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Simulating a novel Electrochemical Impedance Spectroscopy measurement system

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The poster presents a novel Electrochemical Impedance Spectroscopy (EIS) methodology for lithium-ion cells, and a digital model simulating the measurement system. The proposed methodology takes the nonlinear behaviour of the lithium-ion cell into account, modelling the cell as a Volterra system. The digital model is employed to showcase both the strengths and weaknesses of the proposed method and it is hereinafter referred as the Digital Twin (DT).

The EIS methodology is the common approach used to acquire information about electrochemical conditions of the cell, analysing the variations of resistance and reactance in relation to frequency –the Nyquist diagram. The shape of the Nyquist diagram changes as the cell charges and discharges, and the evolving shape over time offer valuable information, primarily related to aging phenomena, State of Charge (SoC), and State of Health (SoH).

Despite its different tasks, the EIS method is almost invariably implemented by subjecting the cell to different tones, as the impedance is calculated by the ratio of the fundamental harmonics of voltage and current at each stimulating frequency.

In contrast, the proposed methodology consists of stimulating the cell with a specific current signal. The current signal is obtained from a deterministic and periodic sampled signal, whose samples have a white uniform distribution. The impedance spectrum for small signal amplitude (i.e., the spectrum of first order Volterra kernel) of the cell is estimated with the Orthogonal Periodic Sequences (OPS) technique, computing the cross-correlation between the output voltage samples and the OPS. The technique is robust towards the higher order Volterra kernels, i.e., towards the cell nonlinear effects. The DT provides a controlled and customizable environment, serving as a reference system for a prior verification of the measurement equipment, before conducting tests on the cell.

Primary authors: Prof. CARINI, Alberto (Università degli Studi di Trieste); Mr MAURI, Alessandro (Università degli Studi di Trieste); Prof. ORCIONI, Simone (Università Politecnica delle Marche)

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