Critical Design Review
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Measure the resistivity of air in northeastern Colorado at altitude

- All materials have a conductivity, $\sigma$, (and thus resistivity, $\rho = 1/\sigma$), which can be described as the material’s ability to conduct electricity. We are trying to measure the conductivity of the air. Current is the amount of charge that passes through a circuit divided by the time for that to occur. We will be using a battery of voltage $V$ to send a current $I$ through 1cm of air using a leaky capacitor design (area $A \sim 0.5m^2$). The measurement of the current, on the order of 100’s of picoamperes (fractions of a nanoampere), will be measured with a transimpedance amplifier and recorded with an A-D converter. The conductivity is $\sigma = (I/A)/V$.

- Resistivity has been measured in air at various altitudes, but vary tremendously. Values as low as $5 \times 10^{11} \, \Omega \cdot m$ have been reported at 100,000 ft altitude (Mozer and Serlin 1969) to as high as $5 \times 10^{14} \, \Omega \cdot m$ (Retalis, Pitta, and Psallidas, 1991). Most papers indicate that the resistivity drops with increasing altitude, which is one piece of information we want to verify. By doing more measurements, we hope to add to the pool of data, thus decreasing the variability of values at all altitudes up to 100,000 ft.
Previous experiments have measured the conductivity of the air at various altitudes, locations, and atmospheric conditions. Between 1884-7, Sir Francis Ronalds measured the atmospheric electric field near London using a lantern probe and straw electrometers. Ronalds’ s experiment did not measure atmospheric electrical conductivity specifically, but it triggered important subsequent experiments.

Air is highly resistive, so it is difficult to measure its electrical conductivity at all. Ronalds’ s ideas, however, inspired experiments that revealed a resistivity between 2 E-12 and 5E-16 ohms. Air resistivity was found to decrease with increasing altitude: “balloon ascents at the end of the nineteenth century and beginning of the twentieth century provided data on the vertical profiles of atmospheric electrical parameters, generally finding a decrease in the vertical electric field’ s magnitude with height” (Chauveau, 1925; Chalmers, 1967).

We also hope to discover the correlation between some atmospheric condition, such as temperature, humidity, or air density and the conductivity of the air.
### Example Mission Requirements Matrix

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Design</th>
<th>Test</th>
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<tbody>
<tr>
<td>The spacecraft must not exceed a weight of 1 kg.</td>
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<tr>
<td>The spacecraft’s center of gravity shall be within 0.25” of the central axis of the ICU and below, but within 10cm of the vertical axis center.</td>
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<td>The allowable static envelope of the spacecraft is a cylindrical right prism with a diameter of 18.7” (47.5 cm) and a height of 18.7” (47.5 cm).</td>
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<td>The voltage sources must provide constant output voltage, including the voltage multiplier circuit output.</td>
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<td>Transimpedance amplifier must reliably and repeatedly measure currents in the 100pA (0.1nA) to 3nA range.</td>
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<td>The spacecraft must be capable of meeting all mission objectives.</td>
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Concept of Operations

- Diagrams are an excellent way to convey the mechanics without cluttering a slide with lots of words.
  - Show events such as: launch, G-switch activation, first accelerometer activated, at apogee first accelerometer deactivated and secondary becomes active, etc, etc, etc.
- Although diagrams are nice, they are not required. A paragraph on operation would also be acceptable.
Functional Block Diagrams

- A Functional block diagram of the entire system should be presented here.
  - It is helpful to box individual subsystems to give reviewers a reference for future presented analysis.

- See examples on next few slides
Structural Drawing Examples
Circuit Schematics

Transimpedance Configuration
Subsystems Overview

- What subsystems do you have: power, C&DH, thermal, etc.
- What top level requirements do you have for each subsystem.
  - Make requirements as quantifiable as possible.
    - Power subsystem shall supply 2W to...
    - Power subsystem shall remain at or above 72 F at all times during the flight.
- Which requirements are design drivers?
- Where is data stored? Hobo
- Be sure to include sensor specifications
- Any states that your payload may have:
  - Active, Active/Safe, Idle…
- Major Components lists
  - Transimpedence amplifier (TIA) is made up of a 1 GΩ precision resistor plus a OP97 high-precision op amp, together with two voltage regulators (7805 and 7905), which provide constant +5V and -5V to the op amp. All electronic parts from Mouser
  - Air capacitor: 6 10cm x 40 cm sheets of foam-core, covered in aluminum foil, constructed with metal tape to final configuration. After electronics are mounted inside on velcro tabs, electronics with heater unit are covered with insulation.
Management AV

– Updated Organizational Chart
– Updated Schedule
– Updated mass/monetary budgets
Test Plans

- Structural integrity tests: swing test, stair test, and drop test were all performed on the mock up.
- Electronics tests: build and test three complete copies of the circuit so that rigorous cold test and shake test and calibrations can be performed, finally with the Hobo A-D converters. The result of the first test is shown:

Potential points of failure

Testing/Troubleshooting/Modifications/Re-Testing Schedule
Conclusion

– Issues and concerns
– Closing remarks
Appendix

– Information and drawings not essential to the presentation, but that could be useful for tough questions

  • Data sheets, 2D drawings, additional schematics/diagrams, any design analysis completed.