Microgravity Communications and Data Acquisition Team

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Microgravity Project
Introduction

• Providing NASA with a low-cost, reliable microgravity testing platform for CubeSats
• Design concept is to drop a vessel (pictured) from a high-altitude balloon and reach accelerations close to 9.8 m/s²
CONOPS

- Deploy balloon with vessel attached over the Shirley Basin
- Track vessel as it rises to 100,000 ft with two ground stations (one mobile and one fixed downrange)
- Send ARM and CUT command from ground stations once the vessel reaches altitude
- Store acceleration data of vessel for 20 seconds, then deploy parachutes
- Continue to track vessel through fall and after parachute deployment
Design Details
Functional Block Diagram

- FirstSensor
- Honeywell Pressure Sens.
- Adafruit GPS
- Max232
- PIC
- Cut-Away Power
- Solenoid 2&3
- Solenoid 1
- Personal Computer
- Inside Drop Module
- P900 Modem
- Ground
- Cut-Away Circuit
- P900 Modem
- MSP430
- Solenoid Control
Main Board PCB Layout
Cut-away

• Main goal
  – Separate the vessel from high-altitude balloon
  – Deploy parachute 20 seconds later

• Hardware
  – Two 5 VDC 2.62A solenoids, two bipolar junction transistors, and two 3.7 volt batteries, and one MSP430.

• How it works
  – MSP430 receives a digital “drop” command from PIC
  – MSP430 sets digital output high to actuate solenoid 1, dropping the vessel
  – MSP430 counts 20 seconds, then actuates solenoids 2, releasing the parachute
Cut-Away PCB Layout
PIC Software

- All code written in C and compiled with MPLAB’s XC-8 compiler (command line freeware)
- Pseudocode Explanation:
  - Set up digital and analog I/Os on the PIC
  - Set up UART
  - Set up timers and interrupts
  - Enter main loop:
    - Query instrumentation for GPS (UART), pressure (SPI), temperature (SPI) and acceleration (SPI) data
    - Load data into buffer and pass to modem
  - Incoming commands are interrupt-driven
    - “Cut” command drives a digital output high to kick the MSP430
Communication

- Point-to-Multipoint Configuration
- Master unit is in the vessel, two slave units are the ground stations
- 9600 Baud, 8 bit, no parity, 1 stop bit
- Reed-Solomon(15,11) FEC
- 30 dBm (1000mW) output power
  - Adjustable, 30dBm is maximum
Power Budget

- Instrumentation powered by three 2300 mAh, 3.7V Li-ion batteries, connected in series
- Cut-away powered by 2 1200 mAh, 3.7 Li-ion batteries, connected in series
- Estimate of 4 hours and 42 minutes of on-time, if no attempt is made to mitigate power consumption

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<th>Current (mA):</th>
<th>Supply Voltage (V):</th>
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Conclusions
Progress This Semester

- Hardware mounted to PCBs
- PDR with NASA in-progress (awaiting feedback)
- Voltage monitoring, accelerometers, pressure sensor, GPS, temperature sensor all functional
- Cut-away circuit prototyped
Successes and Failures

• Most desired functionality implemented
• Size and weight constraints met easily, room for further hardware

• Modem range not yet verified
• ARM and CUT commands not yet functional
• Vessel dynamics only characterized in two dimensions currently
• Temperature constraints not yet addressed
Lessons Learned

• Don’t try to reinvent the wheel- build on what’s been done
• Re-evaluate goals and timelines frequently
Questions?

Special Thanks to:
Victor Bershinsky, Course Instructor
George Janack, ECE Technician
Jerry Hamann, Faculty Support
Shane Cornell, Microgravity Testing Platform Project Manager
Project Justification

- CubeSats have a growing market in commercial, military, research and gov’t sectors
- Currently, approximately 50% of launched CubeSats fail in their mission, partially due to inadequate testing
- To reach launch, adequate TRL must be reached
Shirley Basin

- Equivalent population density of 37 people living in Rhode Island
Main Board Hardware

• Microhard P900 Modem (3)
  – Low cost ($79), small form factor (1.05”x1.3”x0.13”), lightweight (5 grams), 40 mile range (unverified)

• Adafruit Ultimate GPS
  – Low cost ($40), accessible (9600 baud, NMEA output)

• FirstSensor Accelerometer (2)
  – Large measurement range (±8g), low noise density (<20μg/√Hz), also measures temperature

• PIC18F46K22
  – 64 KB program memory, 2-UART, 2-SPI