



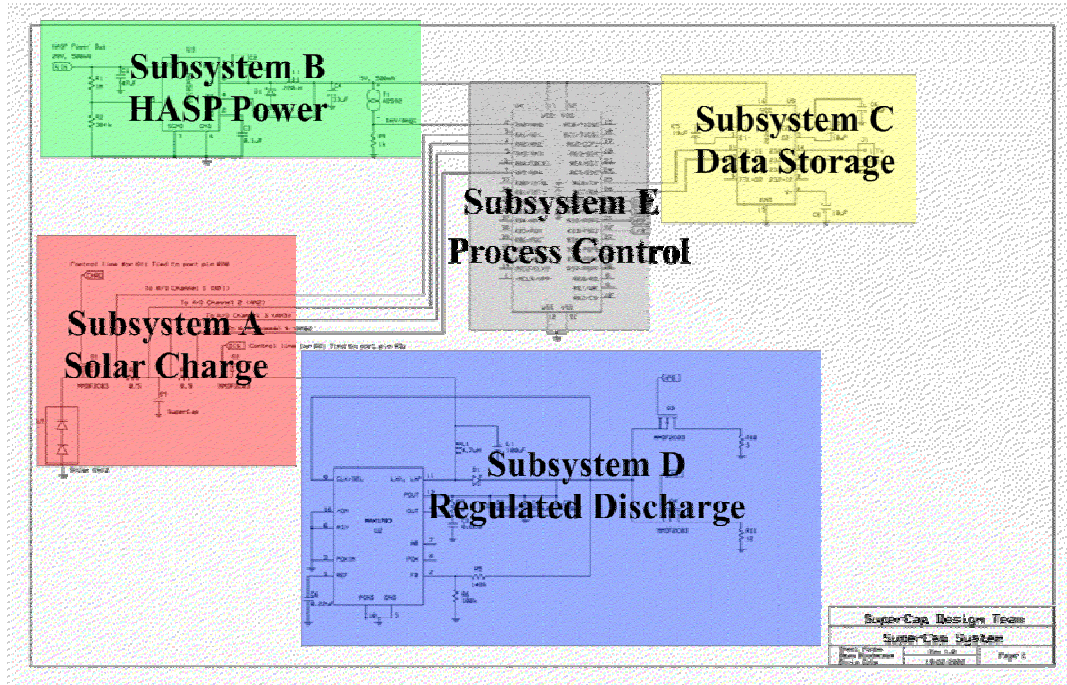
HASP Student Payload Application for 2007

Payload Title: Super Capacitor Driven CubeSat Power System		
Payload Class: (circle one) Small Large	Institution: University of Louisiana at Lafayette	Submit Date: 12/XX/06
<p>The electrical engineering department of ULL first expressed an active interest in aerospace engineering by beginning the Cajun Advanced Picosatellite Experiment (CAPE) in 2004. The finished product is scheduled to be launched into low-orbit in December 2006 via Cal Poly. We are already making improvements to the design for an anticipated second satellite launch. Our payload is an experiment to determine if the power required by the original satellite to properly operate could be provided by super capacitors in place of the currently implemented lithium ion batteries.</p> <p>Participation in the HASP balloon launch would allow us to test the response and efficiency of our system in a high altitude environment. This power system is being designed as a Senior Design project by Chris Cole, Beau Boudreaux, and Trent Poche, under the guidance of Mr. Paul Darby.</p>		
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Payload Description

Our mission is to design and test a power system for use in the CAPE II picosatellite system. The primary goal is to test the efficiency of supercapacitors in space-like conditions. The supercapacitor will be charged using Spectrolab Ultra-Efficient solar cells, and the discharge will vary between fast (1A) and slow (100mA) discharges. Throughout the charge and discharge cycles, sensors will be monitoring relevant voltages, currents, temperatures, and atmospheric pressure in order to document the efficiency and general state of the system.

The basic elements of our power system circuit are shown in the figure below, which particularly illustrates the logical separation of our project into subsystems.



Subsystem Block Diagram

The subsystems and their respective key components are as follows:

<p><u>Subsystem A – Solar Charge</u> Spectrolab Ultra Triple Junction Solar Cells Nesscap 2.5 F EMHSR Super Capacitor</p>	<p><u>Subsystem D – Discharge Cycle</u> MAX1703 Step Up Switching Regulator</p>
<p><u>Subsystem B – Hasp Power</u> MAX5033B Step-Down Voltage Regulator</p>	<p><u>Subsystem E – Process Control</u> PIC18F4520 Microcontroller MMDF2C03 Power MOSFET AD592 Temperature Sensor MPX4115A Pressure Sensor</p>
<p><u>Subsystem C – Data Storage</u> MAX232 RS232 Level Converter HASP On-Board Computer</p>	

Subsystem A – Solar Charge

This subsystem represents the heart of our test system. This subsystem controls the charging of the super capacitor through an N-Channel MOSFET whose state is controlled by the Process Control Subsystem. Turning the MOSFET “on”, provides a low resistance path between the solar cells and the super capacitor. During this time, the super capacitor will charge until the MOSFET is turned “off” as regulated by Subsystem E. When the MOSFET is turned “off” it represents a high impedance between the solar cells and super capacitor which prevents the flow of current into the capacitor. Also, on each side of the capacitor, we have placed current sense resistors which allow us to monitor the power going into and coming out of the capacitor. These resistors have A/D lines on each side of them to facilitate real time measurements of the current and voltages at these key points in determining efficiencies of our system.

Subsystem B - HASP Power

This system utilizes the provided 28V bus to deliver power to our microcontroller, our pressure and temperature sensors, and the MAX232 chip necessary for data transmission to the HASP computer. By acquiring this power from an external source, we are able to help ensure that our tests results are affected only by the components being tested and not the power consumption necessary to conduct the test.

Subsystem C – Data Storage

The data storage subsystem is comprised of our PIC18F4520 microcontroller and the MAX232 chip. Our PIC chip is the brains of our system; all of the data collected during the test flight will be controlled by this chip. We plan to use the PIC’s RAM to temporarily store the data before transmitting it to the HASP on-board computer via RS232 protocol. The MAX232 chip is used to convert the PIC microcontroller’s 5 V CMOS logic levels to the standard 15 V RS232 voltage levels.

Subsystem D – Regulated Discharge

This subsystem is comprised primarily of a voltage regulator, discharge cycle control FETS, and two loads which will be used in the alternating discharge cycles of our supercap. Our specifications require that the currents of our discharges be 1 amp for high power, and 100mA for the low power bus. Limited by the average output of the solar cells, we have decided that the output of the voltage regulator should be a steady 3.0V.

Subsystem E – Process Control

The Process Control Subsystem can be considered the most complex of the subsystems, because it provides instructions and logic required for nearly all of the other subsystems to function properly. The subsystem needs to initiate and halt the charge and discharge cycles of the supercapacitor, while acquiring voltage and temperature data of significant points in the circuit and transmitting to the HASP computer in order for us evaluate the supercapacitors’ efficiency throughout the flight. To handle this task, we have selected the PIC18F4520 as our microcontroller. Reasons for selecting this chip are its 10 available A/D channels for use in data acquisition, its ability to serially transfer this information via RS232 protocol when implemented with the MAX232 chip, and readily available support from other University of Louisiana at Lafayette students who have familiarity with this chip.

Team Management and Structure

Team Members	Contact Information
<i>Chris Cole</i>	<i>P.O. Box 44525 Lafayette, La 70504 (337) 255-7895 colecute@gmail.com</i>
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Our team consists of four student members, all of which are senior electrical engineering students at the University of Louisiana Lafayette.

The team leader, Chris Cole, is in charge of delegating tasks appropriately for the team members, conducting contingency and failure mode analysis, ensuring continual progress on the design, and maintaining team morale and enthusiasm.

Trent Poche is familiar with microcontroller programming, has hand-on experience with small-scale electronics, and is familiar with various simulation programs. Trent played a major role in selecting our essential components in order to best serve the needs of our design.

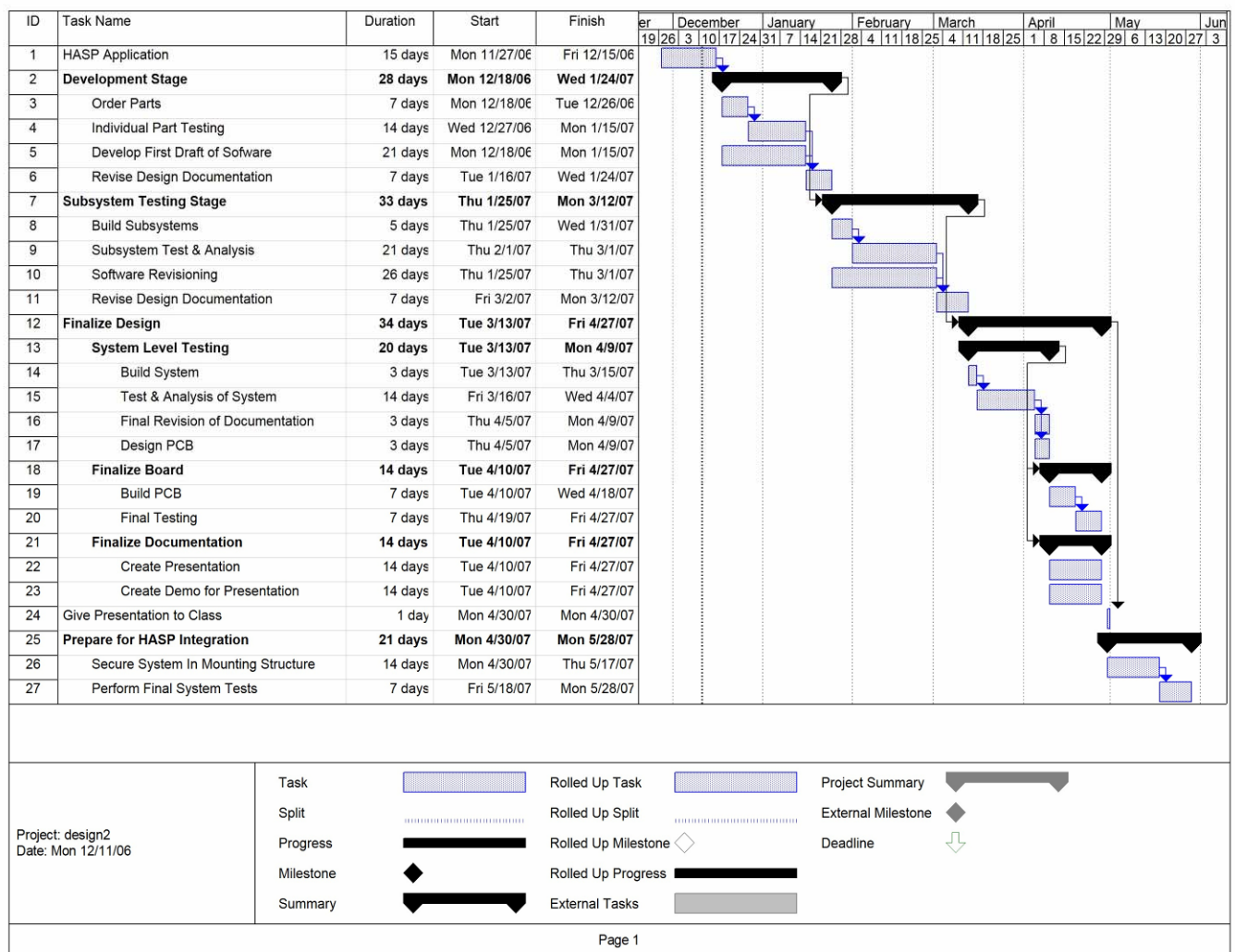
Beau Boudreaux has performed much research and documentation, and has made various size/weight constraint calculations, along with planning of the physical implementation of the cubesat structure.

Jonathan Harrist is a member of the current CAPE team. He has been providing information about the current power system design as well as considerations to be taken when preparing for a launch. Jonathan is our anticipated candidate to perform the final integration of our payload onto the HASP system.

The project is managed by Mr. Paul Darby, who is our Senior Design instructor. Senior Design is typically broken into two separate semesters. Throughout this first concluding semester, Mr. Darby led us, as well as other design teams, through the initial steps necessary when designing a project.

Some of the initial steps taken: the creation of a functional block diagram, the proper method of component selection and alternatives/tradeoffs evaluation, the modeling and simulation of our components using PSpice and Matlab, conduction of a Failure Modes and Effects analysis, combining and organizing all information into an acceptable design report, and creating a Gantt chart to ensure efficient implementation of our system next semester.

Our Gantt chart is provided here as a time-line illustrating the implementation plans of our design throughout next semester. If selected for HASP integration, we anticipate sending two or three student members and one faculty member to both the July integration in Baton Rouge and flight operations at Ft. Sumner.



The following table lists the components anticipated for use in our payload, along with their respective physical dimensions and weights. A weight budget is then calculated from the listed items. All components were selected with the power, physical, and thermal constraints of the HASP flight in mind.

ITEM	DESCRIPTION	VENDOR	QUANTITY	SIZE(LxWxH) mm	WEIGHT grams
1	Ultra Triple Junction Solar Cell	Spectrolab	2	35 x 15.75 x 0.140 mm	.084 g / cm ²
2	Supercapacitor 2.5 F/ 5.4 V	Nesscap	1	23 x 21 x 10.5 mm	5.0 g
3	PIC Microcontroller	Microchip	1	52.45 x 15.88 x 4.83 mm	90 g
4	Power MOSFET Switches	ON Semiconductor	4	6.2 x 5 x 1.75 mm	0.25 g
5	DC/DC Step-Down Converter from HASP Power	MAXIM	1	6.2 x 10 x 4.45 mm	2.35 g
6	DC/DC Converter from Supercapacitor	MAXIM	1	6.2 x 10 x 1.75 mm	1.2 g
7	RS232 +5V Driver/Receiver	MAXIM	1	18.03 x 10.65 x 2.65 mm	3.65 g
8	Pressure Sensor	Motorola / Freescale Semiconductor	1	5.59 x 18.28 x 12.57 mm	4.0 g
9	Temperature Sensor	Analog Devices	1	4.19 x 5.2 x 5.33 mm	0.9 g
10	External Resistors for various components	Ohmite	~10	10.6 x 2.4 x 2.4 mm	0.225 g
11	External Capacitors for various components	Panasonic	~13	14.48 x 6.89 x 12.70 Mm	2.0 g
12	External Inductors for various components	Coilcraft Inc.	~3	18.03 x 12.7 x 7.11 mm	3.9 g
13	External Diodes for various components	IR	~3	9.27 X 6.35 X 6.35 mm	1.4 g
14	Cubesat Structure		1	100mm x 100mm x 100mm	150 g
Total					303.3 g < 1 kg

Power Budget

Several components in our system will be powered directly from the on-board power supplied by the HASP balloon. The on-board power supplies a maximum of 28 V and 500 mA. The table shown below illustrates all of the components which will be using this supply of power and the maximum amount of power each of them will draw:

Component	Purpose	V _{CC} (V)	I _{CC} (mA)	P _{MAX} (W)
PIC18F4520	Microcontroller	5	46	0.23
MAX232	RS-232 Transceiver	5	10	0.05
MAX5033B	Switching Regulator	28	0.450	0.013
AD592	Temperature Sensor	5	0.105	0.0005
MPX4115A	Pressure Sensor	5	10	0.05

By adding all the maximum operating currents together, the maximum amount of current drawn by the system will be 66.5 mA. Note that the numbers listed above for the MAX5033B switching regulator represent its quiescent power draw. When the regulator is operating normally, it will be bucking the HASP power down to 5 V and supplying all the current needed by the system. Therefore, our regulator will be dissipating 0.3325 W of power.

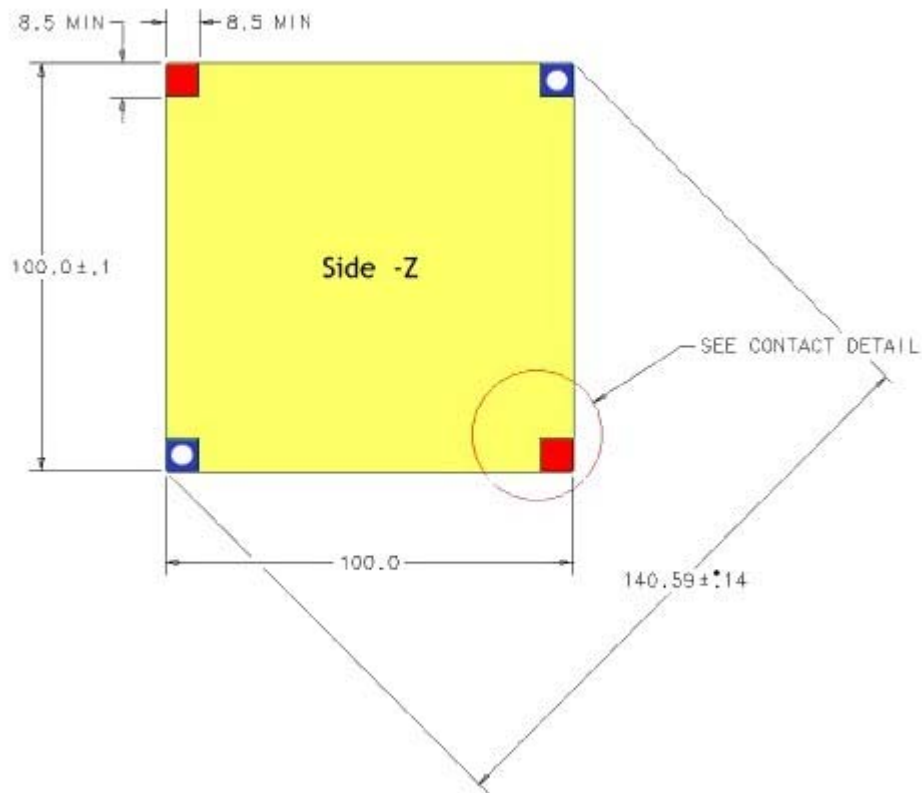
Serial Needs

The payload will regularly utilize the serial connection to the HASP computer in order to store the data accumulated during the charge / discharge cycles of the supercapacitor. Each data sample taken by our microcontroller is 2 bytes. We anticipate sampling 10 sensors, 10 times a second during the charge and discharge cycles. This results in 200 bytes / sec data accumulation during test phases. It will be ensured that a sufficient memory buffer will be present internal to our payload to accommodate the 1200 baud rate restriction for the serial transfer. The test phases are anticipated to occupy approximately 1/4th of the total time in flight.

We do not anticipate the implementation of any additional commands used to control our payload from the ground. The payload will be programmed to operate on its own, with possible use of the default discrete command to toggle the payload power as a means of resetting the system to a default state.

Mounting Plate Footprint

Our payload must be able to properly interface to the HASP platform in order to ensure a successful flight under the harsh conditions of a high altitude environment. The HASP team supplies a mounting plate to all the student teams which are accepted for the balloon flight. On this plate, there is a 15cm x 15cm area in which the student payload is to be placed. Our cube satellite (CubeSat) casing has an area of 10cm x 10cm and will easily fit in the designated area. A drawing of the bottom side of our cube is shown below:



The two blue squares with holes in them represent threaded screw-holes where our team will secure our cube to the HASP mounting plate. Therefore, the only adjustments we plan to make to the mounting plate are to drill two holes spaced as shown in the footprint above.

Desired Position and Orientation

The structure of our CubeSat was designed to ensure optimal exposure to sunlight at all times during the flight. Solar panels are mounted on all the sides of the cube except for the bottom to ensure that at least one or more of the panels receive light no matter the CubeSat's orientation. The HASP balloon holds the small student payloads on two different levels and the number of possible obstructions of sunlight is minimized at the upper levels. Therefore, our team would like to be positioned at one of the positions on

the upper level, if at all possible. Any of these four positions should equally accommodate our payload's needs.

Dimensioned Drawing of Payload

Our payload follows the physical layout and design guidelines of the CubeSat created by the California Polytechnic State University. Our CubeSat matches the dimensions outlined in the following mechanical drawing:

