LFP battery SOC (state of charge) estimation using battery pack hybridization

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Background:

- Lithium iron phosphate (LFP) batteries have huge potential for electrical vehicle usage due to their **long lifecycle** and **thermal stability**.

- The cathode for the LFP battery is made of lithium, iron, and phosphorous. All of these materials are **easier to procure** compared to other Lithium-ion based batteries' raw materials.

Motivation:

- LFP battery's **OCV vs SOC curve** has a **flat plateau** in the mid-range **(10%-90% SOC)** of the graph which makes it harder to estimate SOC. Therefore, the need for an accurate SOC estimation for LFP batteries is immense.

- The proposed LFP and NMC cell hybridization method is expected to help achieve better accuracy than the available SOC estimation methods.

Shortcomings of the other SOC estimation methods:

Coulomb Counting Method: Current sensor error accumulated

Open Circuit Voltage Method: Long relaxation time for OCV measurement

Impedance Spectroscopy method: Difficult for online measurement

Artificial Neural Network method: Large amount of training samples are needed, High computing cost
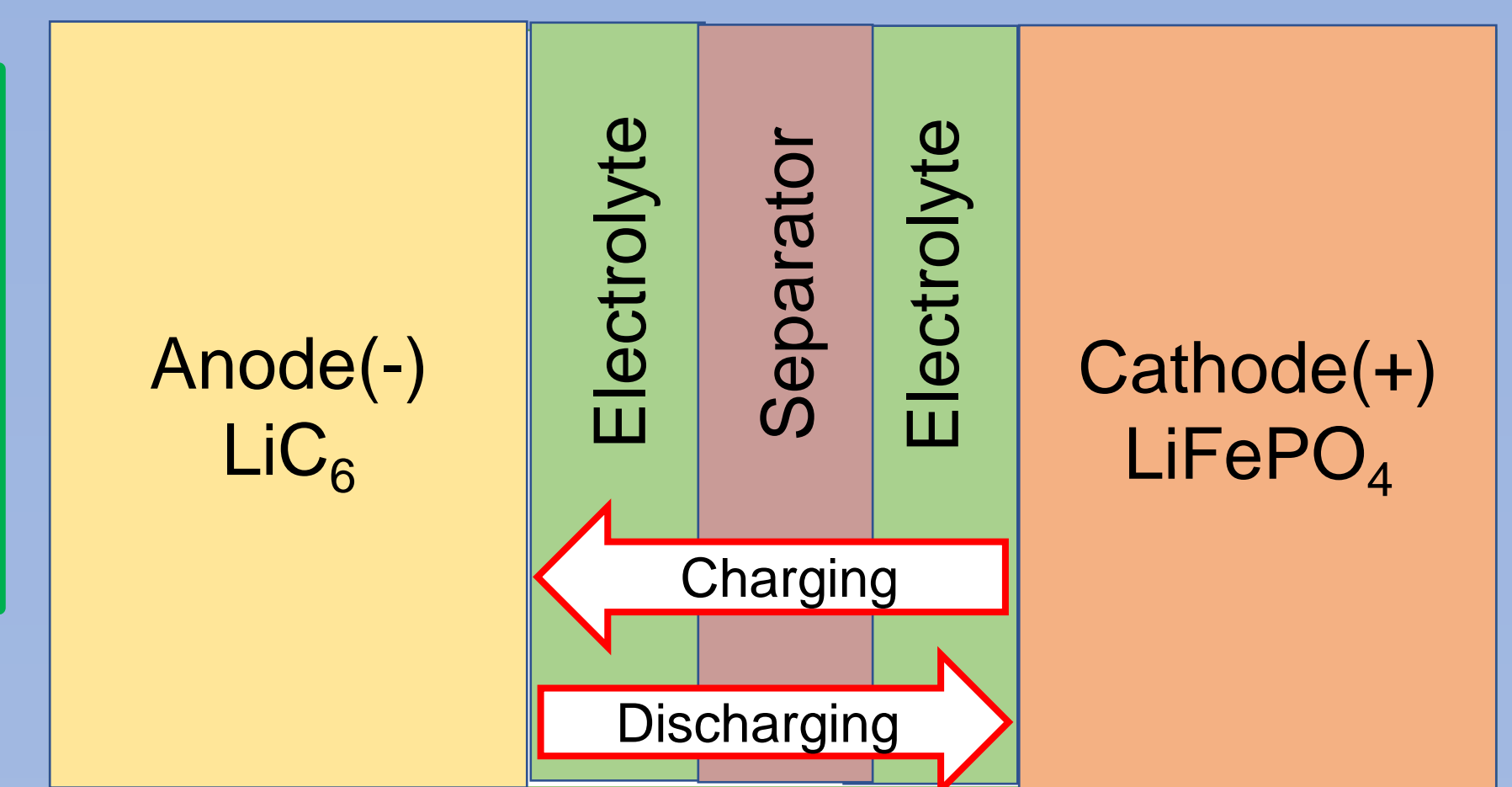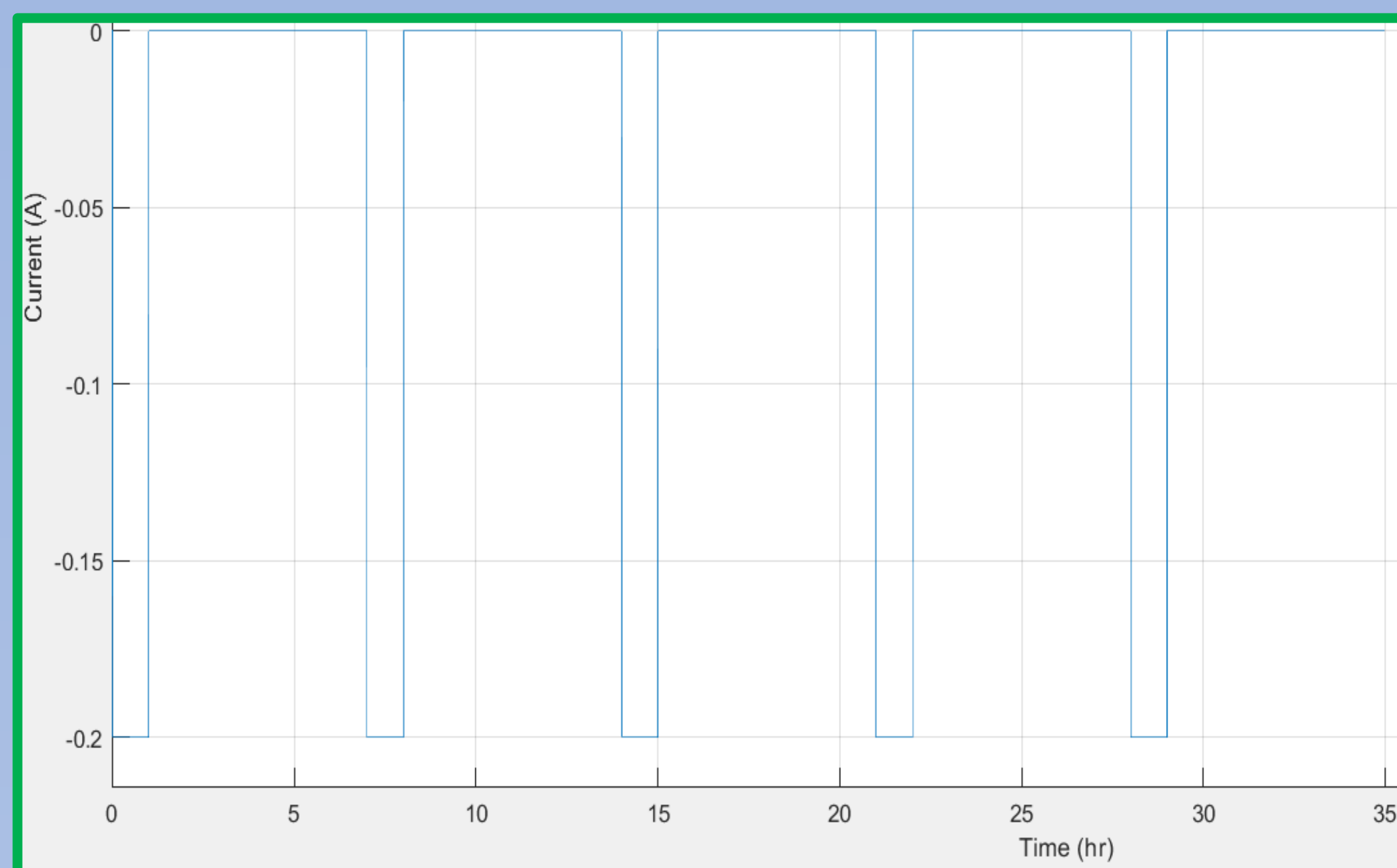

Figure: LiFePO4 cell composition

(Anode(-) LiC_6 | Electrolyte | Separator | Electrolyte | Cathode(+) $LiFePO_4$; Charging; Discharging)

Figure: Current Profile for battery discharging

Figure: OCV vs SOC graph

Flat Plateau
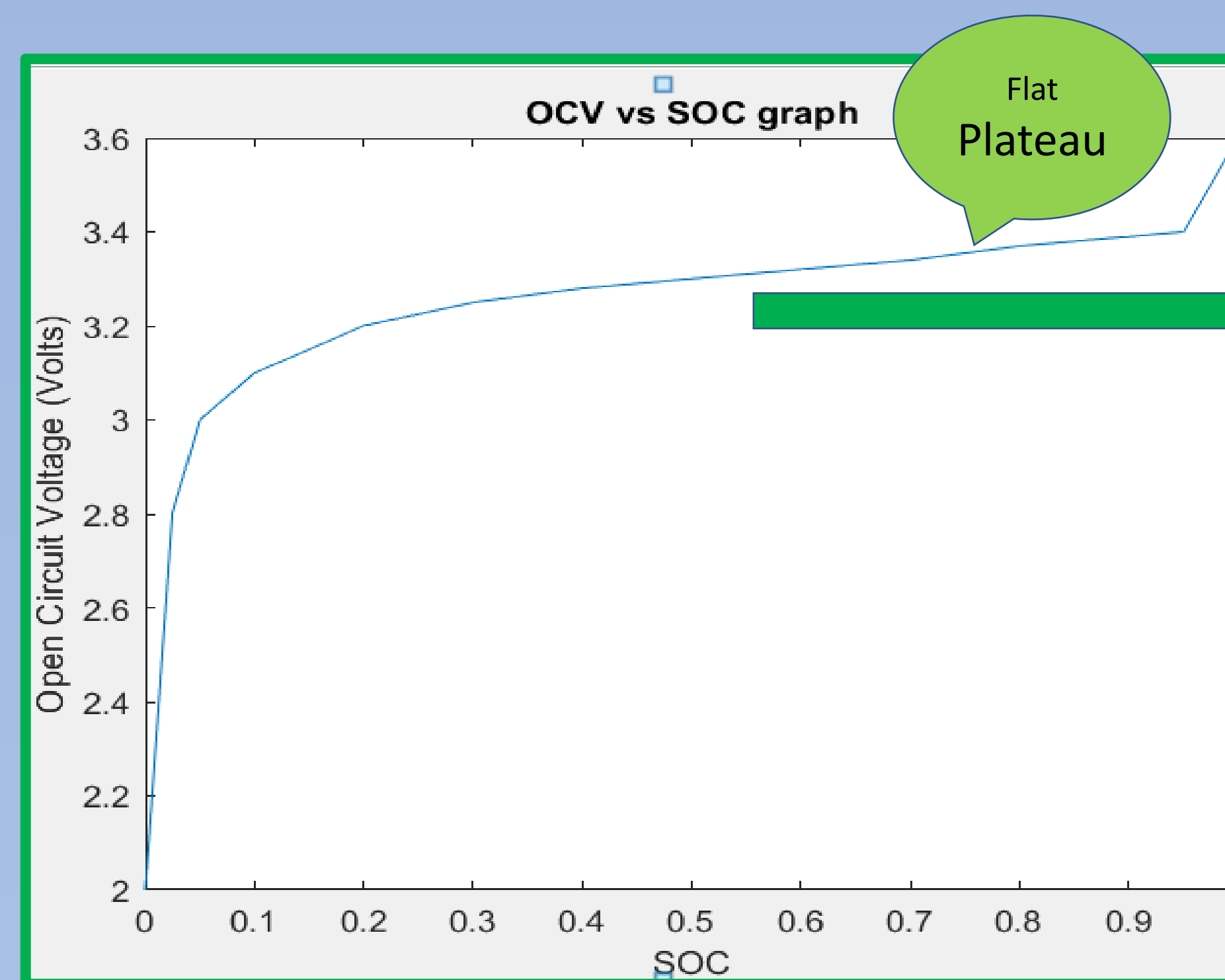
Proposed Solution:
Battery Pack Hybridization:
1. Use NMC battery in Series with LFP battery
2. NMC acts as an unbiased current estimator
3. Allowing us to estimate LFP cell SOC in mid range (10%- 90%) SOCs without a drifting estimation error

LFP — NMC

Main Goal: To explore whether the addition of a NMC battery improves the theoretical bounds for SOC estimation or not which enable more accuracy in SOC estimation.

Lessons Learned:: Collaboration & Communication | Time & Project Management | Unexpected scenarios

Future Research: Use the Arbin Cycler to cycle the batteries → Analyze the obtained data to validate the theoretical hypothesis