Project 5: Modelling the performance of the rechargeable Li-Ion batteries

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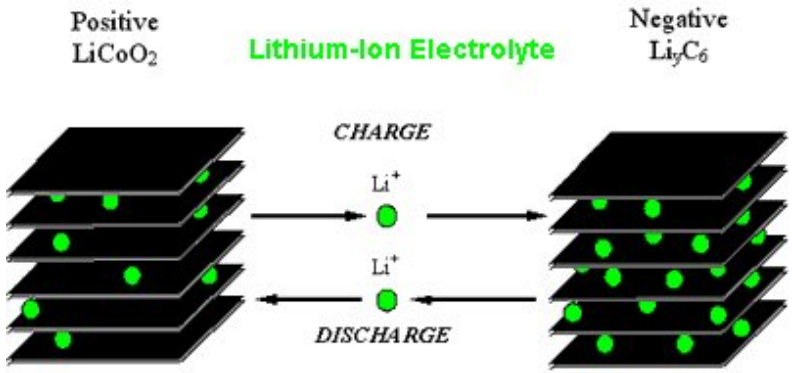
Outline

Background

A lithium-ion battery (Li-ion battery) is a member of a family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging.



Li-ion batteries

Li-ion batteries have many feautures:

- High energy density.
- Long stable power and long run time.
- Ideal for notebook, PCs, boosters, portable devices, etc.

Definitions:
C-rate: designates the rate at which the battery capacity can be consumed or filled.

$$\mathrm{I} = \mathrm{capacity\ x\ C\text{-}rate}$$

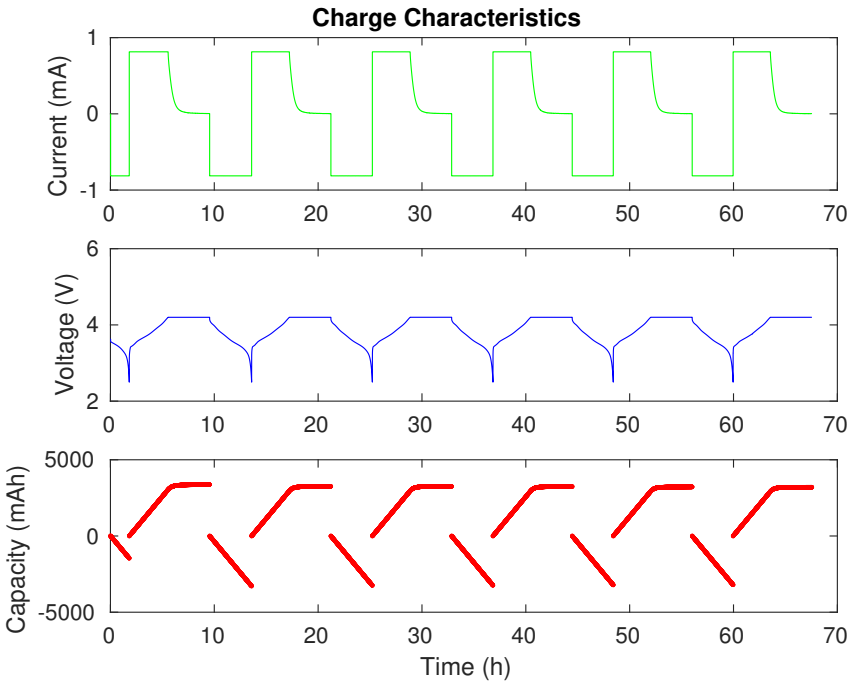
EMF: Electromotive force, is the voltage developed by any source of electrical energy such as a battery.

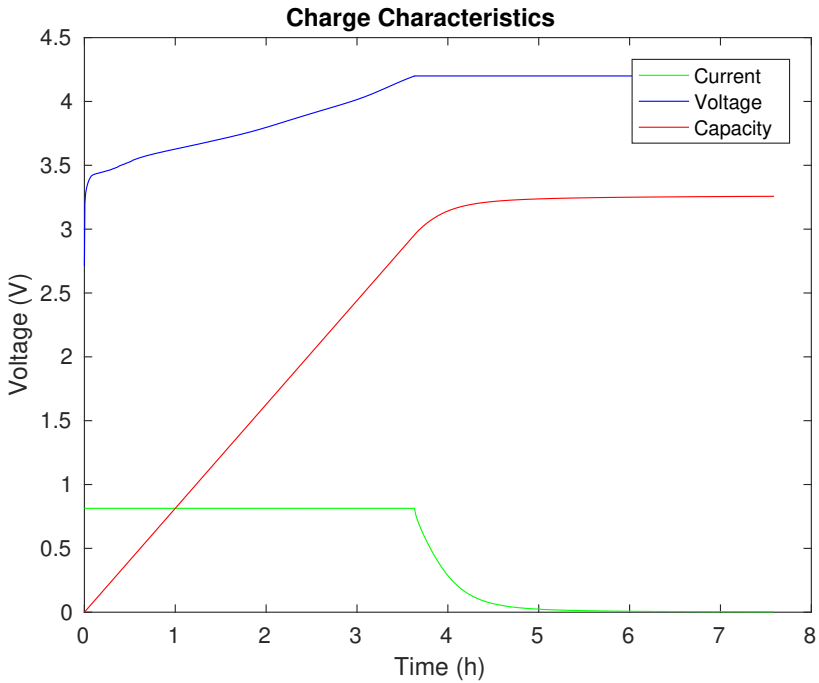
Some Targets

- State of Charge (SOC) and Voltage or Current (or a relationship between them) algebraically determines the rate of change in the SOC.
- First target: empirical fit to this relationship.
- Equivalent circuit models or system Identification (black box fit).

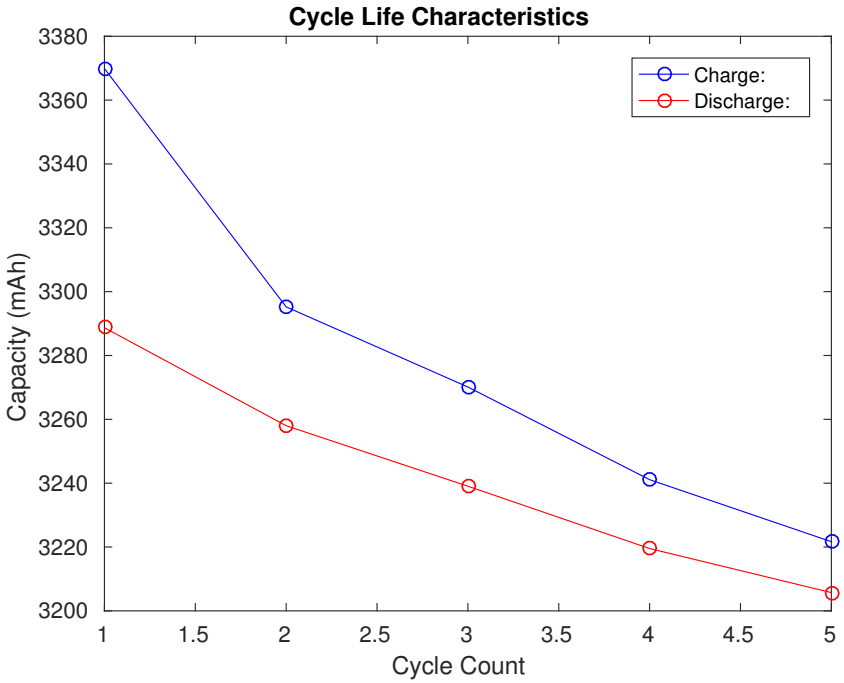
Scientific challenge: How do we fit a model for parallel and series cells to investigate the performance and failure statistics in parallel versus series designs ?

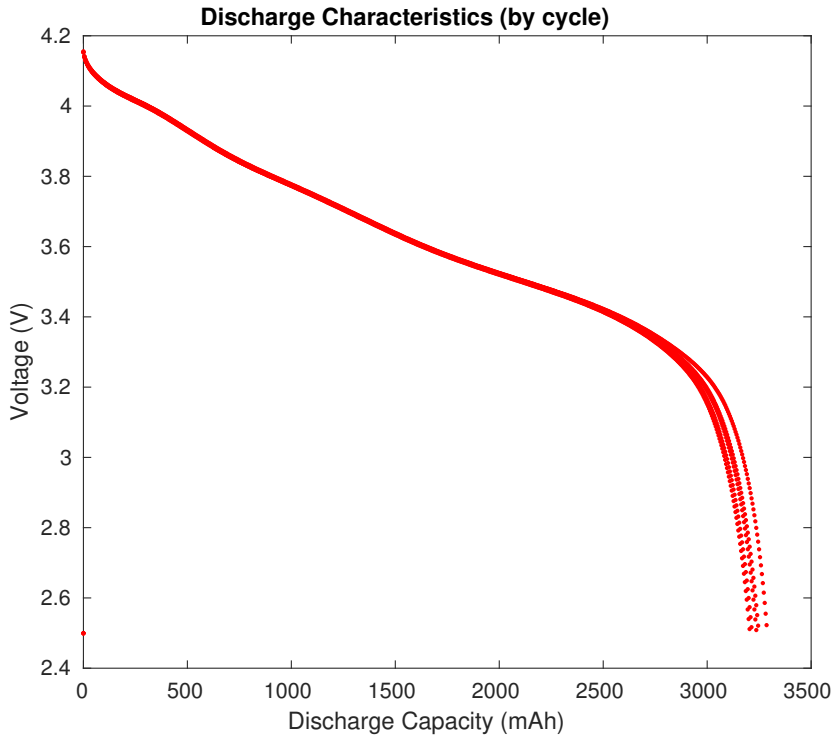
Primary Results: Charge Characteristics



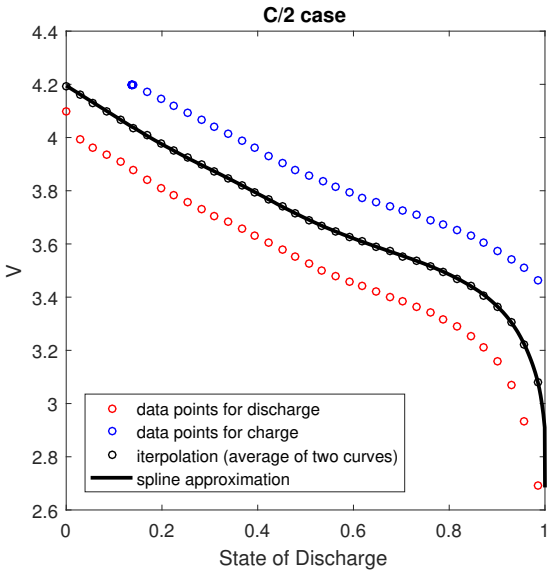


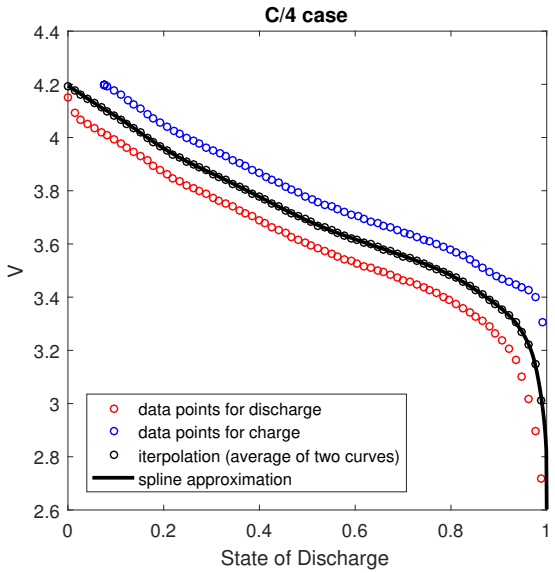
Primary Results: More Characteristics

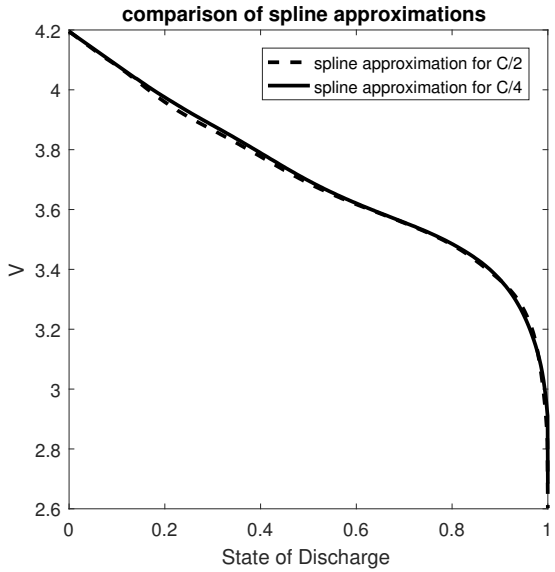




Primary Results: EMF curves



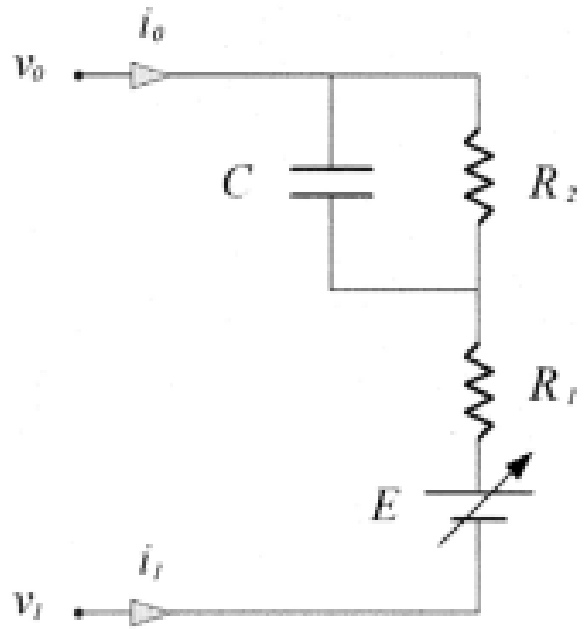




Mathematical Model

$$R_2 C \frac{d\mathcal{V}}{dt} + \mathcal{V} = R_2 C \frac{dE}{dt} - C R_1 R_2 \frac{di}{dt} + E - (R_1 + R_2) i$$

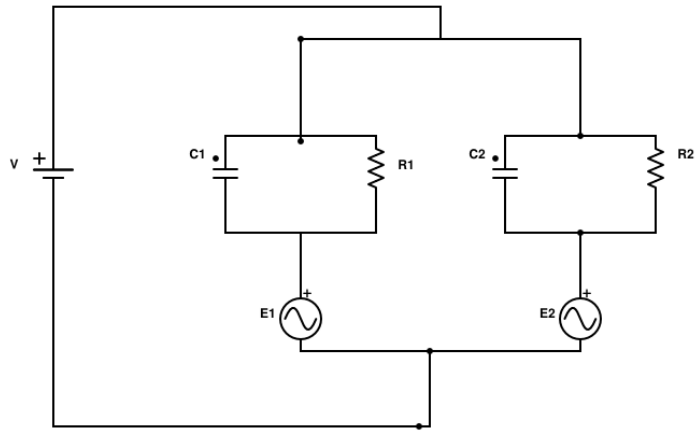
- C - Capacitance (F)
- $\mathcal{V}$ - Battery voltage (V).
- E - Battery equilibrium potential (V)
- R_1, R_2 Resistance (Ω)
- i - Battery current (A).



Equivalent circuit representation of lithium-ion cell.

Ongoing work

- validation with expermiental data for constant resistance
- parallel and series cell model
- describe the model by the system of differential algebric equations



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Thanks!