2012 TEXAS ANNUAL CANSAT COMPETITION

Sensor Subsystem Design

Morris Blaustein

Sensor Subsystem Overview

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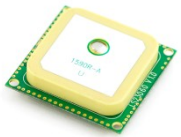
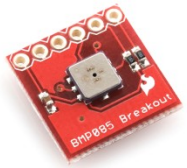
	Type	Model	Connection	Function
	GPS	Locosys LS20031	Digital	Records UTC time, latitude and longitude, mean sea level altitude, and number of satellites tracked.
	Altitude & Temp Sensor	Bosch BMP085	I²C Serial	Records altitude via non GPS and air temperature.
	Video Camera	808 Spy Camera	Digital	Records video of the lander release

- The GPS and video camera will be used in the Carrier.
- The BMP085 will be used in both the Carrier and the Lander.

Sensor Subsystem Requirements

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ID	Requirement	Rationale	Priority	Parent(s)	Child(ren)	Verification			
						A	I	T	D
S-01	Cansat shall transmit UTC time every two (2) seconds	Base Mission Requirement	High	SYS-04	None			X	X
S-02	Cansat shall transmit latitude and longitude every two (2) seconds	Base Mission Requirement	High	SYS-04	None			X	X
S-03	Cansat shall transmit number of satellites tracked every two (2) seconds	Base Mission Requirement	High	SYS-04	None			X	X
S-04	Cansat shall transmit altitude at accuracy of 2 m using sensor other than GPS every two (2) seconds	Base Mission Requirement	High	SYS-04	None	X		X	X
S-05	Cansat shall transmit air temperature in Celsius every two (2) seconds	Base Mission Requirement	High	SYS-04	None			X	X
S-06	Cansat shall transmit remaining battery voltage in volts every two (2) seconds	Base Mission Requirement	High	SYS-04	EPS-05	X		X	X
S-07	Video camera shall record rocket in flight beginning no more than two (2) seconds before lander release	Selectable Objective Requirement	Medium	SYS-09	None			X	X

Sensor Subsystem Requirements

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ID	Requirement	Rationale	Priority	Parent(s)	Child(ren)	Verification			
						A	I	T	D
S-08	Sensors must operate at 3.3V, 3.9V, or 5V	Cansat System regulates power at 3.3V, 3.9V, and 5V	High	EPS-01/02	None		X	X	
S-09	GPS Sensor shall withstand acceleration of the rocket	Able to transmit data following deployment	High	None	None		X	X	

Sensor Changes Since PDR

- Video camera timing controlled by Arduino

Carrier GPS Summary

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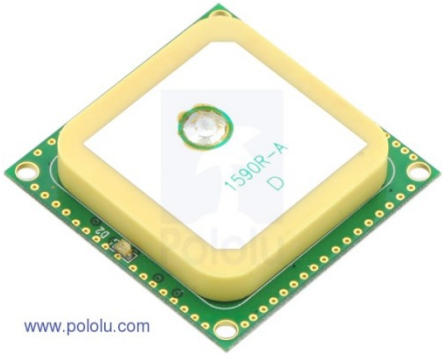
Device	Accuracy (m)	Operating Voltage (V)	Current (mA)	Weight (g)	Update Rate (Hz)	Cold/Hot Start (s)	Dimensions (mm)	**Cost ($)**
Locosys LS20031	2.5m	3.3V	41mA	14g	5Hz	35/2s	30x30mm	49.95



- Low current draw
- High accuracy
- Micro battery holds data for faster satellite acquisition
- 66 Channels
- TTL serial data

GGA Fixed Data Example

$GPGGA,053740.000,2503.6319,N,12136.0099,E, 1,08,1.1,63.8,M,15.2,M,,0000*64

GGA header UTC time Latitude N/S Longitude E/W #Satellites Altitude

Carrier Non-GPS Altitude/ Temperature Sensor Summary

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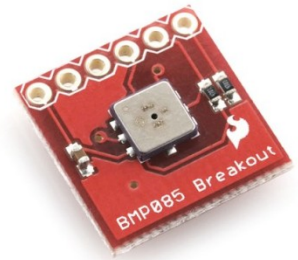
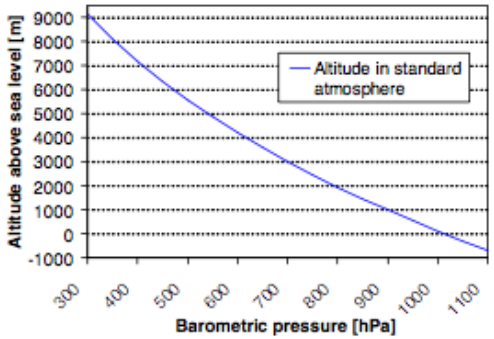
Device	Operating Voltage (V)	Range (kPa)	Current (µA)	Pressure Accuracy (hPa)	Temperature Accuracy (C)	Dimensions (mm)	Cost ($)
Bosch BMP085	1.8-3.6V	30kPa – 110kPa	0.1µA	1.5 hPa	2°C	16.5x16.5mm	19.95



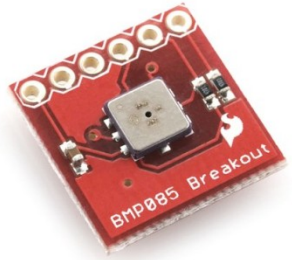
- Low power consumption
- Samples pressure and temperature
- I²C Interface



For pressure to altitude conversion

$$altitude = 44330 * (1 - (p/p_0)^{1/5.255})$$

Lander Non-GPS Altitude Sensor Summary



We will also be using the Bosch BMP085 for the Lander Non-GPS Altitude Sensor.

Carrier Video Camera Summary

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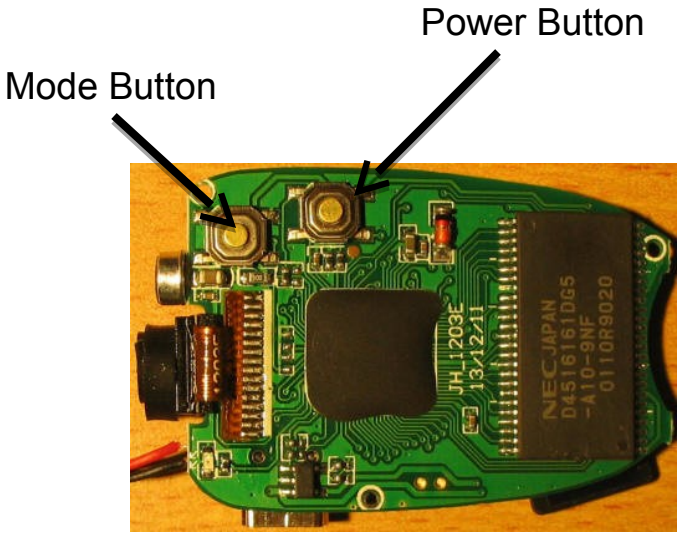
Device	Operating Voltage	Resolution **(pixels)**	Weight (g)	Frame Rate (FPS)	Format	Current **(mA)**	**Dimensions (mm)**	**Cost ($)**
808 Spy Camera	5V	720 x 480	8 g	30 FPS	M-JPEG	100-140mA	63x100 mm	14.26



- Low cost
- Light weight
- High video resolution
- Records via micro SD card
- Outer case and built-in lithium polymer battery were removed
- Video timing controlled by Arduino

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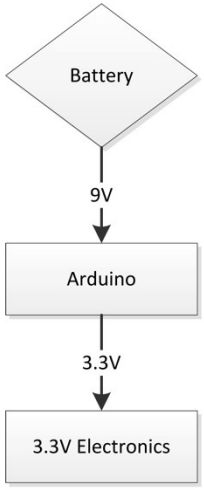
Electrical Power Subsystem Design

Morris Blaustein

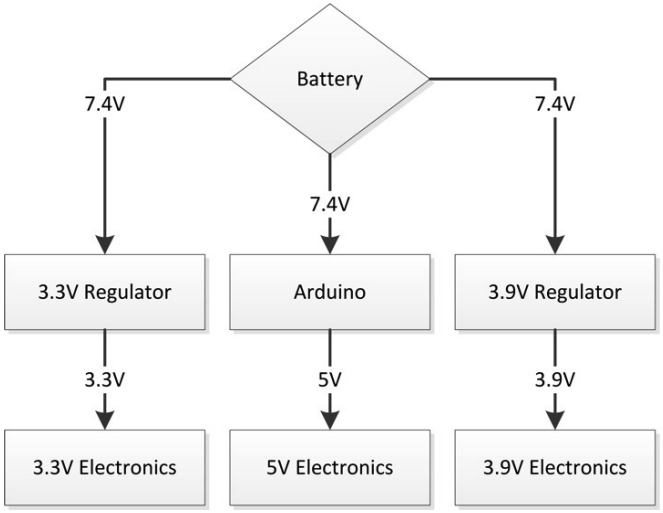
EPS Overview

	Model	Used For	**Voltage**	**Purpose**
Batteries	MH-9V250	Lander	9V	Supply power to Lander electronics
	Tenergy 14500	Carrier	7.4V	Supply power to Carrier electronics
	LIR2032	Lander/Carrier	10.6V	Supply power to the buzzers

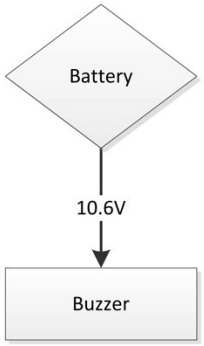
Lander



Carrier



Buzzers



EPS Changes Since PDR

- 9V battery for Lander
- 3.6V Button cell batteries for buzzers
- Added 3.9V regulator
  - Video camera runs at 3.9V, not 5V
- Transceiver powered through 3.3V regulator, not Arduino

EPS Requirements

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ID	Requirement	Rationale	Priority	Parent(s)	Child(ren)	Verification			
						A	I	T	D
EPS-01	Carrier battery shall output at least 5V	Arduino Uno requires 5V	High	CDH-11	S-08, EPS-03		X	X	
EPS-02	Lander battery shall output at least 5V	Arduino Nano requires 5V	High	CDH-12	S-08, EPS-03		X	X	
EPS-03	Battery shall have high enough capacity to last the duration of the flight and recovery (approximately 3 hours)	Must power the system	High	None	None	X	X	X	
EPS-04	Battery shall have sufficient marginal voltage	Compensate for voltage drop	High	EPS-01, EPS-02	None	X	X		
EPS-05	Battery shall be light weight	Keep the system under the weight maximum	Medium	SYS-01	None		X		
EPS-06	Remaining battery voltage shall be measured	Base Mission Requirement	High	S-06	None	X		X	
EPS-07	Carrier and Lander shall have external power switch	Base Mission Requirement/Safety/Convenience	High	SYS-05	None			X	X

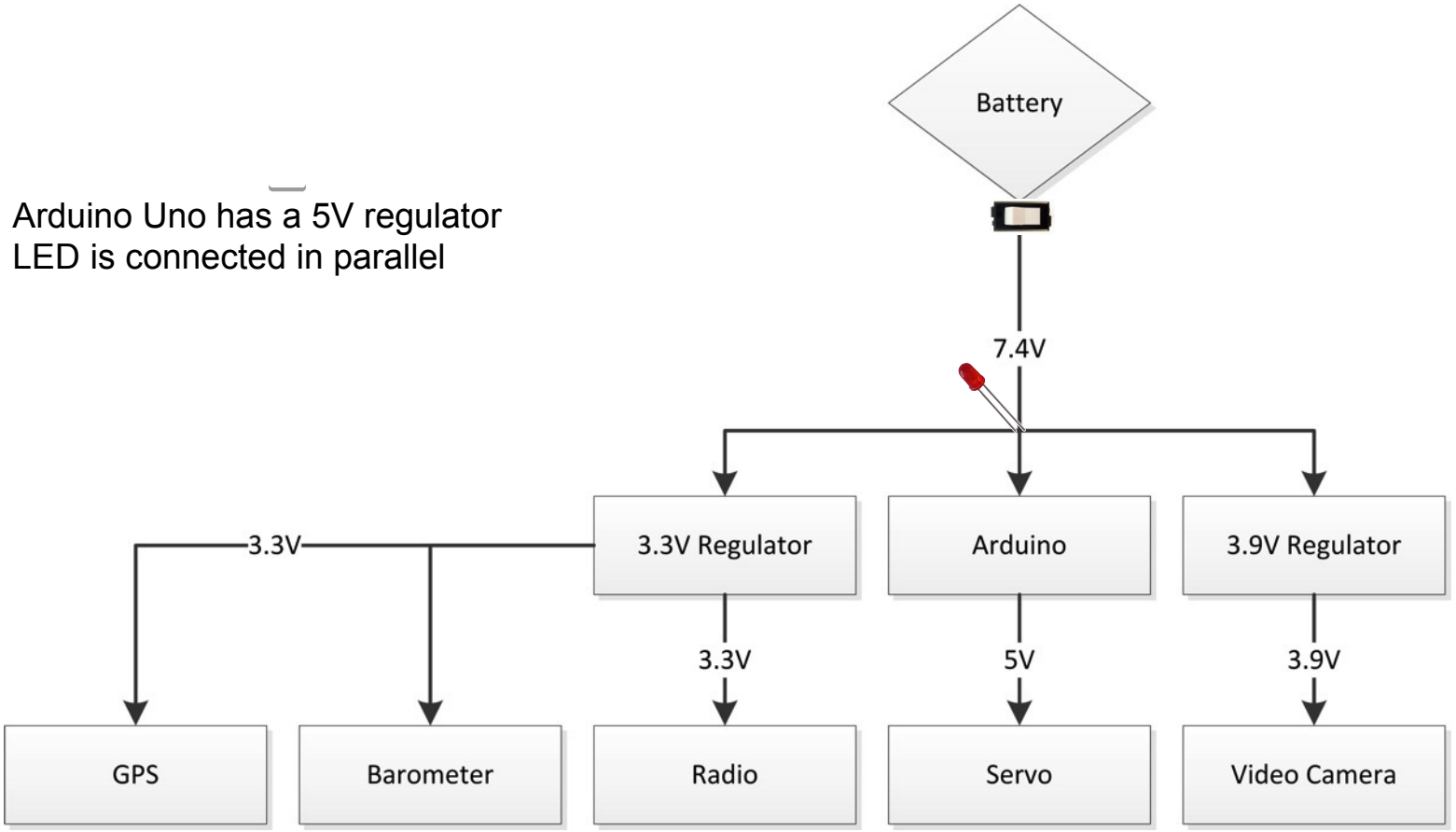
EPS Requirements

2012 Texas Annual CanSat Competition

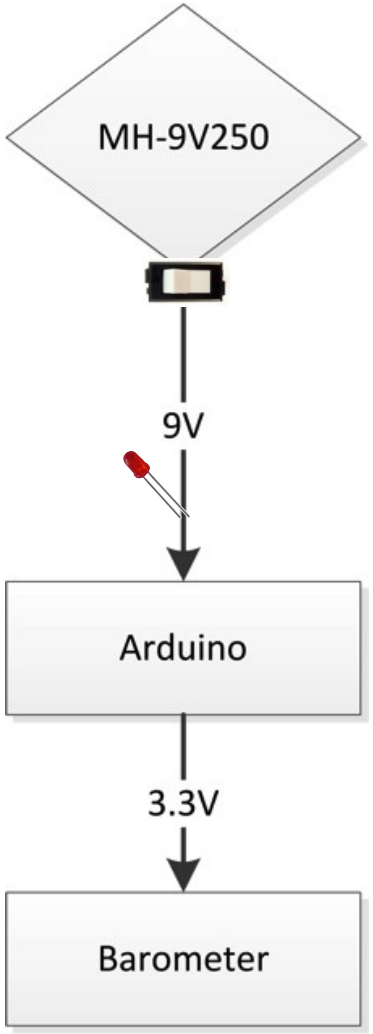
ID	Requirement	Rationale	Priority	Parent(s)	Child(ren)	Verification			
						A	I	T	D
EPS-08	Buzzers in Carrier and Lander shall have independent power source	Base Mission Requirement	High	S-06	None	X		X	X

Carrier Electrical Block Diagram

- Arduino Uno has a 5V regulator
- LED is connected in parallel



Lander Electrical Block Diagram



- Arduino Nano has a 3.3V regulator
- LED is connected in parallel

Carrier Power Budget

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Device	Voltage (V)	Current (mA)	Expected Run Cycle (min)	Uncertainty (min)	Current Consumed (mAh)
Arduino Uno	5 V	140 mA	120 min	5 min	291 mAh
GPS	3.3 V	41 mA	60 min	5 min	44 mAh
Barometer	3.3 V	0.05 mA	60 min	5 min	.06 mAh
Video Camera	5 V	150 mA	20 min	5 min	63 mAh
Servo	5 V	500 mA	0.2 min	0.1 min	2.5 mAh
Transceiver	3.3 V	250 mA	60 min	5 min	271 mAh
Voltage Regulators					10% inefficiency

Total	Available	Margin
674 mAh	800 mAh	126 mAh

Lander Power Budget

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Device	Voltage (V)	Current (mA)	Expected Run Cycle (min)	Uncertainty (min)	Current Consumed (mAh)
Arduino Nano	5V	60 mA	120 min	5 min	125 mAh
Barometer	3.3 V	0.05 mA	60 min	5 min	.06 mAh

Total	Available	Margin
126 mAh	250mAh	124 mAh

Buzzer Power Budget

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Device	Voltage (V)	Current (mA)	Expected Run Cycle (min)	Uncertainty (min)	Current Consumed (mAh)
Buzzer	10.6V	1 mA	180 min	60 min	4 mAh

Total	Available	Margin
4 mAh	40 mAh	36 mAh

Power Source Summary

	Battery	Used For	Type	Voltage (V)	Weight (g)	Dimensions (mm)	Capacity (mAh)	Quantity	Price
	MH-9V250	Lander	NiMH	9V	19g	48 x 26 mm	250mAh	1	$4.60
	Tenergy 14500	Carrier	Lithium	3.7V	21g	14 x 49 mm	800 mAh	2, series	$3.79
	LIR2032	Buzzers	Li-Ion	3.6V	3.1g	20 x 3 mm	40 mAh	3, series	$3.59

- We are considering switching to a 9V battery for the Carrier because 7.4V might drop too low

Battery Voltage Measurement

Arduino ADC (Analog to Digital Conversion)

- Simple and accurate
- 10 bit resolution
- Max input for ADC is 5V.
- Voltage will be scaled with resistors

$$V_{in} = V_{bat} \frac{R_1}{(R_1+R_2)}$$

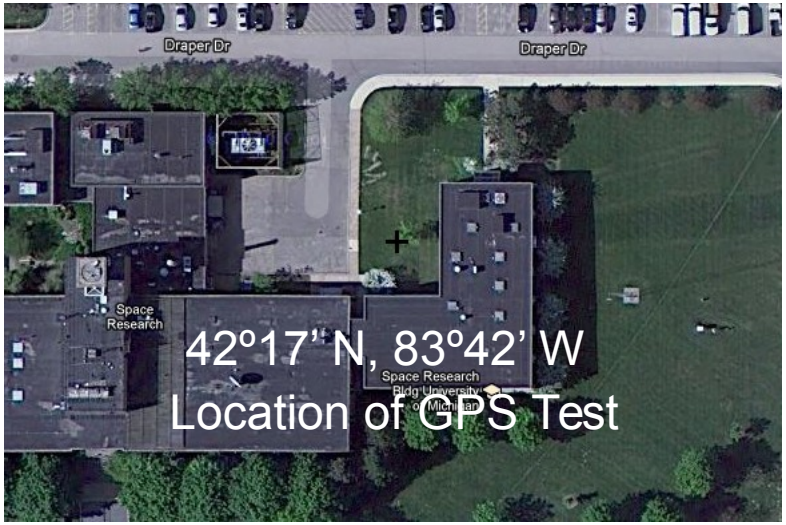
Sensor Subsystem Testing Overview

Locosys LS20031

Sample Data

```
$GPGGA,165256.000,4217.6726,N,08342.6620,W,1, 7,1.28,284.1,M,-34.0,M,,*6E
$GPGGA,165256.200,4217.6726,N,08342.6620,W,1, 7,1.28,284.1,M,-34.0,M,,*6C
$GPGGA,165256.400,4217.6726,N,08342.6620,W,1, 7,1.28,284.0,M,-34.0,M,,*6B
$GPGGA,165256.600,4217.6726,N,08342.6620,W,1, 7,1.28,284.0,M,-34.0,M,,*69
```

GGA header | UTC time | Latitude | N/S | Longitude | E/W | #Satellites | Altitude



- 7 Satellites tracked
- 284 m Altitude
  - Ann Arbor, MI (where data was aquired) is approximately 272m

Conclusion

- LS20031 is working properly
- Still need more tests

Sensor Subsystem Testing Overview

Bosch BMP085

Sample Data

Temperature = 23.00 *C
Pressure = 98059 Pa
Altitude = 275.28 meters

Temperature = 23.00 *C
Pressure = 98053 Pa
Altitude = 275.71 meters

Temperature = 23.00 *C
Pressure = 98061 Pa
Altitude = 275.45 meters

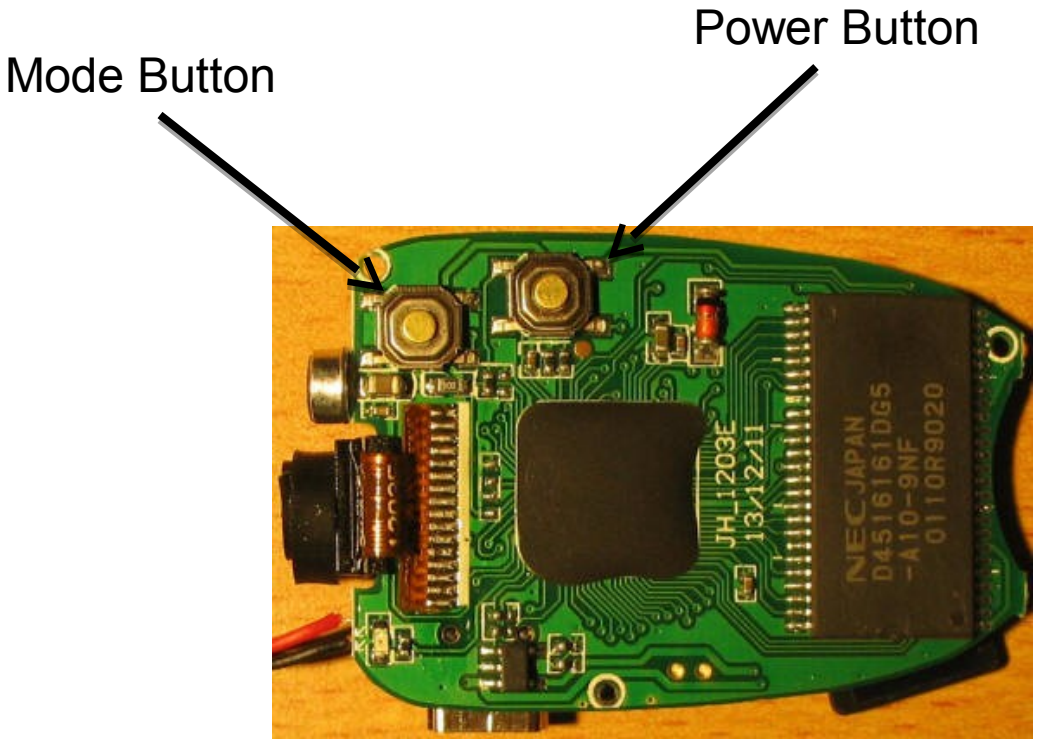
Temperature = 23.00 *C
Pressure = 98064 Pa
Altitude = 275.54 meters

- 275.28 m Altitude verifies GPS accuracy (284 m)
- Temperature is highly accurate
  - Thermometer also showed 23º C

Conclusion

- BMP085 is working properly
- Still need more tests
  - Match altitude with GPS
- Consider appropriate placement in Cansat

Imaging / Video Camera Testing Overview



Wires soldered to power and mode button give video control to Arduino

Buttons activated based on 3.9V (high) or 0V (low)

Imaging / Video Camera Testing Overview

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Current status of testing

- Video resolution is acceptable
- Video camera works on external power source (3.9V)
- Features of power/mode button not yet determined
  - To allow for Arduino control

Screenshot of Video

EPS Testing Overview

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EPS testing when all circuits are complete

- Monitor average current consumption
  - Verify if 7.4V is sufficient for carrier
  - Account for regulator inefficiencies
- Arduino ADC voltage measurement
  - Compare with voltmeter
- Verify that power switch and LED work as expected
- Verify that transistor works as expected