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Lithium Iron Phosphate Battery State-of-Charge Estimation via dQ/dV Analysis

Stanford researchers in the Onori Lab have developed a method for accurately estimating battery state-of-charge (SOC) using the inverse derivative of galvanostatic voltage response (dQ/dV) curve. 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 using sine-wave current pulses and the inverse derivative of galvanostatic voltage response (dQ/dV) curve. By analyzing how a battery responds to these specific electrical signals, the system can reliably infer the battery's current charge state. The system works by:

- Applying a controlled constant current pulse to the battery via a pulse generator.
- Measuring the resulting battery's output voltage response.
- Calculating the "pulse dQ/dV" (inverse derivative of galvanostatic voltage response).
- Comparing this measurement against a reference complete dQ/dV curve across the full SOC range.
- Determining and reporting the battery's current state-of-charge.

This 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: WO2025122659

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