ModuLab®

electrochemistry

Application Guide

EIS cell analysis techniques
High impedance electrochemical measurements using the ModuLab femto ammeter option

John Harper and Brian Sayers
Solartron Analytical, Farnborough, UK.

Application Guide: AGML13

Introduction

Measurement of very high impedance samples (ultra-low current) presents a formidable challenge. Measurement technology has not been able to keep pace with the market demand for sensitive, accurate and reproducible high impedance measurement instrumentation. High impedance applications include ultra-microelectrode studies, high-impedance coating and corrosion research, nano-electrochemistry and research on carbon nanotubes (CNT). The ModuLab femto ammeter option when used with a potentiostat and frequency response analyzer has been designed to fill this measurement void. This demonstration guide focuses on EIS electrochemical measurements. However, the femto ammeter option is also able to perform ultra low current DC measurements and that is referred to in another application guide.

Key system capabilities used in this demonstration

- High resolution signal processing and rejection of noise were fundamental design goals. Measurement performance was not compromised with careful selection of components, layout and screening.
- Double screened measurement circuits, triax cabling and high stability reference resistors permit measurements down to the fA region.

Equipment required for this demonstration

- ModuLab potentiostat, femto ammeter option, frequency response analyzer
- High impedance demonstration cell and connections

Connections

- For high impedance measurements 3-terminal connections are used.
- Connect the ModuLab potentiostat to the high impedance demonstration box using the connection diagram shown in the following experiment.

Experiment setup

Select "AGML13 High Impedance EIS Tests" in the "ModuLab Application Guide" project

Step #	Purpose
Step 1	Run impedance test from 100 kHz to 1 mHz using the 1 pF capacitor circuit in the high impedance demonstration box.

Additional test possibilities:

- When making extremely sensitive measurements, the impedance signal integration facilities provided by ModuLab can very much help to reduce noise. Try experimenting with longer integration times in the frequency response analyzer measurement set-up.
- The HV high voltage options can also be used to inject a higher voltage signal into the sample and therefore produce higher current levels. Of course, non-linearity and sample breakdown may occur if the voltage is increased too much, but in some applications this can be a useful technique.
- Whenever testing a real cell, make sure that adequate precautions are taken to shield the cell from interference (Faraday cage)
- Multi-sine / FFT may be beneficial for low frequency experiments that are typical in this application.

Notes on setup

Consult the setup files in the ModuLab demonstration software for more details.

Data presentation and analysis

High impedance analysis on ultra-microelectrodes or corrosion coatings are demanding applications. Of critical importance is the ability of the instrument to reject noise which is often several orders of magnitude greater than the signal. To get the best results careful attention should be made to screening the test item. In addition, use of longer signal integration time is beneficial. Of course this makes the experiment take longer to run, but use of multi-sine / FFT mode may also help to speed up the analysis. The results shown below show that the system is able to resolve to at least 10 Tohms and with higher signal levels and longer integration, even higher impedance levels can be attained.

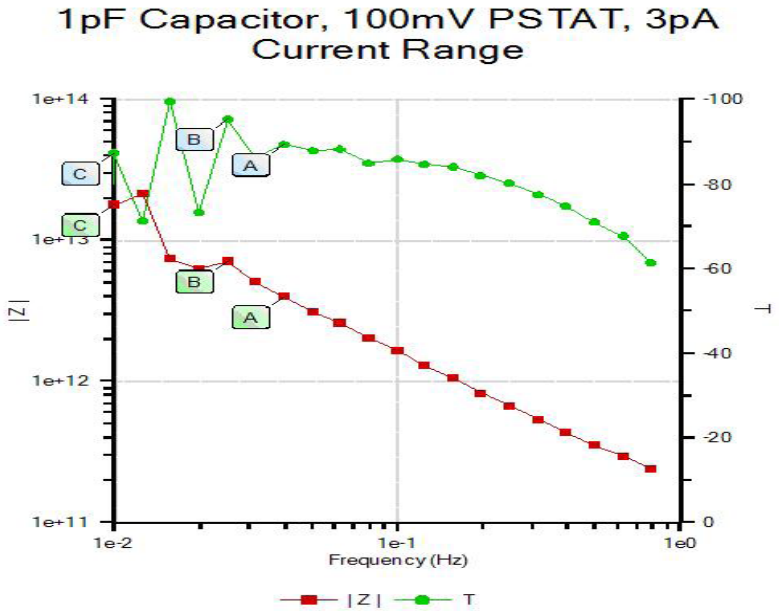

Figure 1. Impedance plot from the 1 pF capacitor in the high impedance test box.

Conclusions

The ModuLab Femto Ammeter option card represents a major technological step in potentiostat design. Attention to detail, using only the best components and rigorous efforts to eliminate noise have made this option the ideal choice for electrochemical measurements in nanoscale applications and on high-impedance devices.

Application Guide

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UNIT B1 ARMSTRONG MALL
SOUTHWOOD BUSINESS PARK
FARNBOROUGH, GU14 0NR
UNITED KINGDOM
Phone: +44 (0) 1252 556 800
Fax: +44 (0) 1252 556 899

801 SOUTH ILLINOIS AVENUE
OAK RIDGE
TN 37831-2011
USA
Phone: +1 865 425 1360
Fax: +1 865 425 1334

Visit our website for a complete list of our global offices and authorized agents

solartron.info@ametek.com www.solartronanalytical.com

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