ASCEND! Fall 2022 Report

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Abstract

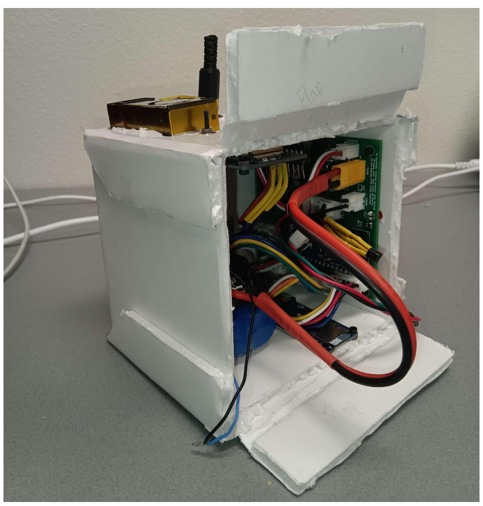
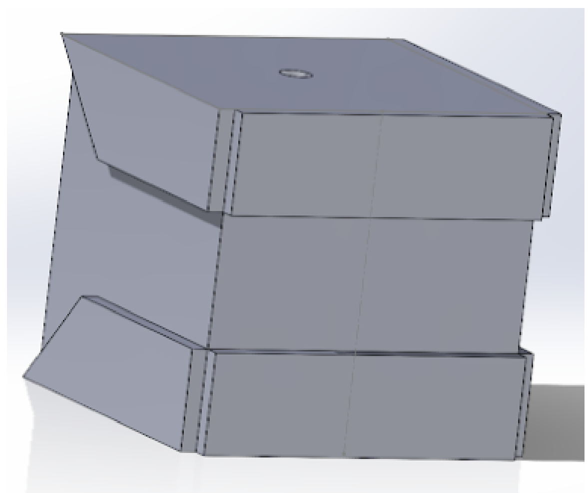
The purpose of this project was to find a way to measure pressure, temperature, humidity, VOC over time and altitude changes. Stratodevils created a payload where they would have to utilize different devices to ensure that data could be recorded, tested and durable, the payload was retrievable, and the system could be monitored. Overall, the mission was successful with the exception of the VOC which did not collect usable data. This did not hinder the meteorological science mission however since that sensor was not initially part of the mission's plan. The electrical team was able to make a reusable design for the ASCEND PCB. The mechanical team experimented with different materials and designs for the payload structure however eventually a 1U CubeSat inspired design was created, tested and launched. The programming team was able to create a small database for the ascend data, and through the use of Arduino and Python scripts program and analyze the data.

Background

The ASCEND program has grown over the past semester but its mission has remained the same – to teach students about high altitude balloon flight and conduct different science experiments proposed by said students. This semester, over 20 students participated in the program and 4 different science missions were proposed. For more information on the other science mission check the corresponding section in this report. One main science mission was decided on and that was Meteorology. Its purpose was to measure various weather data and increase our understanding of the formation of Cloud Condensation Nuclei (CCNs). The significance of measuring different weather parameters like pressure and temperature when altitude changes can have strong effects on technology and organisms, hence its importance for student understanding. Hardware uses and effectiveness can be drastically changed as temperature does.

Aerospace engineers need to ensure that the devices they are designing can withstand low pressure and temperatures and the electrical engineers ensure that the component can have power and withstand any environmental issues. The mechanical team must create a design that works with the electrical schematics, the aerodynamic design and is withable to withstand collision of approximately Gs of force.

Mechanical Design

A. About

Our mechanical design is based off of a 1U cubesat design with overlaying flaps to provide additional support made with styrofoam.

B. Features

The design comes with a hole for the lamp rod attachment, a plug and a VOC hole as it is needed to detect outside the payload construction. The PCB is side mounted, allowing multiple cords of varying length to reach their destinations and not being obstructed by the lamprod.

C. Problems

Carbon Fiber was the original material we wanted to use; however, due to our recent partnership with SDSL, our budget and parts were delayed. We received the needed parts for our carbon fiber project a month before launch, meaning we had no time to test the material designing process and could not pursue it as an option.

Aluminum Machining was the second option we attempted however the metal sheets were not able to be cut in time. Finding and accessing a CNC machine was the limiting factor in being able to machine the parts.

D. Solutions

Foam board was used as the third and final option for the creation of the payload housing. This is a material that ASCEND has mastery over and were able to create a prototype and the actual housing within a day. This also gave us time to test the design.

Electrical Design

Printed Circuit Board (PCB)

E. About

The objective was to design an universal ASCEND! printed circuit board (PCB) that would be outfitted with commonly used devices with the ability to add different sensors. The PCB would ideally have analog sensors that would be capable of mapping the entire extremes of previously flown ASCEND! payloads. The PCB uses a common pin pitch of 2.54mm.

A generic, 2-cell 18650 2000 mAh battery pack; one that could be found on Amazon without a serial number. There was not a persistent concern with using this battery since most 18650 cells can output more than 1 A and can have a wide temperature range - making them a go-to battery type. A separate power supply equipment was used to determine that the sensor board consumes an average of 150 mA. With the present power parameters, the board is expected to operate for more than 8 hours.

An XT30 battery connector was used as a way to distinguish the power port and the specific connector can handle more current if needed than compared to a smaller JST connector. Historically, an ASCEND! Payload experiences around ~9 G's of acceleration. 2.54mm JST connectors & headers have a greater chance of staying connected than regular Dupont connectors. A JST connector allows pinout configuration because the crimped female pins can be configured in a certain order.

There was an idea to use a Li-Ion battery to power both the sensor board and unfinished ADCS board. A simple 2-to-1 splitter cable with fuses was created to be able to power both boards with only one battery. The only issue with this method is power consumption since both boards would rely on the battery for proper supply. The ADCS power consumption may have to be limited to reserve some power for the components board. A huge voltage drop would reset the boards.

KiCAD was used to design the PCB and JLCPCB was the manufacturer.

F. Features

The Printed Circuit Board was centered around an Arduino Every microcontroller based on the ATMega4809 processor. The board can handle an input voltage from 2V to 36V due to the different voltage regulation on board. Several solder jumpers were outfitted on the board which allows configurable power regulation.

An I2C multiplexer was added to the board in the case that two addresses would overlap each other.

Analog Sensors

G. About

At the middle of the ongoing semester, it was decided that the electrical team would attempt to achieve more sensitive analog sensors in order to better map the environment. A Resistance Temperature Detector (RTD), essentially a thermistor, would be capable of detecting temperatures as low as -100 celsius. This would be an improvement from the TMP36 which can detect as low as -40 °C. Additionally, a capacitive humidity sensor was obtained with increasing sensitivity compared to the current sensor.

H. Problems

Material from archived science lab work from the internet was used as references since they closely resemble the team's scenario. It described the use of a differential operational amplifier to detect the voltage difference between a reference voltage and the output voltage of the RTD.

I. Solutions

Unfortunately, the electrical team was not able to complete the analog sensors this semester. We aim to complete it for the upcoming semester.

Programming

J. About

As the purpose of the project was to obtain and analyze data collected from various sensors, the goal of programming was to implement each subsystem's drivers into the payload and ensure that each sensor's code was functional. Members of the programming team were divided and split to work closely with each subsystem. In addition, programming created a website through weebly (https://asuascend.weebly.com/) in which past, current, and future teams document and communicate their findings.

Our science mission was to create a database with the flight information utilizing mongoDB. However after several discussions within the team, we concluded that MongoDB was not the appropriate software for our database. MongoDB is meant for relational and non-relational databases, where different sets of data relate to one another where states and attributes are affected by the data of a related database. In our case, we have one CSV file that contains all of our information.

Using the CSV file containing the data recorded from the flight we created some graphs and maps to visualize the data using python. We used the python library Plotly to graph the temperature data over time and plot the gps and altitude data over a map.

K. Features

Code for the sensors was done within Arduino IDE. Any conversions of units if needed were done with Python. Github was utilized slightly for organization, but is something that should be extensively used for following semesters. All data was saved with SD card modules.

For the Meteorology mission, sensors should output Latitude, Longitude, Altitude, Internal/External Temperature, Relative Humidity. New GPS hardware required implementation of new libraries that are compatible. RX/TX pins used to be RX-RX and TX-TX, but with the Arduino Nano Every and the new GPS sensor it was connected RX-TX and TX-RX. New library used for the GPS sensor was called TinyGPS.

L. Problems

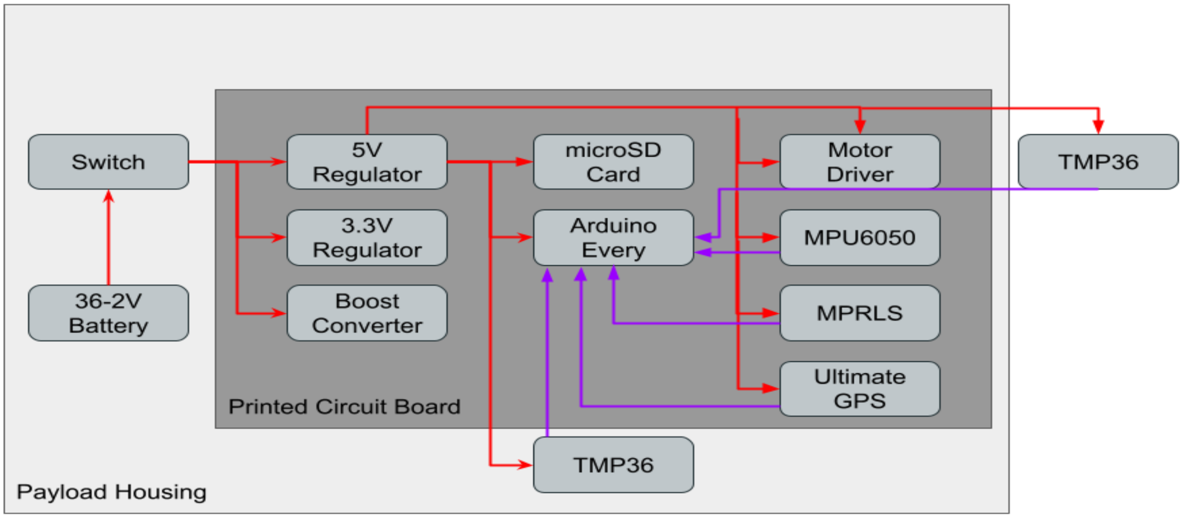
For the Meteorology mission, originally, Sparkfun Ublox library was used for the GPS sensor. However, when implementing within the main code file, there proved to be an issue with memory. The library was extremely massive, and even using the library on its own without implementing anything else took about 80% of the available memory.

M. Solutions

For the Meteorology mission, we had attempted to cut down the sparkfun library and construct a new library with only the functions that were required, but this proved to be difficult as there was a massive amount of code to parse through. We had also thought about just allocating additional memory through the use of another Arduino, but then stumbled upon a smaller and more compact library for GPS called TinyGPS. There were issues at first getting the GPS to read the data we needed, but after some adjustments all data was getting recorded correctly.

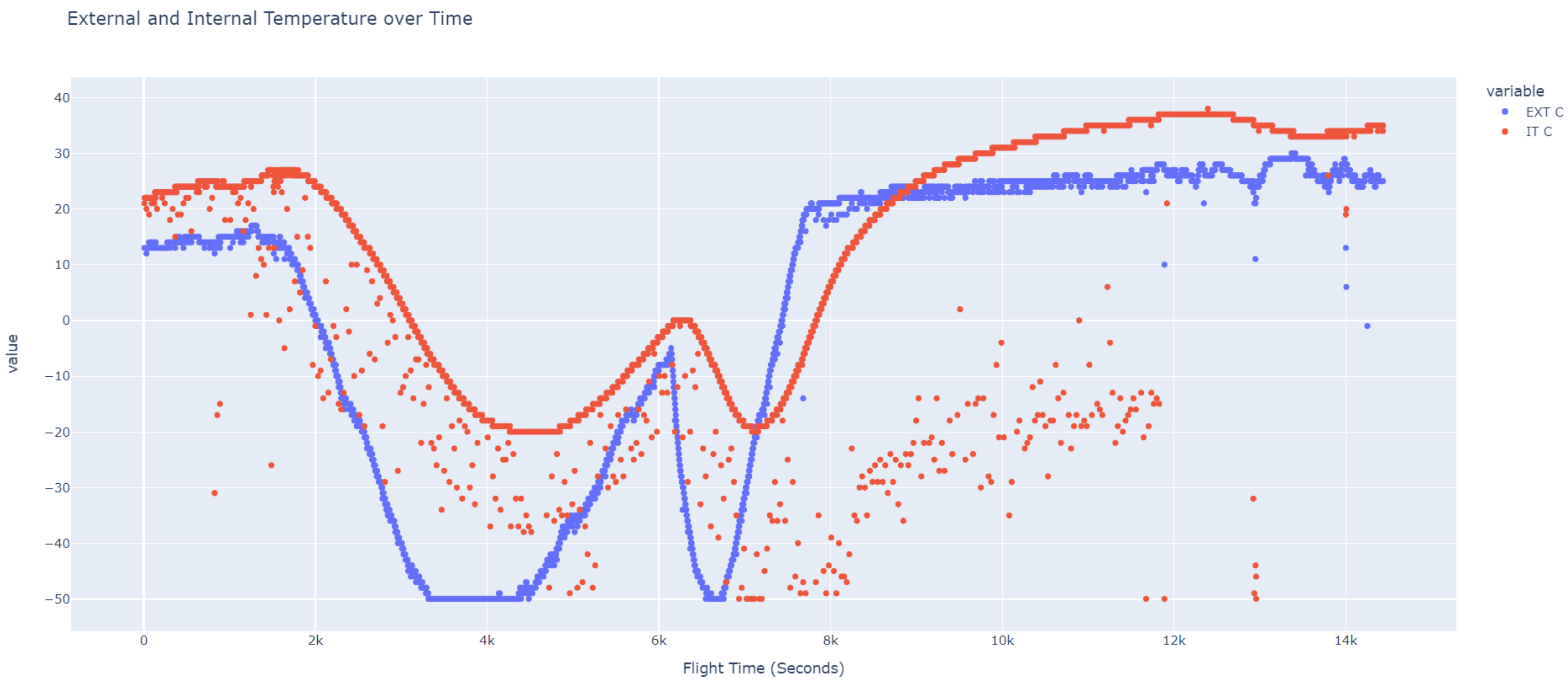
Meteorology Sensors

System Block Diagram of the Meteorology Science Mission



Switch
36-2V
Battery
5V
Regulator
3.3V
Regulator
Boost
Converter
microSD
Card
Arduino
Every
Motor
Driver
MPU6050
MPRLS
Ultimate
GPS
TMP36
TMP36
Printed Circuit Board
Payload Housing

Data Analysis



https://asu-ascend.github.io/ascendEXTandINT/

Flight Path of the balloon, see deeper analysis from the link.

https://spooked321.github.io/ascendTEST/

Future Science Mission

1. ADCS

    The Attitude Determination and Control System (ADSC) has been attempted two semesters for ASCEND but been unsuccessful. This science mission goal is to be able to determine the location of the payload and using a system of motors, stabilize the payloads readings or camera.

    Proposed by Ben Webber.

2. Plant Module:

    This is a new science mission where multiple seeds of a plant are housed in the payload in different conditions. One without any shielding, one with shielding and one group does not fly as a control. After retrieval of the payload they would be planted and accessed.

    Proposed by Genevieve Cooper.

3. CubeSat

Sources

For more information check our website: http://asuascend.weebly.com