Stanford | SCHOOL OF EARTH, ENERGY & ENVIRONMENTAL SCIENCES

Homework 4

ENERGY 293 - Energy storage and conversion: Solar Cells, Fuel Cells, Batteries and Supercapacitors

(50pts)

Fall Quarter 2018

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Due Nov. 27, 2018 at 3pm (Electronic pdf copy on CANVAS and hard-copy to (one of) the TAs)

The goal of HW 4 is to implement and simulate an electrical-thermal model of the Maxwell BCAP1500 supercapacitor device characterized by the specification reported in the table below:

Maxwell BCAP1500	
Capacitance (2.7 V, 25 °C) [F]	1500
Rated voltage [V]	2.7
Equivalent series resistance [mΩ]	0.47
Operating temperature [°C]	−40 to 65
Cyclability	10^6
Energy density [Wh kg^{-1}]	5.4
Power density [W kg^{-1}]	6600
Thermal resistance (R_{th}) [°CW^{-1}]	4.5
Thermal capacitance (C_{th}) [J °C^{-1}]	320

Data from [1]

1. (10 pts) Write the system of coupled equations comprising the second order electrical model and first order temperature model as seen in class in Lecture 14.
2. (20pts) In order to simulate the electrical-thermal model, you need to build a current profile. Following the instructions below, write a MATLAB script containing the following instructions:
    a. the DLC is charged at constant current (100 A) until the voltage reaches the rated voltage (2.7 V);
    b. 15s of dwell ("dwell" phase corresponds to current = 0)
    c. the DLC is discharged at constant current (100 A) until the voltage reaches 50% of the rated voltage (1.35 V);
    d. 15s of dwell
    e. Steps a to d e are repeated 5 times.

3. (20pts) Select the proper electrical and thermal parameters to simulate the coupled model at two ambient conditions Tair = 0°C and 40°C and report the voltage simulated response.
   Note: You can initialize the temperature model with the ambient temperature values.

References

1. Guanetti, J., Fiorenti, S., Guezennec, Y., Onori, S., "Modeling and experimental validation of a hybridized energy storage system for automotive applications", Journal of Power Sources, Vol. 241, pp. 112–120, 2013