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Lithium Iron Phosphate Battery State-of-Charge Estimation via Sine-Wave Pulses

Stanford researchers in the Onori Lab have developed a battery management system (BMS) that uses sine-wave current pulses to accurately determine a battery's state-of-charge (SOC). Monitoring a rechargeable battery's remaining capacity is critical for safe and optimal operation. However, SOC cannot be measured directly by BMS sensors, and existing models are particularly inaccurate due to lithium iron phosphate (LFP) battery chemistry and flat open circuit voltage (OCV)/state-of-charge relationship.

The Onori Lab method overcomes existing limitations through impedance estimation using sine-wave current pulses. By analyzing how a battery responds to these specific electrical signals, the system can reliably infer the battery's current charge state. The system includes:

- A sine-wave pulse generator that applies precisely shaped electrical pulses to the battery.
- A voltage sensor that measures the battery's output voltage response.
- A state-of-charge monitor that performs calculations and analysis.
- SOC monitoring application software that implements the estimation algorithms.

The approach ensures SOC estimation accuracy to help prevent battery degradation and performance issues in rechargeable battery applications.

Stage of Development – Proof of Concept

Software has been trained on battery cycle data and verified in the lab. Continuous improvement work is ongoing.

Applications

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

Advantages

- More accurate & computationally faster SOC estimate.
- Longer, more predictable battery operation.

Publications

- Gao, Y., & Onori, S. (2025). Advancing SOC estimation in LiFePO4 batteries: Enhanced dQ/dV curve and short-pulse methods.*eTransportation*, 100466.

Patents

- Published Application: WO2025122661

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