition
Accelerometer	N/A	The device that measures the acceleration of an object
Arduino IDE	N/A	A program used to write code to be run on the Arduino microcomputer. It uses the coding language C.
Arduino Uno	N/A	A microcomputer that can be used to execute code written on the IDE of the same name.
Bill of Materials	BOM	The total cost of the materials this group used to create the All-in-One module
Computer numerically controlled	CNC	A CNC machine processes material based on the programmed instruction received. It does not require machining done directly by the user.
Jerk	N/A	The derivative of acceleration with respect to time.

LED	N/A	A diode that emits light
LSM6DS3	N/A	The specific accelerometer the Sixth Sense has chosen
Module	N/A	A device, or model. Can be used to reference the whole or individual parts.
Overhang	N/A	Print failure caused by the orientation of the 3D part going against gravity.
Raspberry Pi	N/A	A computer that can be used by drone delivery companies aboard their drones. Used for example by JAMZ.
RGB	N/A	This refers to the usage of red, green and blue to create different colours. RGB LEDs employ this same principle with the light they emit.
Serial Communication	N/A	The method for communicating with the computer onboard JAMZ's drone.
Serial Monitor	N/A	The serial monitor is the port of entry for data sent from a device connected to a computer. This monitor can be opened and read.
Temperature Sensor	N/A	A device used to measure the climate in a given location. It can record temperature, humidity, and other climate data.

1 Introduction

This User and Product Manual (UPM) provides the information necessary for JAMZ to effectively use the all-inclusive climate sensor, violent shake alarm system, anti-theft alarm system and beacon system for prototype documentation.

2 Overview

Delivery Services, especially those that use drones like JAMZ need a way to monitor their package, prevent thefts and alert pedestrians around the package, our module answers these problems.

Often the contents of delivered packages are very sensitive to factors like temperature, humidity, orientation in space and movement, our module can track these to prove that the contents were delivered safely, as well our module can send flags to the delivery service so that they can quickly react and fix the problem.

Specifically for drone services, there is also the risk of the drone falling, being stolen or being investigated by pedestrians. This puts both an expensive piece of equipment, the contents of the package and customer satisfaction at risk. Our module can prevent these risks as well as help the drone operators in the worst-case scenario.

The main differences between the Sixth Sense product and others both on the market and created by other GNG1103 project groups is that it has a fully functional, comprehensive solution to all four problems described by JAMZ, all while remaining well under the budget, waterproof, consistent, lightweight, compact, easily maintainable and user friendly. Our module has an anti-theft system, an emergency beacon, a climate sensor and a violent shake alarm, all of which have been meticulously calibrated to be as close to accurate values as possible. As well, algorithms have been created in the code so that even if the sensors are outputting inconsistent data, the program will continue to work and deliver reliable output with averaging and calibration.

The key features of the module are as follows:

1. Arduino Case
2. Sensor Case
3. Step-Down Converter Case
4. Climate Sensor

5. Violent Shake Alarm
6. Emergency Beacon
7. Anti-Theft System

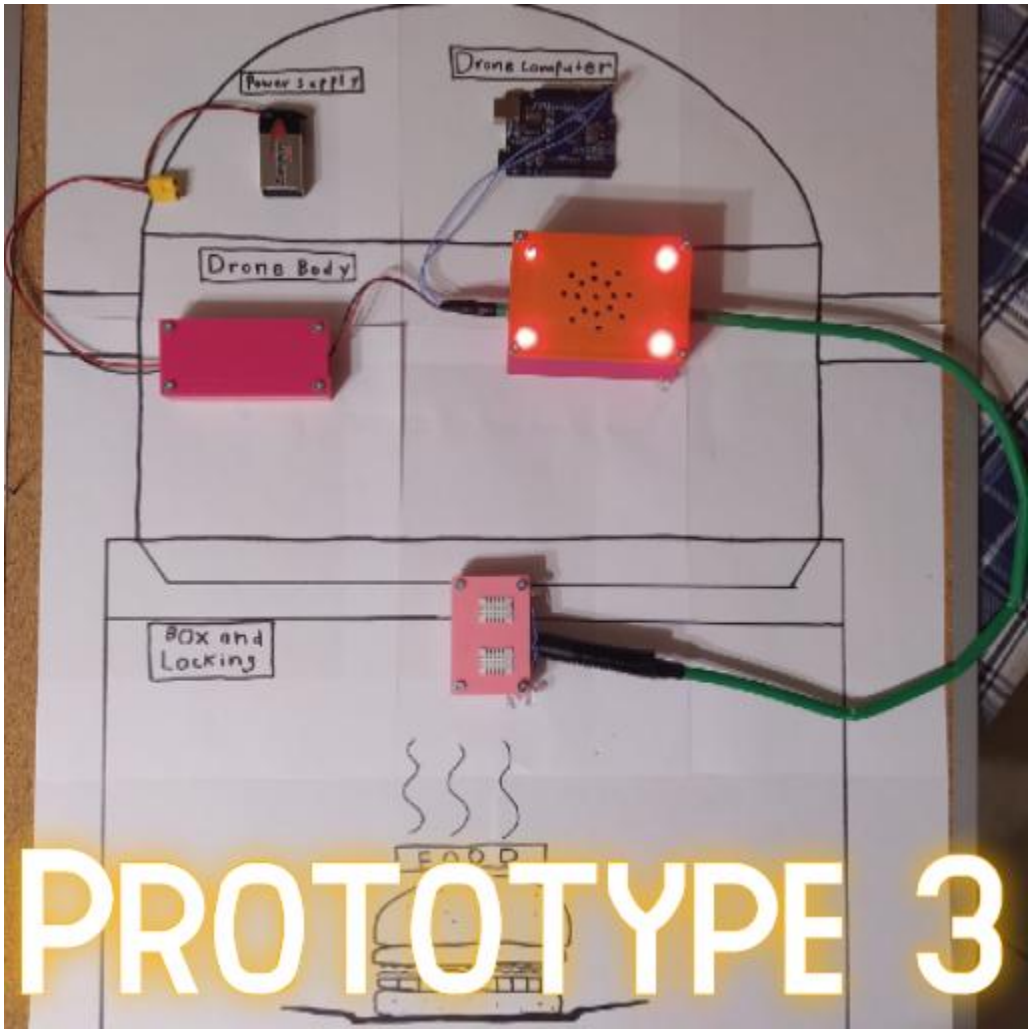

Figure 1 - Fully Assembled All-In-One Module. Orange = Arduino Module, Speaker and LED's, Red = Stepdown Converter, Pink = Sensor Module, Climate Sensor and Accelerometer

2.1 Conventions

No command syntax for the reader.

2.2 Cautions & Warnings

Users should understand that while there is a voltage step-down converter in place to ensure that the Arduino board only receives a voltage that it is capable of accepting, do not assume that the converter

can work for any amount of voltage. Its maximum voltage is 60V, and before using the All-in-One system ensure that the converter is calibrated to output no more than 12V, which is the recommended limit of the Arduino board used in this device, the Arduino Uno R3.

Users should also understand that all libraries that are present in the code that is in the final module are required to be there for the module to function properly, and tampering with those libraries can have an effect on the output of the module.

There are no waivers that need to be signed to use this device, nor are there any copy permissions that need to be granted.

3 Getting started

3.1 Set-up Considerations

The input devices for the system are the serial communication with the Raspberry Pi, as well as the sensor module containing two DHT-22 temperature and humidity sensors and one LSM6DS3 accelerometer. For the system to function there needs to be a connection between the power supply and the step-down converter and a connection between the Arduino and the Raspberry Pi using digital pins zero and one.

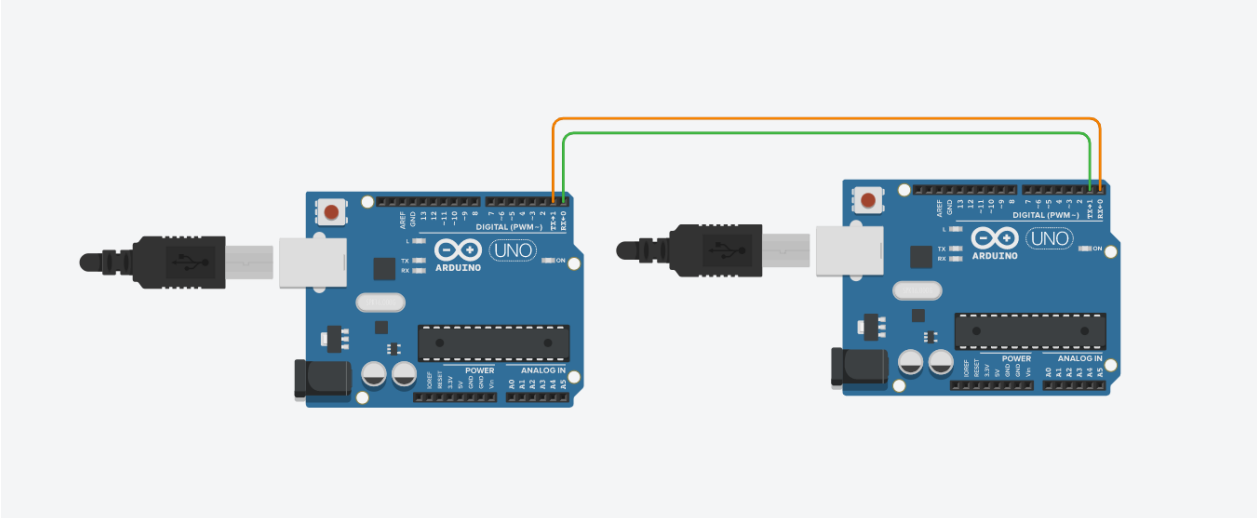

Figure 2 - Serial communication between two microcontrollers (Arduino). Use same configuration for Arduino to Raspberry PI communication

3.2 User Access Considerations

The all-in-module has been designed specifically for the JAMZ drone project. Having this in mind, it is important to note that only JAMZ officials or delivery personnel should have access to the modifications of this system.

3.3 Accessing the System

The start-up process for our all-in-one module has been made as simple as possible for the user. The steps are as follows

1. Plug your USB Type A-B cable into your computer and the Arduino.
2. Upload the file name “Consolidated Code.ino” to the Arduino and unplug once you are done.
3. Screw the four corners of the Arduino case closed.
4. Use the provided screws to attach the Arduino Case, Step-Down Converter Case and Sensor Case in their appropriate locations as decided by the user.
5. Attach the XT-60 Female Adapter to the Male Adapter at your power supply.
6. Attach the wire labelled RX to the TX pin of your microcontroller and the wire labelled TX to the RX pin of your microcontroller.
7. There should be a tone played by the speaker as well as a blinking pattern on the beacon to show that the module has been powered on.

3.4 System Organization & Navigation

The system is organized into three main parts, the step-down converter module, the Arduino module and the sensor module. The step-down converter module is, as the name says, the module that converts the 44.4V received from JAMZ to the 5V needed to power the Arduino. The Arduino module is the main component of the system, it houses the Arduino, all the wiring, the speaker and the LED’s. The third module is the sensor module which contains the two DHT-22’s and the LSM6DS3. The power supply is wired to the step-down converter, which is wired to the Arduino module, which is wired to the sensor module. See figure 1 for global navigation, and figure 13 for circuit navigation.

3.5 Exiting the System

To turn off the module simply unplug the XT-60 Female Adapter from the Male Adapter at your power supply.

4 Using the System

The All-in-One module accomplishes every task a delivery drone needs to properly serve its customers. There is a climate sensor that transmits temperature conditions from around the food straight to the pilot in real-time the pilot to analyze the environment around the food in real-time alarm onboard alerts the pilot that their drone is violently shaking, giving a user the ability to keep both themselves and the customer informed on the potential state of their drone. An anti-theft system and emergency beacon on board ensure that passers-by stay away by notifying them using audio and visual alerts.

The climate sensor uses temperature and humidity measurements from thermostats and smoothes out the results. The results are then compared to a user-determined range of either hot or mild temperatures, to measure whether the food is in the right temperature conditions or not. The result of this comparison is then able to be sent out via the serial port on the module to any central computer.

In determining whether a drone is violently shaking, the alarm onboard uses acceleration's derivative, jerk, to determine the drone's situation. High jerk values suggest a drone that is changing direction frequently and suggests a deviation from a normal flight pattern. If the rise in jerk is significant enough to alert the alarm on board, then the module will again use serial communication to alert the pilot of the security state of their drone.

The anti-theft system in place on the drone provides potential passersby to a fallen drone with a clear audio message to stay away from the drone. This ensures the security of the drone from when it hits the ground to when it is recovered. The message alerts pedestrians to the fact that they must stay away from the fallen drone, and clearly informs passersby that the fallen drone must be left untouched

The emergency beacon works hand-in-hand with various subsystems on the drone and blinks specific colours to signify different problems on the drone. In addition to serving its primary purpose of helping an operator to identify the drone in the event of a crash, the emergency beacon further allows the operator to identify what can cause potential drops in the quality of the food, or increases in threats to the drone.

4.1 Climate Sensor

The Climate Sensor of the Sixth Sense's All-in-One module measures and transmits precise temperature and humidity data concerning its surroundings. By using its three thermostats, including two DHT 22s and the LSM6DS3 accelerometer which has a thermostat on it, and data smoothing, the temperature is tracked to a precision of 0.13% difference with standardized temperature readings. This represents a difference of 0.05℃. In addition, both DHT 22s measure humidity and calibration can bring

their percent difference down to 1.9%, making it accurate to 2.75% relative humidity. The code as represented in the flow chart calculates a weighted average of the readings and sends a binary output through serial communication depending on the temperature and humidity range provided by JAMZ as well as visual cues with the RGB LED's.

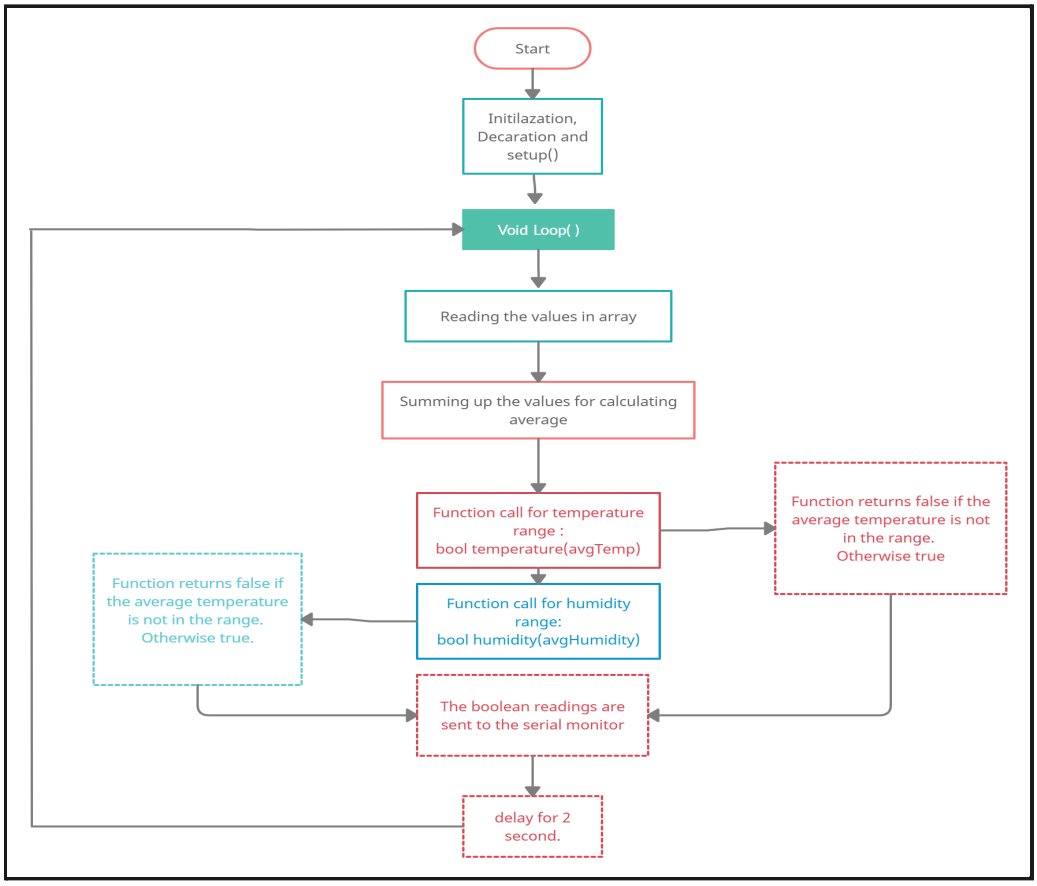

Figure 2 - A flowchart of how the climate sensor functions, using its code

Output from the sensor will be binary, dependent on whether the measured temperature and humidity values are within a certain predetermined range. The range for the humidity will be static, however for the temperature the user must choose whether they wish to use a hotter range or a more mild range to measure food before starting up the system. If the sensor detects temperature or humidity values that are outside of the ranges, then the system will change the last two characters of the string it sends every pulse. The second character in the string will be "t" when the temperature is out of range, which would result from a false value as shown in the flowchart. The third character in the string will be "h" when humidity is out of range. For each character sent there is a corresponding LED configuration as explained in section 4.4. The ranges for temperature and humidity values can be set as the user desires by

changing the values in the tempCheck and humidCheck functions in the code. The recommended ranges are humidity 20-80% and temperature 5-30 degrees celsius.

4.1.1 DHT 22

The DHT 22 temperature sensor forms the backbone of the climate sensor in the All-in-One module. The two thermostats on board measure both temperature and humidity at a frequency of 0.5 Hz, with ranges of -40℃ to 85℃ and 0-100% for temperature and humidity. The temperature is measured to a precision of ±0.5℃ with no calibration, and similarly, the humidity is measured to an accuracy of ±2-5%. Using data smoothing, this precision is increased by a factor of 10 with regard to the temperature, to ±0.05℃, and down to ±1.9% with regards to the humidity.

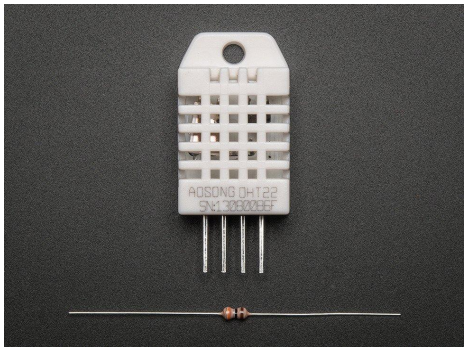

Figure 3 - The DHT 22 that was used in this module

4.1.2 LSM6DS3 Temperature Sensor

The LSM6DS3, though it may be an accelerometer, is a key part of the climate sensor aboard the All-in-One module. This is due to the presence of a thermostat, which makes it capable of measuring temperature with the component. Its temperature range is from -40℃ to 85℃, offering a wide range of accurate measurements for the module. In addition, it plays an important role in the shake alarm.

4.2 Shake Alarm

The All-in-One's Shake Alarm works to ensure the safety of any drone it is attached to. The shake alarm works by using an accelerometer to measure jerk at multiple instances over a short period of time. If at least 50% of the jerk measurements are greater than the shake threshold of 0.2 g/s (corresponding to 1.96 m/s^3), then the drone is deemed to be violently shaking. If the shake alarm determines that the drone is shaking then the first character in the string that is sent every time the module completes a cycle will be set to "j".

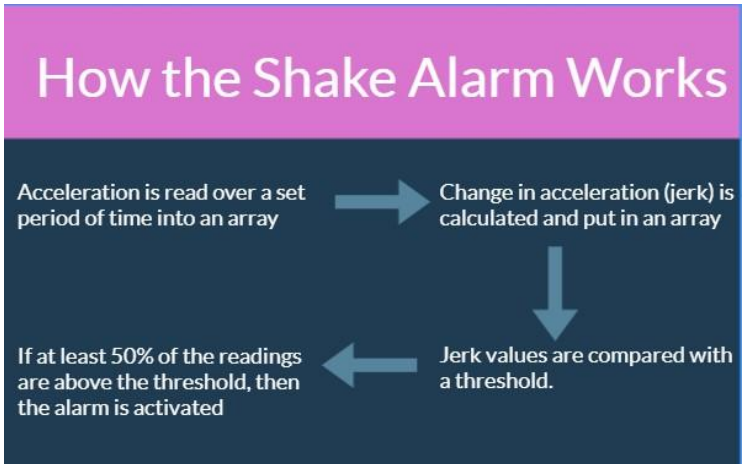

Figure 4 - A flowchart of how the shake alarm works over the course of 0.5 seconds, 10 readings

An important factor to note with regards to our shake alarm is that the shake alarm assumes relatively constant acceleration will be the norm for the drone it is on. While velocity and position can be increasing at relatively fast rates, in order for the shake alarm to work best it assumes the acceleration is constant, except for small changes when the drone is stopping and starting. The alarm can be falsely triggered by erratic flying conditions by the drone or vibrations, but collecting ten readings should minimize these false alarms.

4.2.1 LSM6DS3 Accelerometer

The accelerometer used in the All-in-One Module is the LSM6DS3. This accelerometer has a frequency of 104 Hz per its datasheet and is the backbone for the shake alarm. The accelerometer is used to measure the change in acceleration, and taking the module's frequency into account jerk is calculated from the module's measurements. In addition to its functionality as an accelerometer, it also has a thermostat which is referenced previously in section 3.1.2, meaning it is an integral part of both the climate sensor and the shake alarm, and therefore the All-in-One module as a whole.

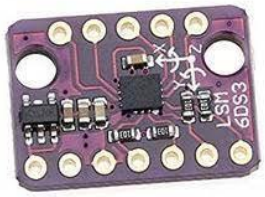

Figure 5 - The LSM6DS3 that was used in this module

4.3 Anti-Theft

The Anti-Theft System in place on the All-in-One module works to dissuade and warn anyone who is passing by a fallen drone that the module is not free to be taken and prevent theft of any of the contents of the drone. The system works by playing an audio recording, stored on the Arduino board inside the module. This recording indicates to people nearby that this drone is private property, stating "Step away from the drone". This is repeated each time the drone detects a jerk. This message serves to protect the drone from people who would otherwise seek to take parts of the drone or take any remnants of food from a crash. This also acts as an audio guide at short distances for any operator trying to find the drone. The anti-theft system protects the drone from those who would wish to harm it or disturb the contents inside. The recording cannot be changed at this time due to storage constraints, in a future update an SD card could be integrated into the Arduino module for different or longer recordings.

4.4 Emergency Beacon

The emergency beacon system aboard our drone serves to highlight and transmit any problems that are taking place aboard the drone. Depending on the issue at hand the emergency beacon will flash a certain colour. The LEDs used in the beacon are RGB, and so if multiple issues present themselves (such as violent shaking and out-of-range temperature), then the LEDs can reflect this multitude of problems by changing to a mix of the two problems' respective colours, in this context purple as it is a mix of red and blue.

Figure 6 - The colour wheel that is used on our emergency beacon. In addition to these colours, white is also used. See appendix for colour code meanings

In addition, in the event of a crash, the beacon will flash, helping to alert any potential searchers for the fallen drone to its whereabouts.

The emergency beacon serves the purpose of helping to keep everyone informed as to the quality of the food through its general colour-coded alerts. It also serves to help operators and other searchers to find and recover the fallen drone that had been lost, in the event of a crash.

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

The Emergency Beacon on the device has an assortment of colours that correspond to certain systems failing. This colour wheel was referenced previously in section 3.4 and will be fully explained in section 9.1.

If one or more of the temperature sensors in the climate module fails, the All-in-One module will send a message to the serial monitor of the computer it is connected to indicating which specific computer has failed and the module will continue to work as best as possible without crashing the code. For example, if a temperature/humidity sensor fails it will be excluded from the average output, if the accelerometer fails there will be no accelerometer readings.

Soldered connections can be prone to disconnecting if the casing is opened and the wires are pulled. This error will be highlighted by the error messages discussed earlier. To fix this behaviour use the testing code provided to isolate which sensor/component is causing the error, then attempt to reconnect any wires as shown in the wiring diagram.

If there are still problems after this there is the chance of faulty soldering causing a short-circuit that has potentially damaged the components. To fix this error search for bare wires that could be touching and cover each individually in either heat-shrinking material, electrical tape or other materials that will not conduct. If the components still do not work as required it is possible that the components have been damaged beyond repair and replacement may be necessary.

5.2 Special Considerations

The only consideration with our module is that the humidity and temperature values may take time to adjust to the surroundings. For example, it may take time for them to respond as soon as they are exposed to a new environment and when they are exposed to high humidity or heat there is the necessary cool-down period to return to ambient temperature. If the sensors are functioning, but not accurately give them time to cool down in a dry, cold place.

5.3 Maintenance

In order to keep the module in the best shape possible, regular maintenance will be necessary to perform. Recommended maintenance includes the following:

- Recalibration of the step-down converter whenever a different power source is used
- Unplugging the module if it is unused
- Unscrewing the lid, both to clean any dust or debris that may build up and to allow heat to escape. Both reasons can be valid after extended use

For help with any more complex maintenance either consult the support team as explained later in section 4.4 so they can perform the maintenance or consult them for further instructions. Every situation is special and there is no catch-all maintenance routine. It is best if the experts analyze the system and determine what needs to be repaired or updated.

As far as storage is concerned, it is preferable that the sensor module be kept away from extreme temperatures when turned off, as the temperature sensors may be disabled by extremely high or low temperatures. As well try to store the module in a dry place to prevent condensation buildup in the humidity sensors that would skew the output values. When storing the All-in-One module take care to ensure that no power is going through the circuit while it is not in use.

5.4 Support

All support services can be provided by the team, each providing support with their respective subsystems as shown below.

For help with casing contact Lucas Siviero - lsivi056@uottawa.ca or Timi Tella - otella056@uottawa.ca

For help with wiring and troubleshooting components contact Riley de Gans - rdega009@uottawa.ca

For help with code troubleshooting and calibration of components contact either Noah Aynalem - nayna096@uottawa.ca or Rakshita Mathur- rmath049@uottawa.ca

For code updates and bug fixes consult our public GitHub repository Link

For purchasing components consult the links in our bill of materials, we suggest Simcoe DIY for cheap and reliable parts

To report a problem or to receive support email the corresponding team member with the following information:

Name:

Phone Number:

Email:

Description of Problem:

Description of Troubleshooting Steps Taken:

Code Used (Upload .ino File):

Circuit Used (Upload Image File of Actual Circuit and Wiring Diagram):

6 Product Documentation

6.1 All-In-One Technical Lists

6.1.1 BOM (Bill of Materials)

Table 3. Bill of Materials for All-in-One Module

Component	Price($CAD)	Source	Link
DHT22 x 2	5.94 x 2 = 11.88	Simcoe DIY	*Link*
LSM6DS3	3.24	Simcoe DIY	*Link*
Voltage Converter	5.64	Simcoe DIY	Link
30 AWG Wire	3.78	Simcoe DIY	*Link*
Bundled ethernet cable	1.00	Makerspace	*N/A Variable Cost*
M3 Bolts x10	2.33	Robot shop	*Link*
Protoboard / PCB	0.56	Amazon	*Link*
Arduino Uno	8.67	Simcoe DIY	*Link*
3D Printed Case	N/A	Maker Space	*N/A*
4 Ohm Active Speaker	4.00	Dollar Store	*N/A*
4 x 4 Pin RBG LED	1.12	Simcoe DIY	*Link*
XT60 Female Converter	3.99	Orléans Hobbies	*Link*

NPN Transistor	0.56	Simcoe DIY	*Link*
Total Price	$46.77		
Coding Libraries			
DHT 22 Library	0	Arduino IDE	*Link*
LSM6DS3 Library	0	Arduino IDE	*Link*
I2C Library	0	Arduino IDE	*Link*
PCM Library	0	Arduino IDE	*Link*
SPI Library	0	Arduino IDE	*Link*
Wire Library	0	Arduino IDE	*Link*

6.1.2 Equipment list

Table 4. List of Equipment Needed to Build the All-in-One Module

List of Equipment	
Equipment Name	Type/description of Equipment
Laser Cutter	CNC
3D Printer	Additive Manufacturing
Handheld Drill + Drill Bits	Powered Mechanical
Sandpaper	Abrasive Refinement
M3 Screwdriver	Handheld Mechanical
M3 25mm Screw	Mechanical fastener
M3 30mm Screw	Mechanical fastener
Soldering Iron	Powered Mechanical
Flux	Eases the binding of metals
Solder	Lead-free tin solder

Multimeter	Electrical Measurement Instrument
Laptop	Computing Hardware
Industrial Temperature and Humidity Sensor	Temperature Measurement Instrument
Heat Shrink	Insulates the connection of wires
Electrical Tape	Insulates the connection of wires
Hot Glue Gun	Handheld Hot Adhesive

6.2 Case Housings

6.2.1 Instructions

Subsystem 1- Sensor Case

Step 1) 3D Printing the Case

The sensor case is 3-D printed using PLA (Polylactic Acid) which is water-resistant. All files used for 3D printing can be accessed through this shared drive link containing all the raw.STL files. These files are universal across most 3D printing software including Ultimaker Cura and Dremel, the GCODE can be obtained by inserting these files into the software corresponding to the specific 3D printer used. Slice the cases with 30% infill and 0.8mm nozzle size (or lower, 3D printer dependent). Below is an example print using an ultimaker 2+ Cura:

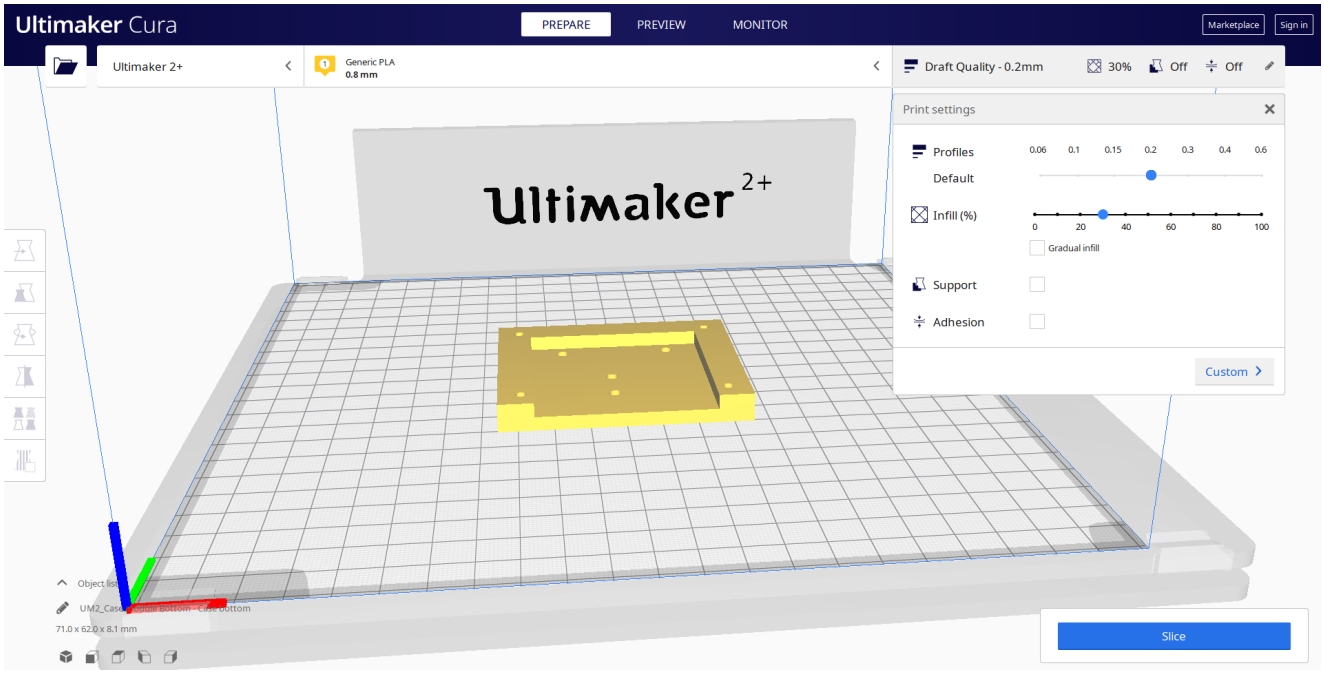

Figure 7 - Climate sensor bottom ready to be exported into GCODE

Step 2) Attaching the M3 Screws

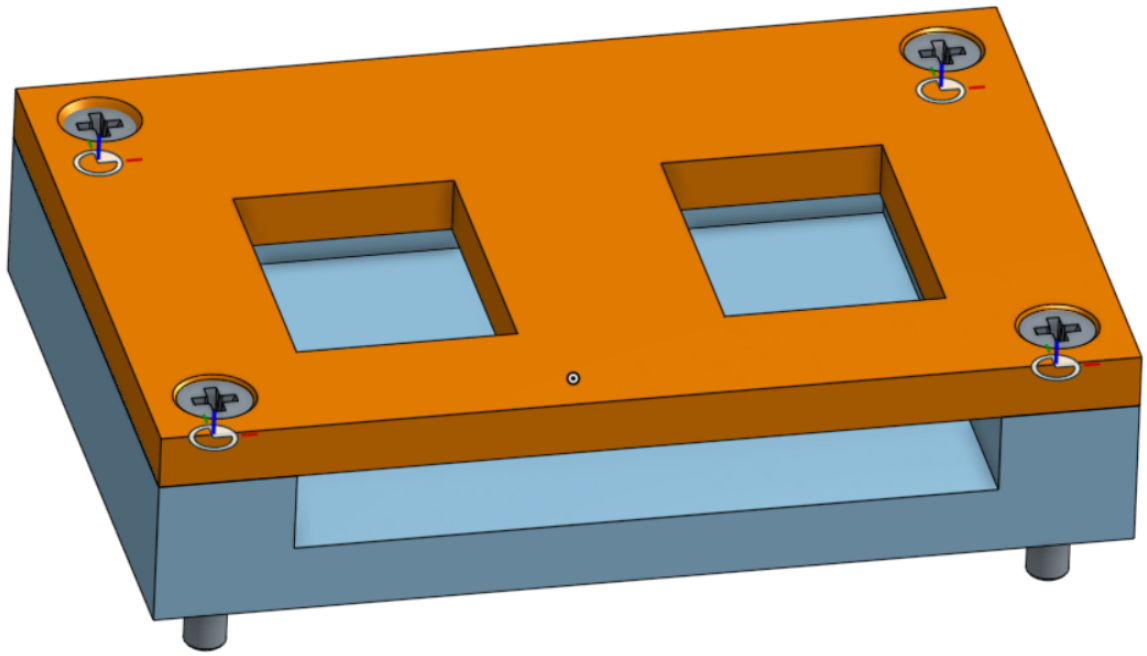

Figure 8 - Case configuration using M3 screws

Ensure the DHT22 and accelerometer components are safely inside the case. Attach 4 M3 25mm screws to the 4 corners of the case top, to securely fasten it in place.

Subsystem 2 - Step-Down Converter case

Step 1) 3D Printing

The Step-Down converter case can also be 3D printed using PLA with 30% infill and 0.8mm nozzle size. Once again this is accessed through this drive link in the pull-down converter case folder link. This system contains only the step-down converter attached from the main power source of the drone to the arduino case.

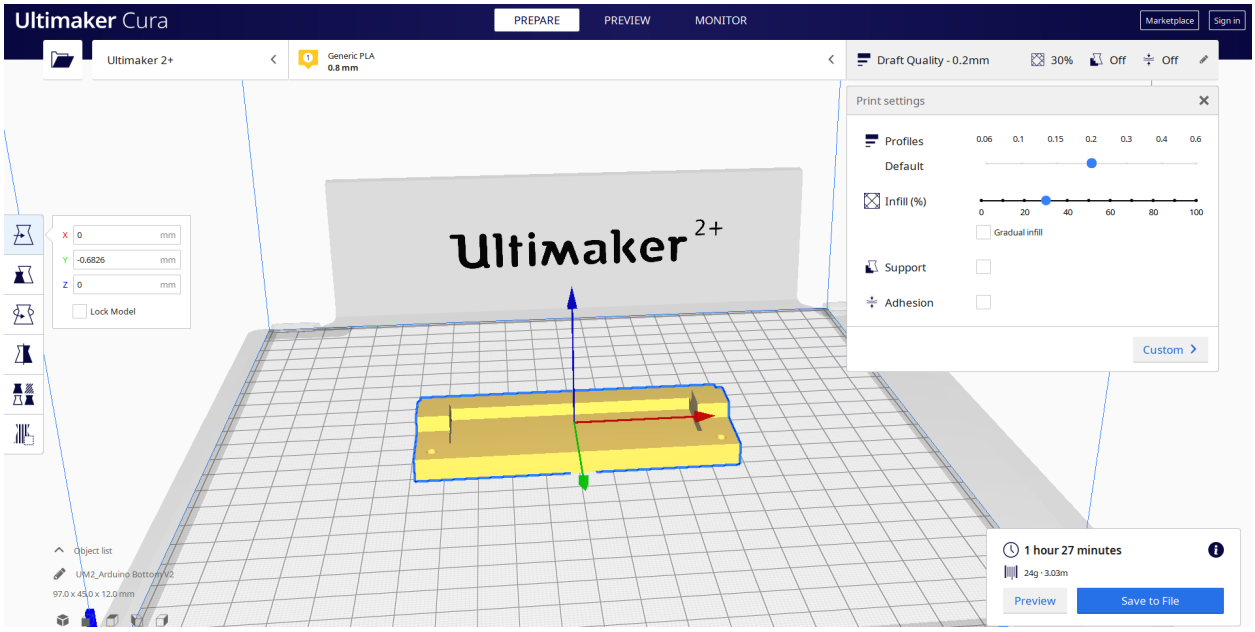

Figure 9 - 3D printing setup using Ultimaker 2+ Cura

Step 2) Attaching the M3 Screws

Ensure the step down converter is fitted snugly inside the case. Attach 4 M3 30 mm screws on all 4 corners of the case to fasten it in place. Seen below is the proper configuration:

Figure 10 - M3 Configuration of step down converter

Sub system 3 - Arduino Case

Step 1) 3D Printing

The Arduino case can also be 3D printed using PLA with 30% infill and 0.8mm nozzle size. Once again this is accessed through this drive link in the pull-down converter case folder link. This system contains the arduino speaker, LEDs and wires. Ensure the box lays flat as shown below, if not overhang will cause the print to fail.

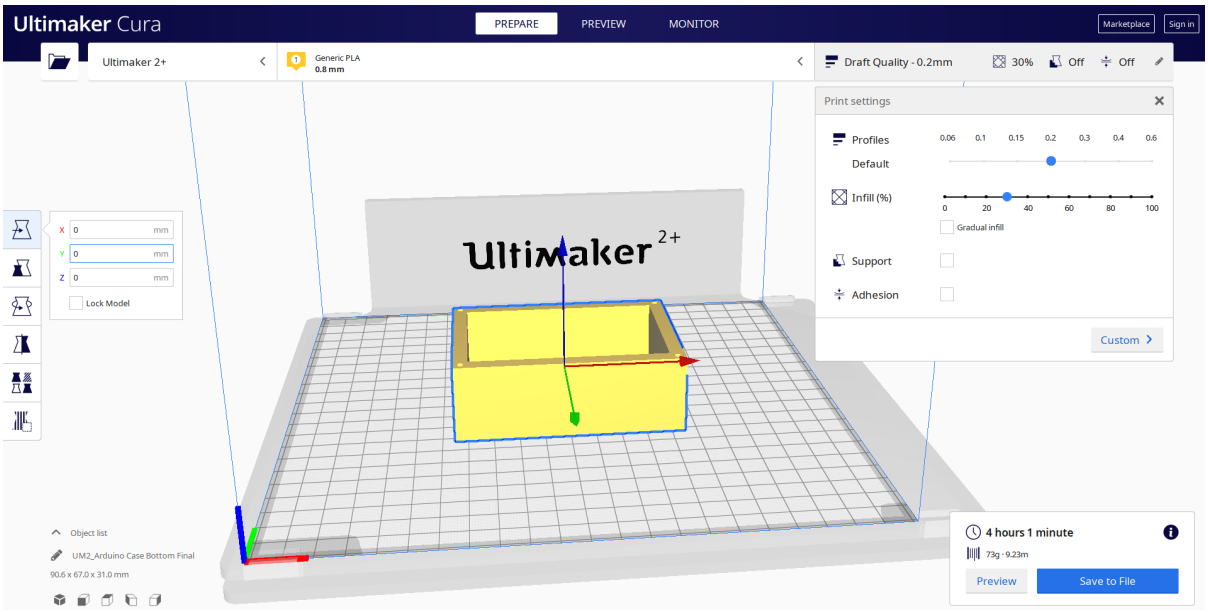

Figure 11 - Arduino Case bottom is Cura Software, bottom rests on 3D plane

Step 2) Attaching the M3 Screws

Place the arduino inside the case first so it rests on the bottom. Lay the speaker on top of the arduino so it rests near the speaker holes on the top. Place the LEDs in the 4 designated holes on the top of the arduino case. Attach 4 M3 25mm screws to the bottom arduino case module using the hole configuration shown below:

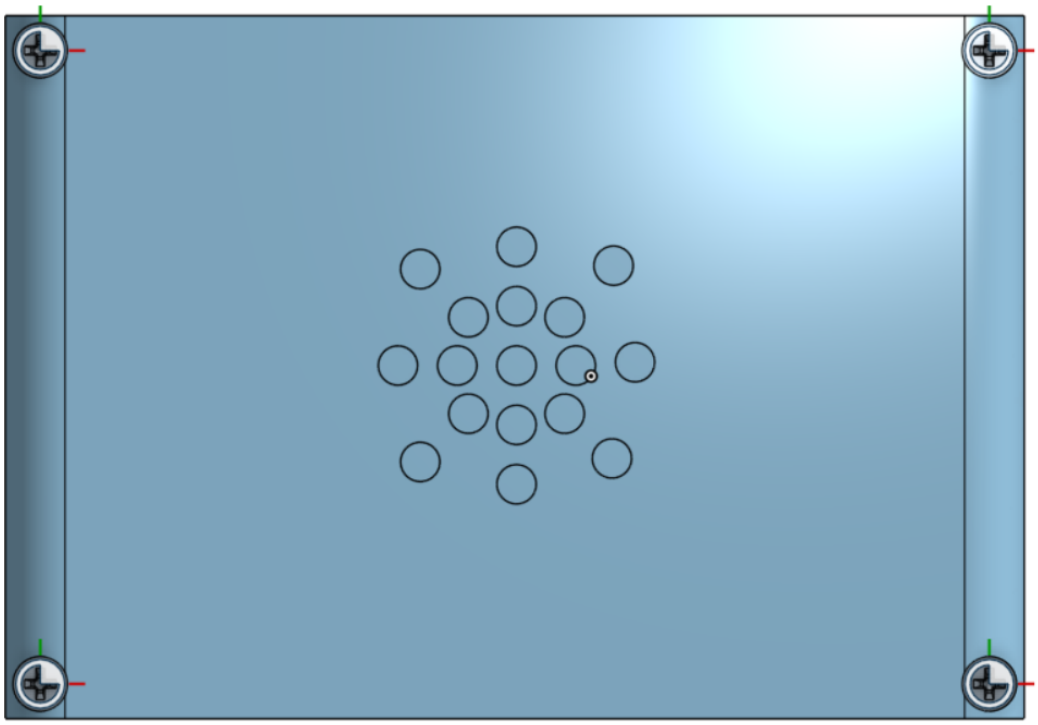

Figure 12 - M3 Configuration for Arduino case top

Subsystem 4 - Wiring

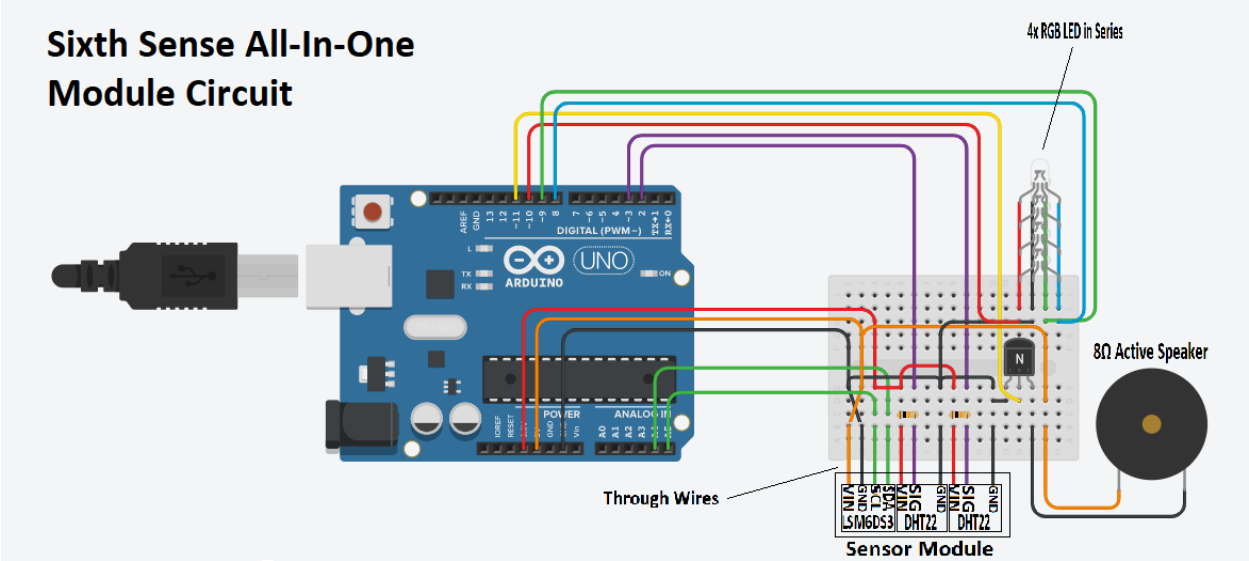

Figure 13 - Comprehensive Wiring Diagram

Above is a comprehensive wiring diagram, many of the wires such as 3.3V, 5V and ground are shared among many devices, so this will require the necessary forking. When preparing the wiring take into consideration which components will be in which case and how this relates to the length of the wire required. In our implementation of the wiring the LSM6DS3 and both DHT-22's were held in the sensor case and attached using a waterproof bundled through wire with eight 30 AWG wires. The through wire was approximately one foot long, but this length can be adjusted for your uses. The eight wires were as follows; 3.3V for DHT #1, 3.3V for DHT #2, shared ground for all three sensors, signal pin for DHT #1, signal pin for DHT #2, 5V, SDA and SCL for the LSM6DS#. On the sensor module end of the through wire the ground was forked into three wires. On the Arduino module end of the through wire the 3.3V was forked into two wires. In the Arduino module the 5V was forked to two wires to attach to the speaker and the through wire. The LED's were connected in series with approximately 10 cm of wire in between them to attach to the 4 corners of the case. The speaker was connected to the NPN transistor and the Arduino using approximately 10 cm of wire so that it could be connected to the underside of the case lid.

Comprehensive System:

Note* It is strongly recommended to secure the opening to the through wire using a gasket or a heat adhesive. As well all electronic parts must be manually soldered together if building from scratch. However, this manual assumes the parts have been soldered together when sold to a consumer. The gasket placement can be seen in the figure below where the green wire enters the orange casing.

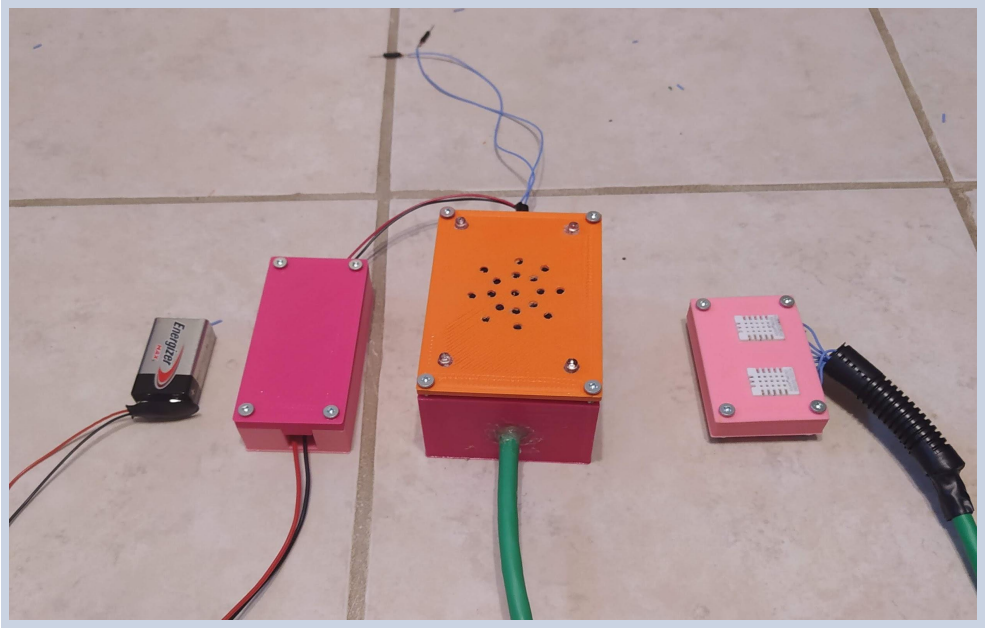

Figure 14 - Completed comprehensive system after attaching the components to their relative housings

6.3 Accessing the Code

The code used for All in one module is very user friendly and well commented code. The code has a smooth flow of understanding. First we include all the libraries used in the code.Second we initialize all the variables used, the consolidated code shared in the form of git repository contains the comment in front of each variable. Third is the setput of all the components and at last the void loop which reads the reading and printing the output on the serial monitor.

The code is designed in such a way that the output won't be all the raw data that the sensor collected but instead useful information either in RGB lights form or binary output on a serial monitor . For the temperature sensing the code will read the weighted average of the reading of temperature from the accelerometer and the readings from two DHT22 sensors. The code also takes care of the situation where any one of the sensors stops working, instead of showing NAN on the serial monitor the down sensor is excluded from the reading and the weight changes for the rest of the working sensor. There are two different functions tempCheck and HumidityCheck, anyone can enter the desired range for which they think the food will stay good and the code will give a binary output False as when the average temperature and the average humidity are out of range.

For the code of the accelerometer, the values of the reading are stored in an array, the function checks if 50% of the reading is not in the rate then the code will output a string on the serial monitor for showing jerk. The code takes the reading from all the three axes and checks with the threshold value. The code also gives different values for RGB combinations depending on the subsystem that is in use.

After doing all the connections on the circuit, download all the mentioned library packages, run the consolidated code using an arduino ide and you will see the output according to the serial monitor.

6.4 Testing & Validation

The first test conducted in the creation of the product was comparing the measured temperature and humidity to accepted values from an industrial temperature and humidity sensor. Then the values from this test could be used to calibrate our sensors. To conduct this test for yourself you need to record the readings from both sensors over your desired time period and at your desired sample rate. Next, when you decide there is a large enough sample size, input all of the data into the corresponding rows of this automated spreadsheet Link. It will then calculate the difference between the measured and accepted readings, plot them against each other, as well as on a residual plot. Then those values will be used to calculate the average difference value which will be used as a calibration of the values up or down and can be applied in the code. After this calibration has been applied the same plots will be created again with calibrated values instead of measured values. Finally, it will calculate the accuracy and percent error of the readings before and after calibration to show the improvement in performance.

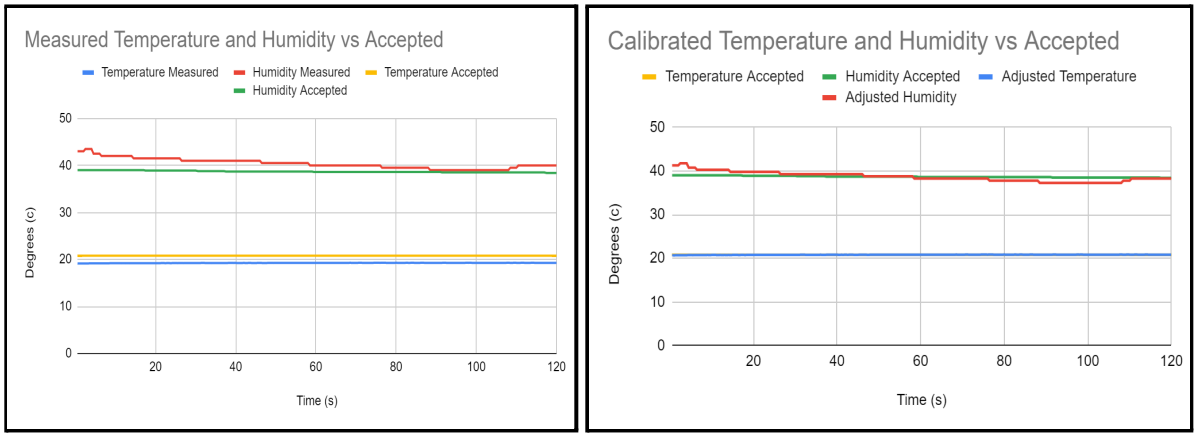

Figure 15 - Measured values plotted against accepted values before and after calibration for the temperature and humidity sensors

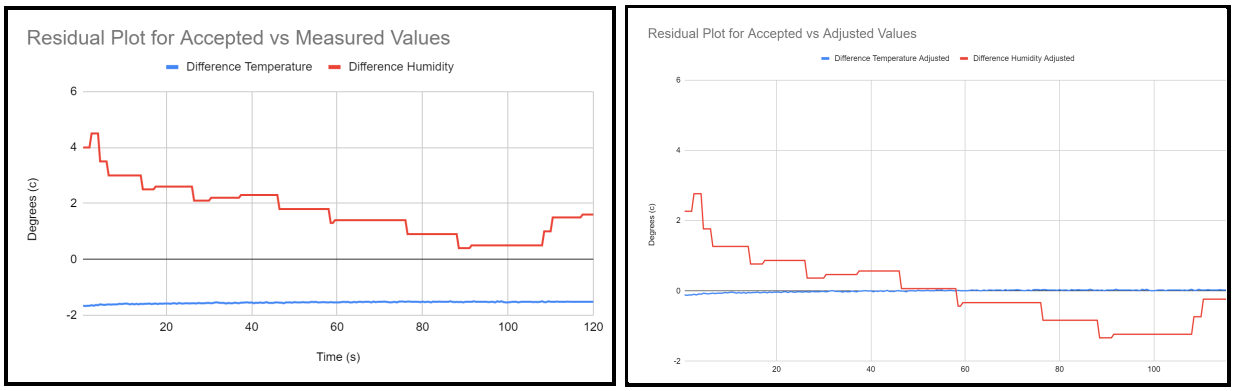

Figure 16 - Testing and residual plots for climate sensor average testing

The second test conducted in the creation of the product was measured at what shake frequency different count variables (the number of non-zero changes in acceleration out of ten readings over the course of 5 seconds) changed in the code triggered a violent shake. The desired frequency to trigger a shake was 120 BPM, because this was a moderate value. Triggering violent shakes at lower frequencies would cause more false alarms and triggering violent shakes at only higher frequencies would reduce sensitivity to the point where the module would become useless. This test was conducted by moving the sensor back and forth linearly along a 15 cm line and moving the sensor around a circle with a diameter of 15 cm. Once the test has been conducted the values can be plotted as shown in the figure and the ideal count value can be chosen based on your specific needs or our recommendations of triggering at 120 BPM. To implement this change simply change the count variable to your desired value in the code and re-upload the code.

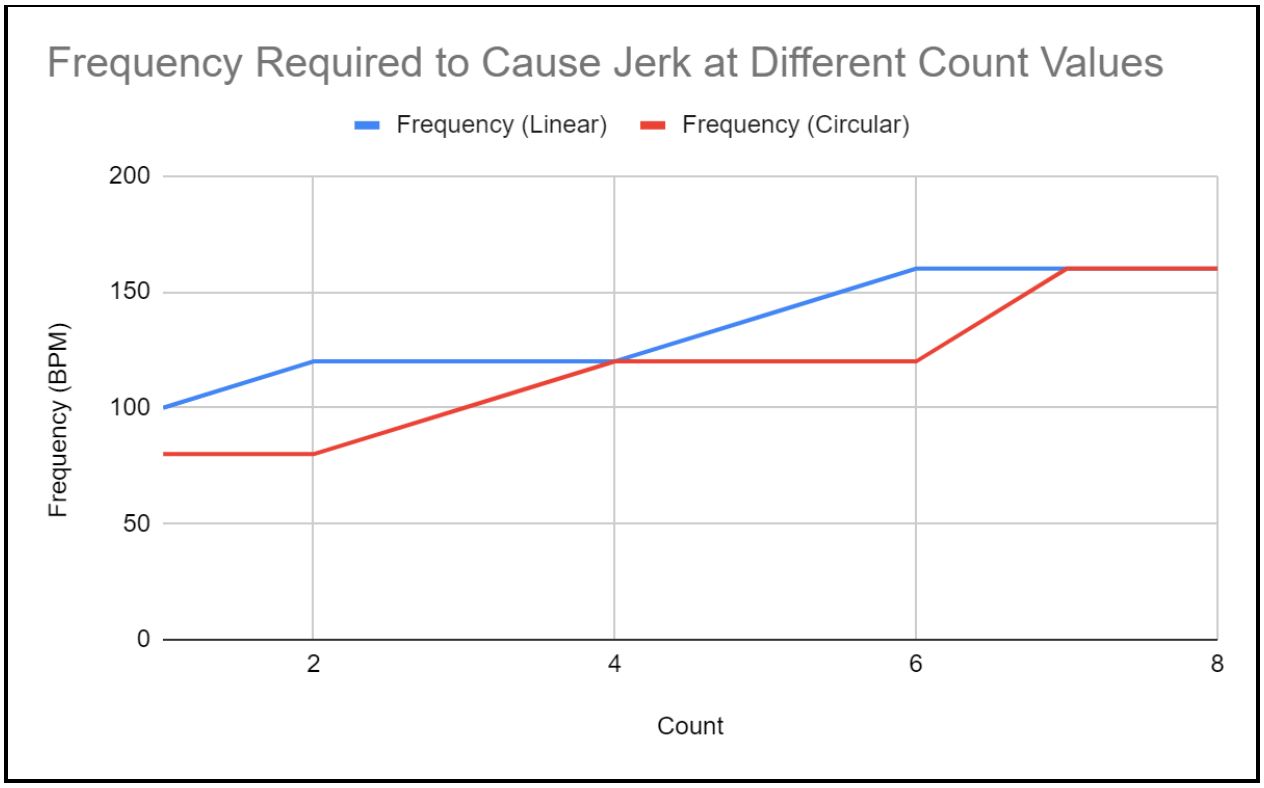

Figure 17 - Frequency testing for speaker component based on variable counts

The third test conducted was comparing the measured volume of the different speaker configurations at different distances. The values were then plotted and the best configuration was chosen based on the highest volume and how well the sound carried at a distance. The 5V with NPN transistor configuration was chosen for our application since it is loudest at any range. If power consumption is a concern for your application, consider reducing the voltage from 5.5V to 3.3V since there is only a small decrease in volume. To recreate this test simply download the following app Link and record the peak volume at each distance with each configuration while using the *audioplayback.ino* testing file provided. Plot these values using your preferred software with the volume on the y-axis and distance on the x-axis and choose the product which best suits your applications.

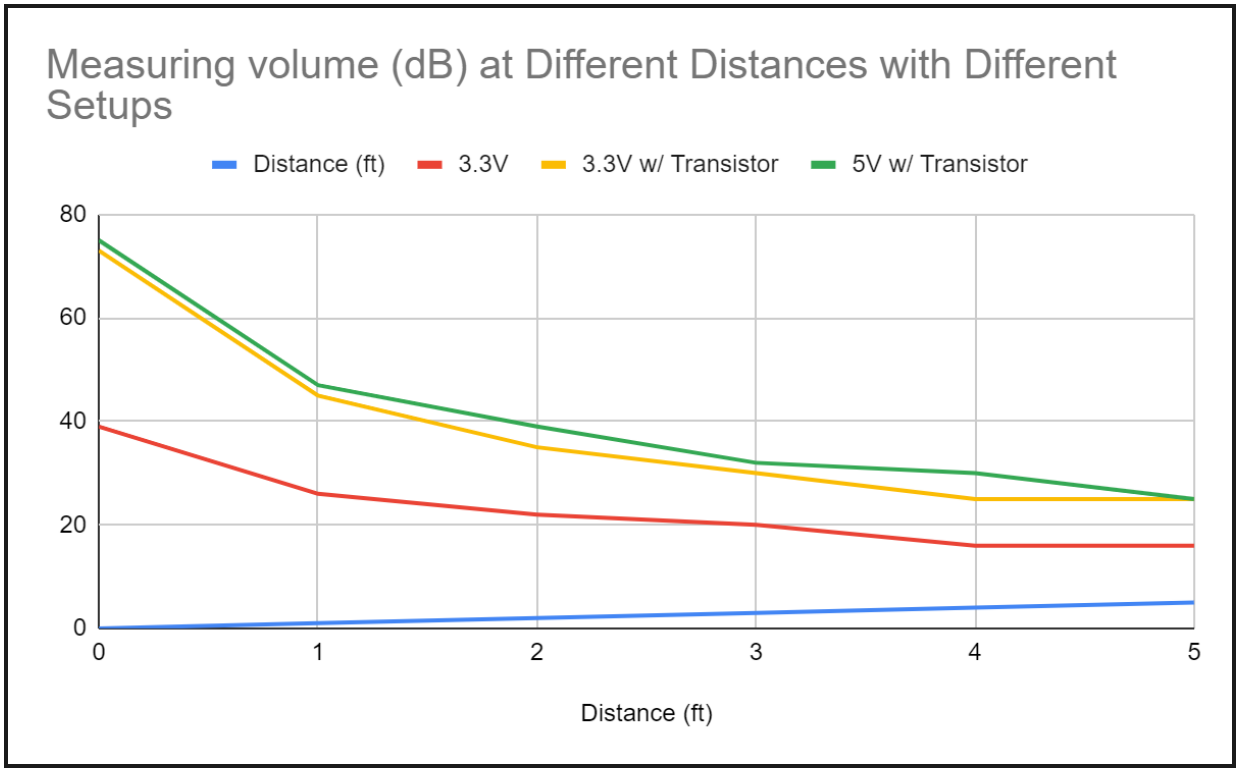

Figure 18 - Volume testing for speaker module as a function of distance

7 Conclusions and Recommendations for Future Work

Over the course of the past few months, the Sixth Sense learned many lessons in the course of the creation of this All-in-One module. Lessons in being thorough with work, in teamwork and communication, and in the relative availability of cheap, and yet precise components. The group learned of the importance of time management, and through the addition of more subsystems the Sixth Sense learned to use time efficiently in order to maximize the capabilities of the drone. Work was not rushed on any component or subsystem, but rather an efficient testing, prototyping, benchmarking and research of the components that were needed by the group led to having the ability to add as many components and subsystems to the module as possible, hence the All-in-One name.

In as much as the future holds, there are many possible ways to improve on the module that has been designed. Initially, the group considered the possibility of using a camera to keep track of the food

that is being delivered. Although the initial client of the group dissuaded the Sixth Sense from following this path, it is a promising path for those that have the time and means, and the addition of a camera to this All-in-One module can truly make a difference and increase the quality of any modules based on this one. It allows for the possibility to monitor the beacon and the food inside, which would be very convenient and useful. A camera would also provide in real-time a second vantage point for any operator or pilot of the drone that is being flown, offering them an additional sense of security while flying and affording them an extra point of view to detect any potential hazards.

In addition to a camera, another optimization would be a retracting module for the sensor. This was also an idea that the group initially chose to follow, but was later dissuaded to do so by JAMZ, the initial client. The addition of a retractable arm to the All-in-One module would be the finishing touch on any module similar to this one, as the ability to retract the sensors from their vantage point under the food would serve to solidify the module as a whole, and ensure that when not being used to measure the temperature conditions around the food it is secure and in one piece. This would be a useful part for when a drone is flying back from delivering food, and there is no food to be surveyed.

If given a few more months the Sixth Sense would certainly go after and attempt to solve the issues that have just been laid out above, as these were both key in the initial ideation phase. Although the group managed to successfully integrate every major concern that JAMZ asked for in the beginning, these last two improvements would most likely be the group's main focus. Regardless, even if there are still areas where the group feels it could improve the module, on the whole, the Sixth Sense remains very proud of the creation of the All-in-One module, and are proud to submit it as a testament to the work that was put in over the course of the past three months.

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- https://randomnerdtutorials.com/9-arduino-compatible-temperature-sensors-for-your-electronics-projects/
- https://wonderfulengineering.com/10-best-arduino-cameras/
-
- Camera:
- https://www.arducam.com/product/arducam-5mp-plus-spi-cam-arduino-ov5642/
- https://www.robotshop.com/ca/en/charmed-labs-pixy-2-cmucam5-image-sensor.html
- https://www.sainsmart.com/products/5mp-ir-cut-infrared-light-surveillance-camera-module-for-raspberry-pi
- https://www.waveshare.com/ov9655-camera-board.htm
- https://www.amazon.ca/Arducam-Module-Megapixels-Arduino-Mega2560/dp/B012UXNDOY
-
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- https://www.sparkfun.com/products/245
- https://www.amazon.ca/365buying-DS18B20-Digital-Temperature-Sensor/dp/B007STHA22/ref=sr_1_24?crid=20UT0XH6IJ020&dchild=1&keywords=ds18b20+temperature+sensor&qid=1612472178&s=electronics&sprefix=ds18b20%2Celectronics%2C166&sr=1-24
- https://www.digikey.ca/en/products/detail/texas-instruments/LM35DMX-NOPB/334900?s=N4IgjCBcoLQBxVAYygMwIYBsDOBTANCAPZQDaIATAJwBsIAugL6OEVkgAyAsgMwCsAES4ANAPQA5APIAFAEINGQA
- https://www.digikey.com/catalog/en/partgroup/lm35/11023
- https://www.sparkfun.com/products/10988#reviews
- https://www.sparkfun.com/products/14049
- https://github.com/milesburton/Arduino-Temperature-Control-Library/blob/master/README.md

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- https://www.robotshop.com/ca/en/3v-hobby-motor-6600-rpm-gear.html?gclid=Cj0KCQiA0-6ABhDMARIsAFVdQv8rIVJLWCObZ2YEhd2uIt0T33feI6K9Mq6DyBzY_OMpaa
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-
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- https://www.youtube.com/watch?v=ynNeiFEJnrA
- https://www.ti.com/lit/ds/symlink/hdc1080.pdf?ts=1612440079920&ref_url=https%253A%252F%252Fwww.google.com%252F
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APPENDICES

9 APPENDIX I: Design Files

Table 5. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
MakerRepo	https://makerepo.com/lucas11s/806.the-sixth-sense-all-in-one-module	April 11, 2021
Case Housing Files	https://drive.google.com/drive/folders/1lTJk_iQEg9-lUZtDDVmCAjQ6eSF-G6Zc?usp=sharing	April 11, 2021
Speaker testing spreadsheet	https://docs.google.com/spreadsheets/d/1nz6vc3U-zzPhtQU0ABapmfnJlGZjAILhaRV3lhFE6qI/edit?usp=sharing	April 11, 2021
Climate Sensor spreadsheet	https://docs.google.com/spreadsheets/d/1nz6vc3U-zzPhtQU0ABapmfnJlGZjAILhaRV3lhFE6qI/edit?usp=sharing	April 11, 2021

Coding Files	https://github.com/rakshita003/Group15-code	April 11, 2021

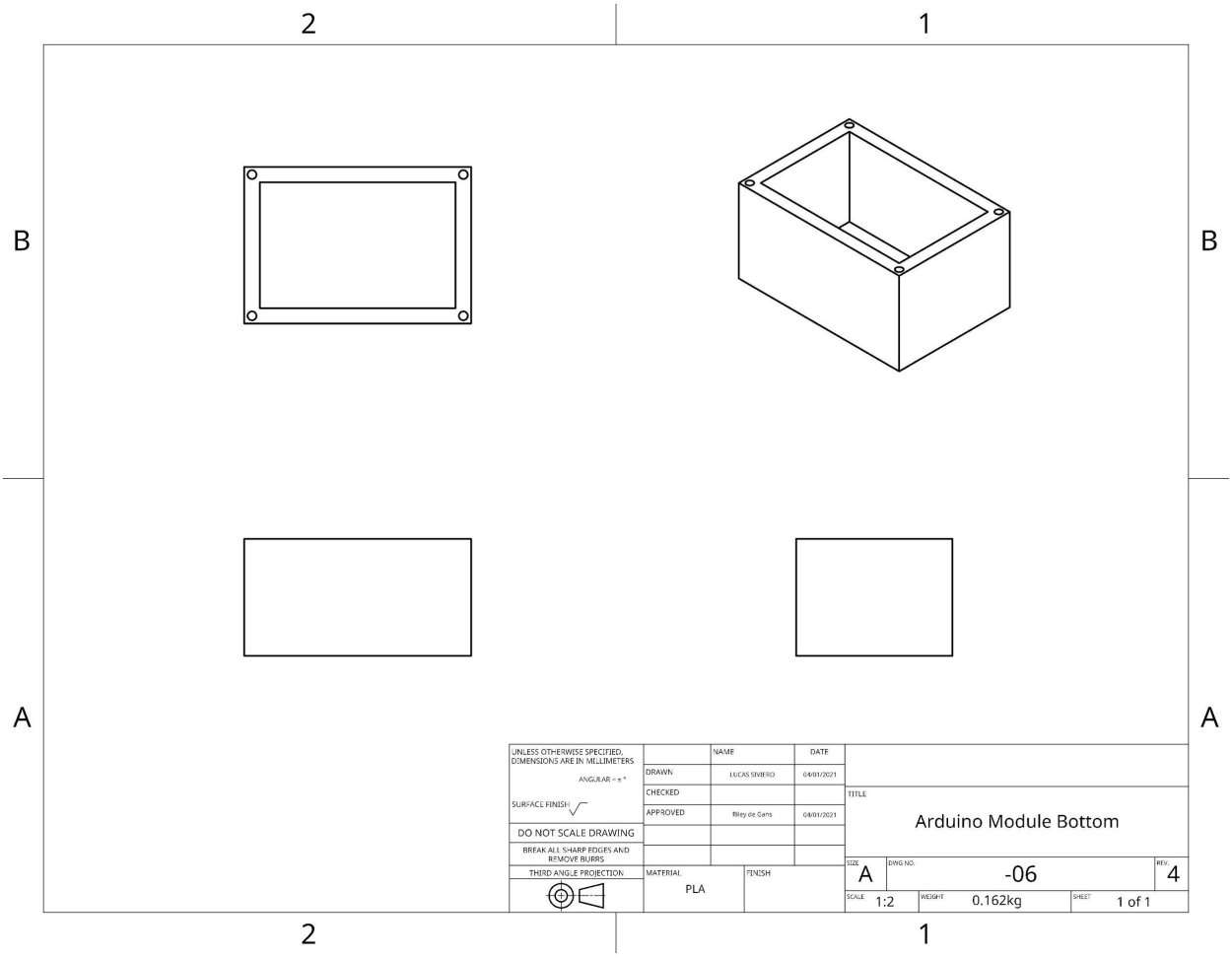


Figure 19 - Additional Sketches

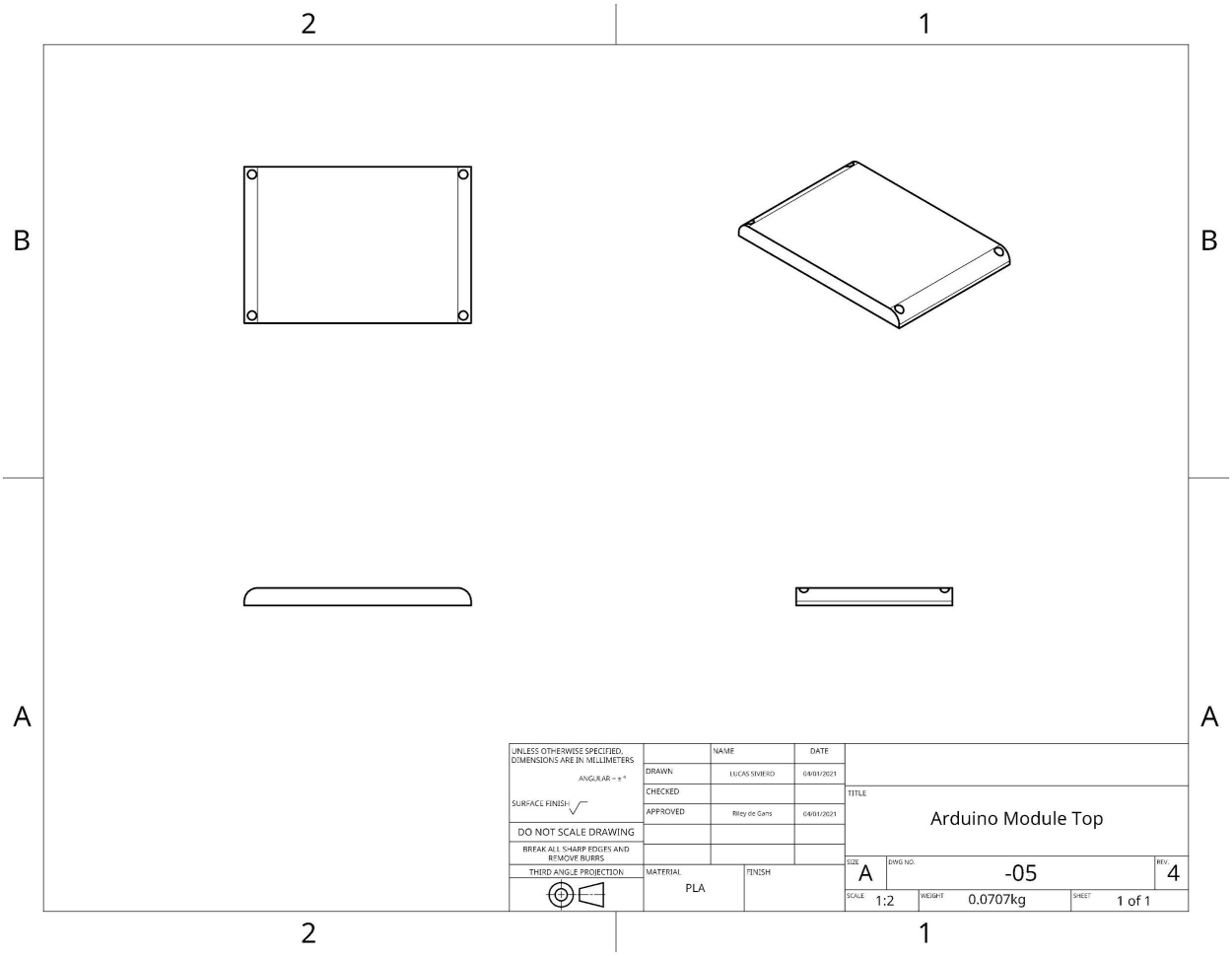


Figure 20 - Additional Sketches

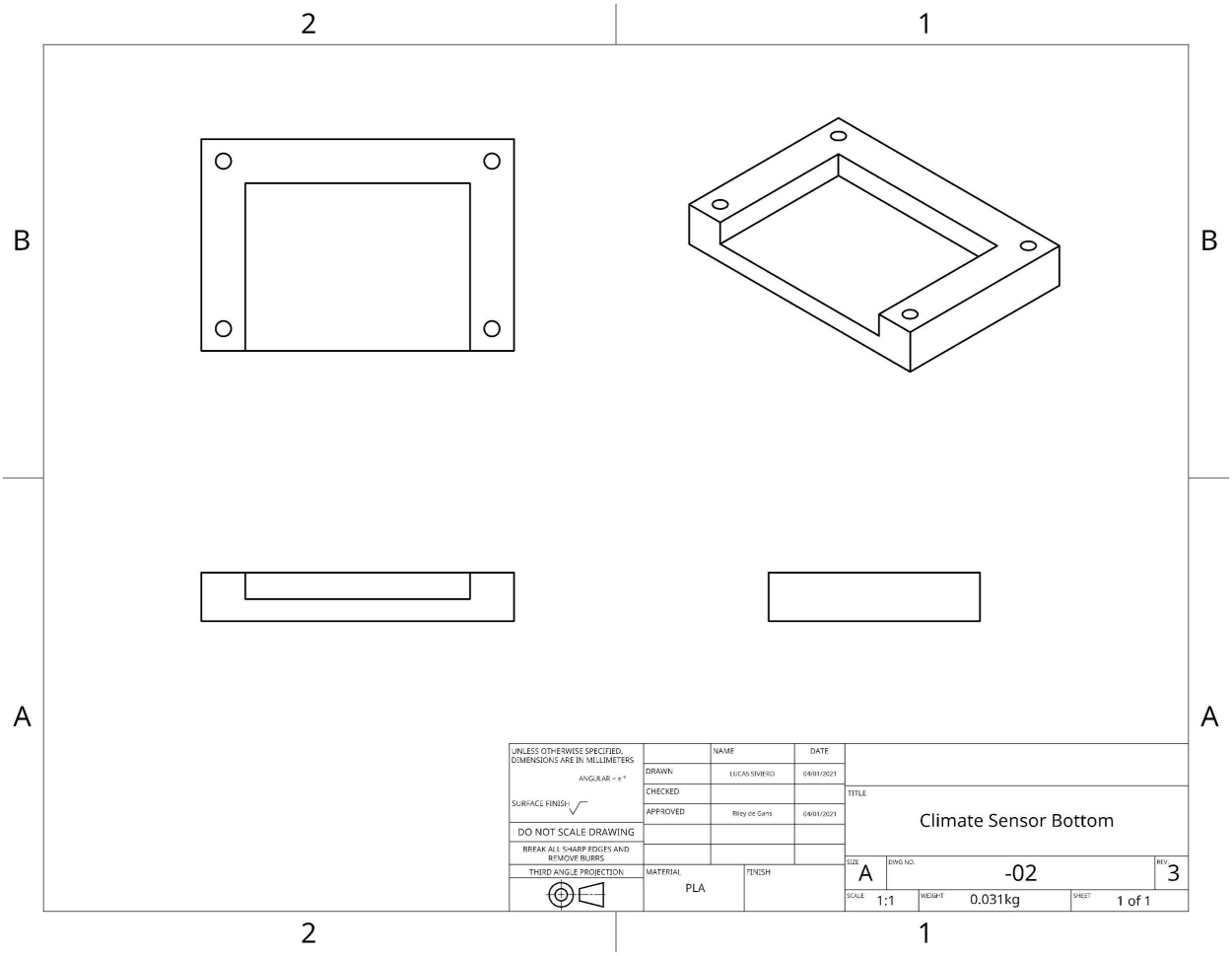


Figure 21 - Additional Sketches

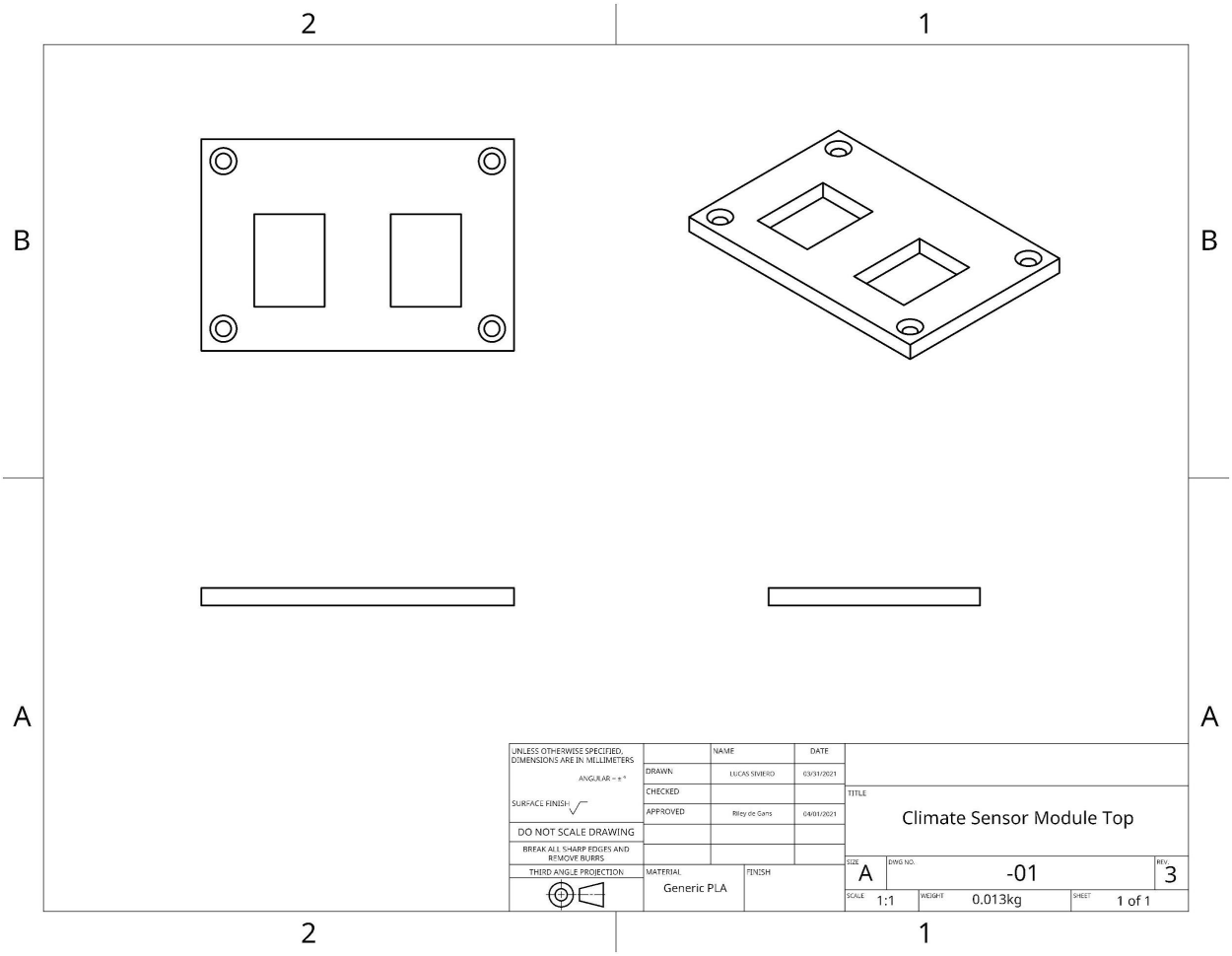
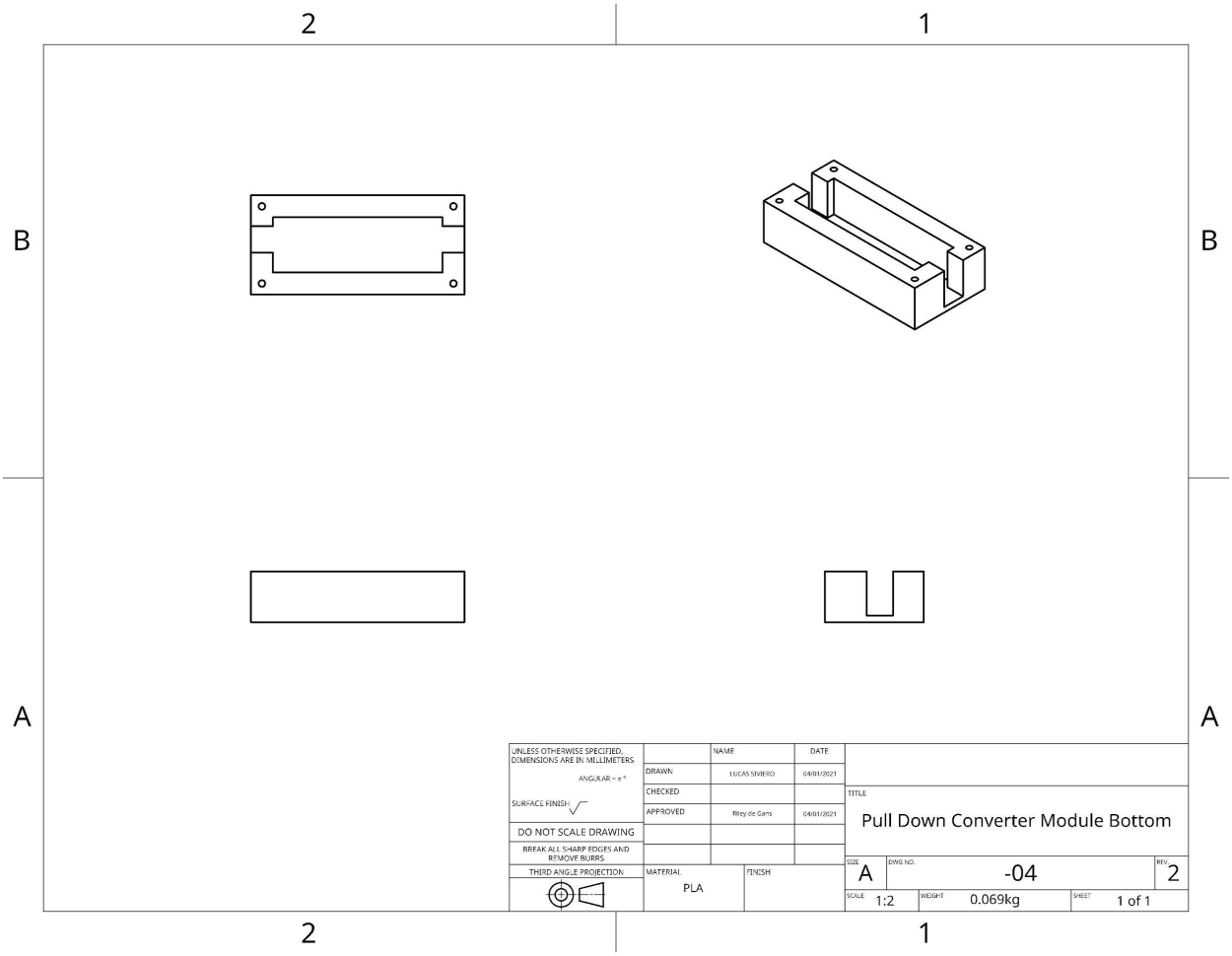


Figure 22 - Additional Sketches



UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS ANGULAR ± ° SURFACE FINISH √ DO NOT SCALE DRAWING BREAK ALL SHARP EDGES AND REMOVE BURRS THIRD ANGLE PROJECTION		NAME	DATE
	DRAWN	LUCAS SIVIERO	04/01/2021
	CHECKED		
	APPROVED	Riley de Gans	04/01/2021
MATERIAL: PLA	FINISH		

TITLE: Pull Down Converter Module Bottom

SIZE	DWG NO.	REV
A	-04	2
SCALE 1:2	WEIGHT 0.069kg	SHEET 1 of 1

Figure 23 - Additional Sketches

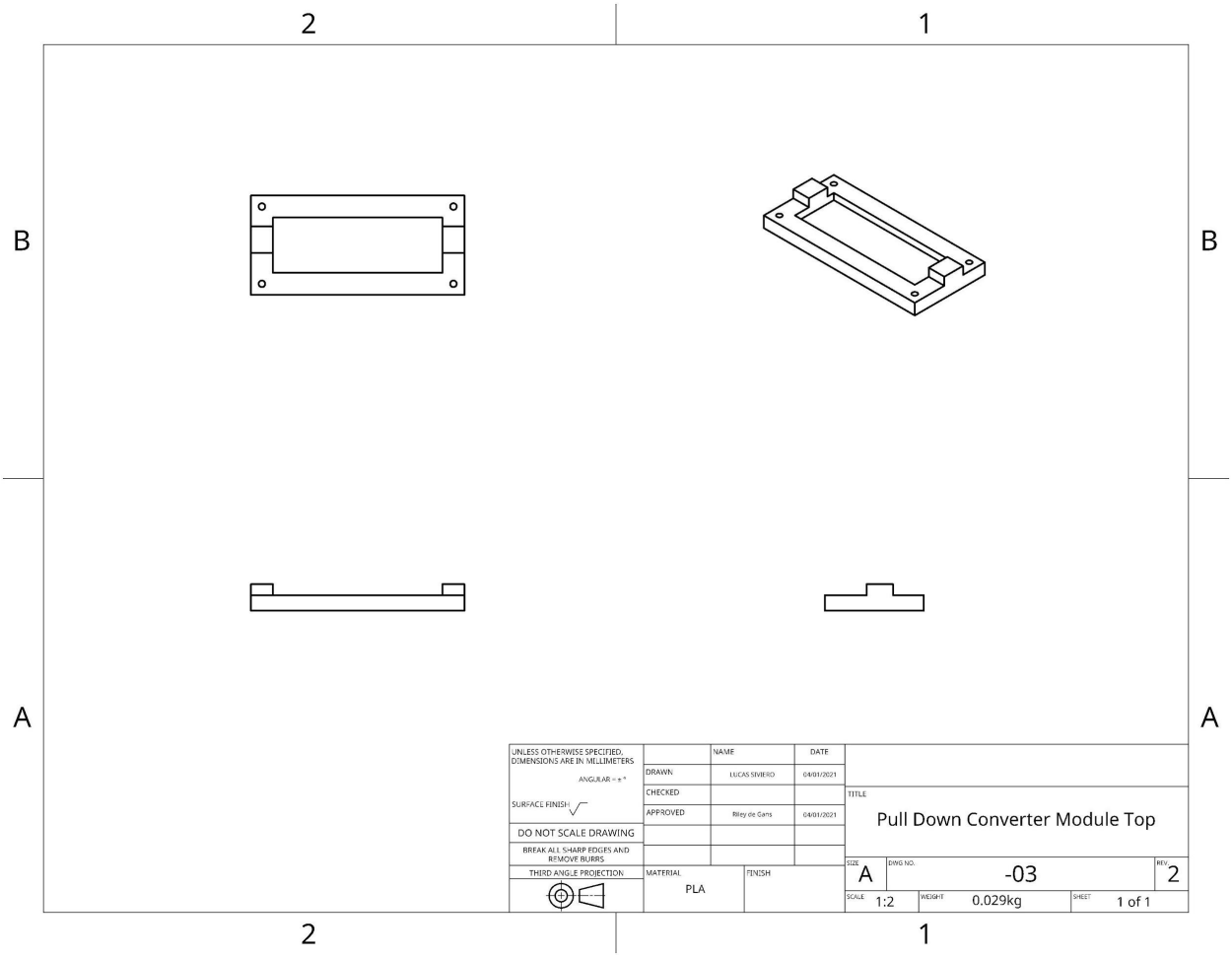


Figure 24 - Additional Sketches

9 APPENDIX II: Other Appendices

9.1 Emergency Beacon Colour Wheel

Figure 25 - Colour Wheel
Blue: Temperature out-of-range
Red: Violent shake
Yellow: Humidity out-of-range
Green: Temperature and humidity out-of-range
Purple: Violent shake and out-of-range temperature
Orange: Violent shake and out-of-range humidity
White: Violent shake, out-of-range temperature and humidity