Boston University

Electrical and Computer Engineering

EC463 Senior Design Project

**First Prototype Testing Report**

**HYP Batteries**

By Team 23

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**Required Materials**

Software:

* Julia Script:
  + Battery Performance Data (Spec sheets and discharge curves)
  + User Tunable Parameters
  + Hybrid Battery Circuit Simulation
  + Flight Condition Simulation

**Setup:**

The only equipment required for our testing experiment is a computer capable of executing Julia script. To set up the experiment, data specification sheets for the batteries being tested are needed. These specification sheets need to include: cell capacity, cell voltage, charge current, discharge current, weight and discharge rate characteristics. In order to model the different discharge rates expected to be used by gliders during flight, the code uses discharge rate characteristics given by the battery manufactures to interpolate and estimate discharge rates used in flight. An important step of the setup process is to create CSV files for each battery, detailing the voltage versus capacity relationship curve for different discharge rates. Each CSV file will be specific for a discharge rate, and require 60-70 data points of battery capacity (Ah) with the corresponding voltage (V). Once all the cell information is obtained, input single cell capacity, single cell mass, single cell maximum discharge rate, individual cell energy capacity and CSV files for each battery into the code.

Next, aircraft specifications such as airplane mass, climb velocity, and glide ratio will be needed for the simulation. This will be used to determine the height and velocity of the aircraft during flight.

Lastly, the diode voltage-drop used in the circuit will need to be specified in order to be accounted for. If necessary, test the voltage across two terminals on the diode to determine the diode voltage drop.

**Measurable Criteria:**

1. Battery weight needs to be under 10 kilograms
2. Saturation of LiFePO4 battery needs to be reached by 60-120 seconds
3. Input electrical power needs to reach total power requirement
   1. Seen in Input electrical power graph
4. None of the cell voltages go below their absolute minimum value --until at altitude--
   1. Seen in Pack Voltage graph
5. Sustainable glider height needs to be reached before saturation of lithium ion battery pack
   1. Seen in Height AGL graph
6. Reach Departure height within four to five minutes
   1. Seen in Height AGL graph

| Test One | Number in Series | Number in Parallel |
| --- | --- | --- |
| Lithium Ion | 14 | 7 |
| LiFePO4 | 21 | 1 |

| Test Two | Number in Series | Number in Parallel |
| --- | --- | --- |
| Lithium Ion | 12 | 8 |
| LiFePO4 | 19 | 1 |

**Score Sheet:**

|  | Weight(kg) | Saturation Time(s) | Meet Power Requirement | Cell Voltage above minimum value | Sustainable Height Reached | Departure Height Reached |
| --- | --- | --- | --- | --- | --- | --- |
| Test One | 8.5 | 145 | Meet | Meet | Meet | Meet |
| Test Two | 8.1 | 108 | Meet | Meet | Meet | Meet |

**Conclusion:**

After running multiple simulations, we are able to conclude the best possible configuration of Lithium-ion and LiFePO4 batteries to reach our requirements. Our simulation shows P42A Lithium ion and A123 LiFePO4 batteries have the best discharge characteristics for our hybrid battery pack design. Our measurements show that P26A Lithium-ion batteries require more cells to reach the voltage requirement, resulting in more weight and higher cost. On the other hand, A123 LiFePO4 batteries are more affordable and also satisfy our requirements.

In our test, we used the P42A Lithium ion and A123 LiFePO4 batteries with two types of configurations. The first test used 14s7p (14 in series and 7 in parallel) of P42A batteries and 21s1p A123 batteries. The weight, power requirements, cell voltage minimum value, sustainable height and departure height were met, but the saturation time was too high (145s > 120s ). This shows the battery configuration is not as efficient as the client has requested. In test two, the battery configuration was able to meet all the previous requirements met in test one as well as the saturation time requirement. Additionally, the test two battery configuration is lighter than the test one battery configuration. Since we have to design the case for the box, a lighter battery pack will allow for more freedom in the case design in order to meet the total weight requirement. This makes the test two’s configuration more favorable. From these two simulations, we have decided to go with 12s8p of P42A batteries and 19s1p A123 batteries.

Our simulation shows that our circuit will work in theory. The next steps are to test the circuit using real batteries. Since the currents we are working with are dangerously high, we will need to scale down our model for safety reasons.