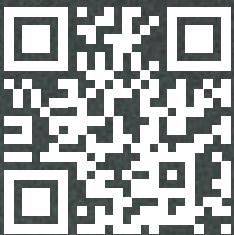




EIS-based SoT estimation

EIS-BASED STATE OF TEMPERATURE (SOT) ESTIMATION FOR ADVANCED BATTERY MANAGEMENT SYSTEMS

Accurate battery temperature monitoring is essential for safe and reliable battery operation. Within the NEMO project, CSEM developed an innovative **State of Temperature (SoT)** algorithm that estimates the internal temperature of lithium-ion batteries using **Electrochemical Impedance Spectroscopy (EIS)**. Unlike conventional approaches that rely solely on temperature sensors, the method exploits the electrochemical impedance of the cell itself to provide temperature information that can be integrated directly into advanced Battery Management Systems (BMS).



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Research approach

NEMO demonstrates how EIS measurements can be used not only for battery diagnostics but also for real-time estimation of key battery states. The SoT algorithm forms part of the project's EIS-driven electro-thermal model and is designed for future deployment within the NEMO battery management architecture, alongside other SoX functions such as State of Charge (SoC).

What problem does it address?

Internal battery temperature is a critical indicator for performance, ageing, and safety. Direct measurement of internal temperature is often impractical because sensors cannot easily be placed inside commercial cells.

How does the algorithm work?

The algorithm continuously monitors the phase shift in EIS measurements. A specific impedance phase angle is correlated with cell temperature.

Key algorithm aspects

Minimal dependence on State of Charge, allowing characterization at a single SoC and simplifying deployment.

Integration perspective

- ◆ Designed to operate within advanced BMS architectures and complement other EIS-based battery state estimation functions.
- ◆ Supports future real-time battery monitoring and control strategies in the NEMO ecosystem.

Key Findings

The SoT algorithm was validated using multiple 75 Ah lithium-ion cells under two experimental conditions:

- ◆ **Dynamic thermal management setup:** Estimated temperature closely tracked measured temperature, achieving an RMSE of approximately **1.2°C**.
- ◆ **Controlled climatic chamber validation:** After thermal stabilization, the estimation accuracy improved to **0.5°C RMSE**.

Lessons Learned

- ◆ The phase-temperature relationship exhibits only a weak dependence on SoC, significantly simplifying calibration and implementation.
- ◆ Thermal lag between the cell core and surface can introduce a small offset under dynamic operating conditions, but estimation accuracy improves notably once thermal equilibrium is reached.

Expected Impact: benefits for Battery Management Systems

- ◆ Improved safety monitoring and thermal management.
- ◆ Reduced reliance on extensive sensor networks by leveraging information already contained in EIS measurements.

Key Takeaway

The NEMO SoT algorithm demonstrates that EIS-based temperature estimation can deliver highly accurate internal temperature information with errors below **0.5°C RMSE**, providing a promising pathway toward smarter, safer, and more autonomous battery management systems.