ModuLab®
electrochemistry

Application Guide

EIS cell analysis techniques
Low Impedance EIS Tests

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Application Guide: AGML12

Introduction
Energy storage devices are typically very low impedance (often well below 1 mΩ), so accurate impedance measurements of these low impedance devices are of critical importance in the development of new technology fuel cells, batteries and supercapacitors. Usually galvanostatic (current control) mode is used for testing these devices since potentiostatic (voltage control) can lead to an unpredictable amount of current flow through the cell. A small voltage change of a hundred µV or even less can lead to many amps of current flow. However, current control can lead to very low level AC voltage waveforms. Often higher current may be needed in order to obtain a measurable amount of AC voltage, so the use of current boosters and sensitive voltage measurement instrumentation are important when selecting a test system. This application guide concentrates on the area of very sensitive voltage measurement. The demonstration makes use of a length of very low resistance metal alloy that is used to show the remarkable voltage and hence impedance sensitivity of the ModuLab system.

Key system capabilities used in this demonstration
- AC voltage resolution, leading to measurement of impedance in the sub-mΩ region.
- 4-terminal measurement capability, critical for low impedance measurement.
- Use of the Booster 2A option for higher current capability, giving higher voltage to measure.
- External boosters up to 25 A may be added if higher current is needed.

Equipment required for this demonstration
- ModuLab electrochemical test system with Booster 2A (experiment may be run at lower current if the potentiostat only is available)
- ModuLab low impedance demonstration box

Connections
- Connect the ModuLab potentiostat to the low impedance demonstration box using the connection diagram shown in the following experiment. Use CE to red, WE to black, RE2 to green and RE1 to the blue connector close to the CE red terminal. Then move the RE1 connection to the next blue connector in sequence making impedance measurements at each position.

Experiment setup
Select "AGML12 Low Impedance EIS Tests" in the "ModuLab Application Guide" project

Step #	Purpose
Step 1	100 mA Galvanostatic Impedance measurement 1 kHz to 1 Hz at each connection position

Additional test possibilities:
- Auxiliary channels can test between consecutive blue terminals to simulate low impedance cells in a stack
- Higher current levels can be used by adding external boosters

Notes on setup

In this experiment, the potentiostat reference voltage inputs are connected to different positions on the Low Impedance demonstration box. The impedance between each successive blue terminal on the box is around 100 μΩ. As progressive impedance sweeps are run, a series of curves emerge with separation between the curves of 100 μΩ. This shows the very high resolution capabilities of the ModuLab system. As higher current levels are applied, the voltage drop across the demonstration box increases and becomes easier to measure. This experiment was run at only 100 mA AC signal level, so there is a lot of additional resolution in reserve if the boosters are used.

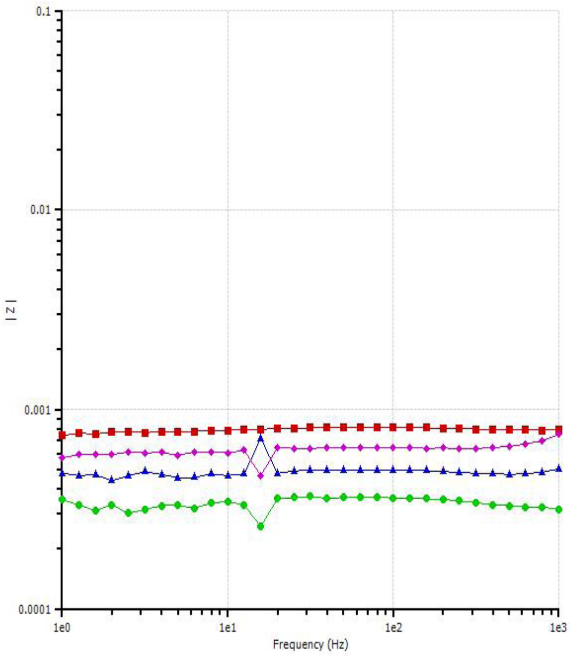

Figure 1a - Impedance traces at 100 μΩ separation

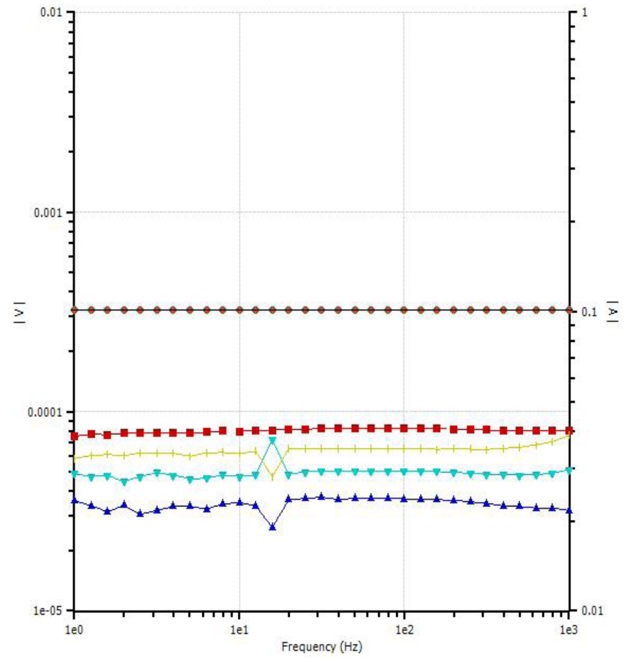

Figure 1b - traces at 10 μV separation, 100mA stimulus

Data presentation and analysis

The data may be displayed as impedance magnitude and phase plotted against frequency (Figure 1a). Various plots can be overlaid by clicking on a data file in the tree and then use the "drag and drop" facilities to place the file into the graph area of the screen. This creates an automatic overlay. When the required graphs have been selected in this way, then simply click on "Save" at the top of the display setup to create a graph file with all traces saved in place.

The ModuLab software also allows the same data to be displayed as AC voltage and AC current vs. frequency (Figure 1b). This display is very useful for monitoring the voltage level that is actually being measured (in the above example the difference in voltage between adjacent traces is only 10 μV and there is still plenty of resolution available). The experiment may be re-run at different AC current levels to see the effect of measurement noise on the data.

Conclusions

The ModuLab system was very much designed with fuel cell, battery and supercapacitor measurement in mind. The system has excellent voltage resolution which is ideal for this application and the capabilities of the software to display data in various formats is very useful for optimization of the experimental conditions.

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