Fast EIS
Development of a new technique for fast electrochemical impedance spectroscopy

Master Project (30 ECTS) / Semester Project (10 ECTS)

Administrative

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Location: Sion or remotely (travel allowance offered)
Remarks: If interested, please send your CV, with a short motivation letter, to Florian.

Project description:

Electrochemical Impedance Spectroscopy (EIS) is a powerful diagnostic technique widely used for characterization of electrochemical systems such as fuel cells and electrolyzers.

The conventional method to acquire a full spectrum consists of sweeping sequentially through a predefined list of frequencies, one at a time. For each frequency, the impedance is measured by the system response to a pure, mono-frequency, sinusoidal excitation signal. Although widely used, this method suffers from very long acquisition times, especially at low frequencies. At 0.1Hz, measuring over 2 periods requires 20 seconds. At 10mHz, it requires more than 3 minutes for a single point, and tens of points are needed to get a full spectrum. This is often too long to maintain stable experimental conditions and does not allow continuous monitoring.

To overcome this limitation, EIS techniques using multiple simultaneous frequencies have been developed, drastically reducing measurement time. For instance, pseudorandom white noise or multi-sine EIS, where multiple pure sinusoids are applied simultaneously and the response is then analyzed with a DFT. However, wisely choosing these optimum frequencies is still an open research topic.

The goal of this project is to develop such a method for fast EIS. Different techniques are already described in the literature, and some manufacturers are slowly implementing them on their devices.

Your tasks:

- **Literature review**: Study the techniques used by different manufacturers (Gamry optiEIS, Zahner, Biologic, Solartron & more). Some research groups are also developing similar techniques (contact us for all references).
- **Mathematical development**: Definition of the problem and selection of the best technique.
- **Matlab Simulink:** Implementation of the algorithm, simulations on basics circuits and evaluation of the results.
- **Real-world application**: If possible, this technique may be tested in the GEM lab on various fuel cells (SOFC/PEM) and electrolyzers (SOEC/AEM) thanks to a fully customizable and programmable 18kW power supply/EIS system developed internally.

Requirements:

- Knowledge in electronics, electrical engineering, signal processing, data analysis and modeling in Matlab.
- Experience with fuel cells/electrochemical systems is beneficial but not necessary.