Modeling Battery Discharge

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Introduction

There is a growing need for alternative energy sources so we can preserve our natural resources. Therefore, we must investigate energy sources like batteries, and determine if they are realistic possibilities. Hence, my mentor, Saakar Byahut, under the guidance of Dr. Alejandra Uranga, is conducting research regarding the viability of battery-powered aircraft.

Image © NASA
The X-57 Maxwell is a plane currently being developed by NASA. This plane is an example of battery-powered aircraft.

Objective & Impact of Research

The lab's research goal is to understand the behavior of batteries in order to design potential future electric aircraft. Battery-powered propulsion systems could take the place of gas turbine systems that currently power aircraft. In order to confidently propose this change in energy source, we must understand battery behavior. Electric aircraft may be possible if batteries are found to be viable as a new power source, as their behavior is modeled reliably. This electric power could be more friendly to the environment than conventional gas power.

Project Overview

My project was half of the work done to analyze battery behavior/performance as batteries charge and discharge multiple times. My work focused on the calculation and analysis of data given by battery manufacturers in order to create an equation called the Nearly Linear Battery Discharge Model. This equation is used to model the discharge behavior of batteries.

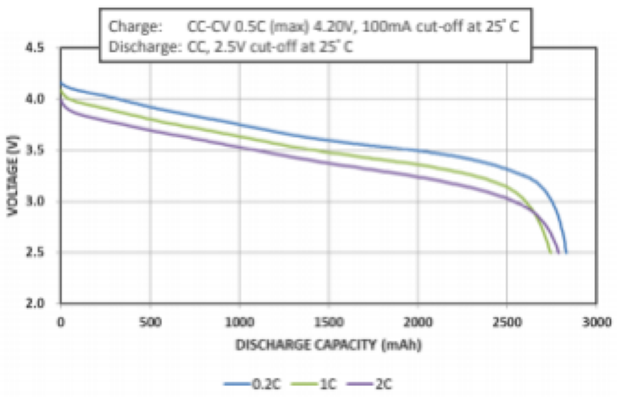
Nearly Linear Battery Discharge Model:

$$V = V_0 - KQ - RI - GIQ$$

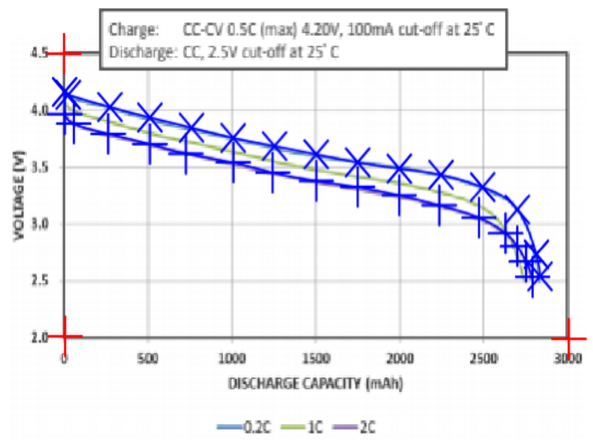
- V: Voltage, where V_0 is the starting voltage.
- K: Primary dependence of voltage on capacity discharged
- Q: Midpoint of the lines
- R: The internal resistance of the battery
- I: Current of the battery
- G: Change in slope of discharge curve (due to current)

My project consisted of 5 steps:

1. Look up the spec sheets of different 3.7V batteries.

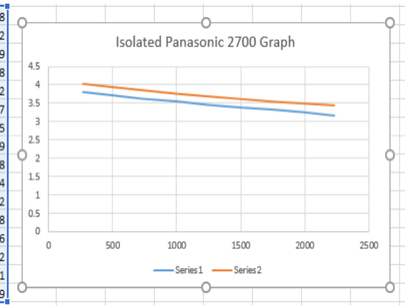


2. Use the Engauge Digitzer to convert discharge curve data into numbers.

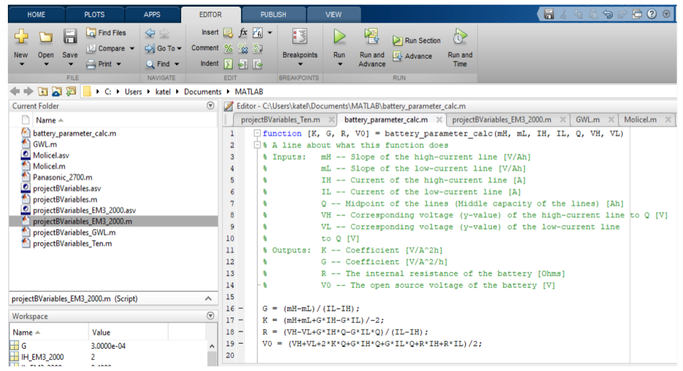


3. Export the data and isolate the section of the curve that is linear.

7	272	3.7915	4.0308
8	508.5	3.7066	3.9422
9	509.3	3.7063	3.9419
10	722.5	3.6216	3.8658
11	756.8	3.6116	3.8532
12	1003.7	3.5472	3.7647
13	1004.4	3.547	3.7645
14	1240.9	3.4584	3.6969
15	1252	3.4546	3.6938
16	1498.9	3.3879	3.6234
17	1499.6	3.3877	3.6232
18	1746.5	3.3354	3.5528
19	1747.3	3.3352	3.5526
20	1994.2	3.2647	3.5002
21	1994.9	3.2645	3.5001
22	2231.4	3.1759	3.4509



4. Use MATLAB to calculate the unknown values in the Nearly Linear Battery Discharge Model.



5. Catalog values found for different batteries

Brand	Capacity	G (V/A^2h)	K (VA/h)	R (Ω)	V_0 (V)
Panasonic	2700	0.0000004	0.0003	0.0494	3.73
Panasonic	3300	0.002	0.29	0.0345	4.1

Skills Learned

- Using Engauge Digitizer
- Analog Electronics (Circuits)
- Basic Aircraft Design Principles
- Linearity (Mathematical Relationship)
- MATLAB

Outcome of the Project

Building the Battery Database: By calculating data for multiple batteries, I have built a collection of values to compare across various companies.

Brand & Capacity (mAh)	G (V/A^2h)	K (V/Ah)	R (Ω)	V_0 (V)
Samsung 3000		0.365	0.023	3.2
Tenergy 2600		0.18	0.04	3.8
EM3 2600		0.18	0.04	3.8
Panasonic 3300		0.29	0.035	4.1
EM3 2000		0.0048	0.125	3.9
GWL 3200		0.268	0.06	4.1
Molicel 2100		0.0002	0.114	3.8
Panasonic 2700		0.0003	0.049	3.7
Sounddon 2200		0.0003	0.078	3.7

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