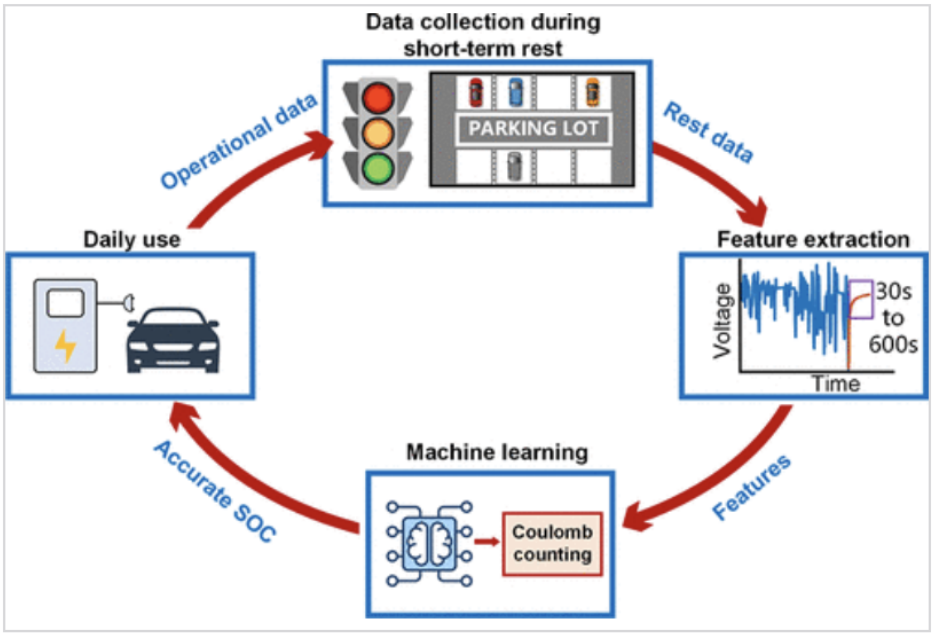
Docket #: S24-490

Enhanced SOC Estimation for LFP Batteries: Synergistic Approach Using Coulomb Counting Reset, Machine Learning, and Relaxation

Researchers in the Onori Lab have developed a state of charge (SOC) estimation technique for Lithium Iron Phosphate (LFP) batteries using machine learning. LFP batteries account for over 30% of lithium battery cathode chemistries and are increasingly used for EVs and grid storage due to safety, sustainability, and cost advantages and resilience to supply chain disruptions LFP battery path-dependent behavior, hysteresis effects , and flat open circuit voltage (OCV) characteristics challenge traditional model-based SOC estimation methods that rely on OCV-SOC relationships.



State of Charge (SOC) Estimation for Lithium-Iron Phosphate (LFP) Batteries
(Image courtesy the Onori Lab)

The Onori Lab machine learning-based SOC estimation approach:

> Enhances the standard Coulomb counting method by addressing incorrect initialization
> Uses relaxation voltage and temperature measurements during short rest periods (when current is zero)
> Incorporates historical current data to improve estimation accuracy
> Works with low sampling frequency data (1/30 Hz), making it practical for real-world Battery Management Systems

This solution offers practical implementation for battery management systems in electric vehicles and energy storage applications, with potential extension to state-of-health estimation.

Stage of Development – Proof of Concept
Extensive testing across 430+ working conditions demonstrated mean absolute errors below 3.25% with just one minute of relaxation voltage data. The approach is robust to various conditions and machine learning algorithms.

Applications

- LFP battery state-of-charge (SOC) estimation for:
  - Electric and hybrid vehicles
  - Consumer electronics
  - Smart grids and Battery Energy Storage Systems (BESS)

Advantages

- More accurate & computationally faster SOC estimate
- Minimal computational resources
- Seamless integration into existing BMS, uses existing sensors
- Longer, more predictable battery operation
- Potentially extendable to state-of-health estimation

Publications

- Che, Y., Xu, L., Teodorescu, R., Hu, X., & Onori, S. (2025). Enhanced SOC Estimation for LFP Batteries: A Synergistic Approach Using Coulomb Counting Reset, Machine Learning, and Relaxation. *ACS Energy Letters, 10*(2), 741-749.

Patents

- Published Application: WO2026122973

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