Technical Note

Princeton Applied Research

AMETEK

Subject: General Noise Mitigation Techniques

Introduction

Our Global Support Team has decades of experience providing our users practical solutions to common issues in electrochemical measurements. This document is part of a series to formalize these suggestions and make them directly available to our users.

Data that appear "noisy" can be the result of a myriad of experimental factors. Users must consider contributions from environmental noise, the electrochemical cell itself, and the experimental parameters under which an experiment is being run. A discussion of all possible sources of noise and how to address each one is beyond the scope of this Technical Note. Rather, the purpose of this Technical Note is to make users aware of the many noise mitigation techniques that are available, whether in general or specific to certain Princeton Applied Research potentiostats.

Environmental and Experimental Setup (Pre-Experiment):

Consider the experimental set-up – use standard cables in good working order, a low impedance reference electrode that has been well maintained, power-off and unplug nearby equipment (stir/hot plate, other instruments), power potentiostat and PC using the same outlet if possible, etc.

Employ a Faraday Cage, which is highly recommended for measuring currents below 100 nA of current. The importance of a Faraday cage depends on the impact that a couple of nanoamps of pickup will have on your signal levels.

If the line power being supplied to the instrument is unstable, which could lead to noise pick-up a line conditioner can be used to remove these variations.

Notch Filters are available on the PARSTAT 4000, PARSTAT MC and VersaSTAT 3F and are specific for those frequencies associated with line power (50/60Hz). Use of the appropriate Notch Filter, based on the line power frequency supplied to the potentiostat, can reduce noise pick-up from power sources. *Note that this filter should only be used in DC mode.*

Filters and Experimental Parameters (During Data Acquisition):

In the Advanced Properties window within an Action in VersaStudio, there are E and I Filters that can be selected to decrease noise in the system during the acquisition.
Consider the cell response when making these selections. Slower (Longer) filters reduce noise the most, but at the extreme this can impact your signal and response.
This is generic filter behavior and more details are available in "VersaStudio Instrument Properties – E & I Filters" available on the Princeton Applied Research website.

Ensure that the correct current range is being employed. Details are available in “VersaStudio Instrument Properties – Current Range” available on the Princeton Applied Research website.

Consider the scan rate (mV/s) being used. There are 2 components to scan rate – Step Height (mV) and Duration (s). Note the voltage resolution and do not make steps that are smaller than this value. Also note the Non-Faradaic / Faradaic current ratios and do not make the steps too large. For example, 100 mV/s defined by a 100 mV step every 1 sec is not necessarily equivalent to a 1 mV step every 10 ms.

Averaging (Post-Data Acquisition):

After the data is acquired, there are several different averaging algorithms that can be implemented under "Graph Properties → Smoothing". These are mathematical processes -- sometimes called digital filters – that use math, as opposed to hardware components, to smooth out the responses.

The smoothing options offered in VersaStudio include sliding average (5, 10, 15, or 20 Point Sliding Average), moving average (5, 10, 15, or 20 Point Moving Average), or a Savitsky-Golay algorithm (5 or 10 point quadratic fit). Smoothing with either a Sliding Average or Savitzky-Golay algorithm can reduce the effects of noise or jitter, particularly on current data. A Moving Average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends.

If you anticipate that you will use averaging, you should consider oversampling, or taking extra data, during acquisition so that the averaged data maintains the intended resolution. This approach will make the data appear smoother, but caution and good judgement should be used to avoid loss of relevant information (*i.e.* smoothing out a meaningful peak).

Summary

More detailed information and suggestions for optimizing your experiment so that the best measurement can be acquired are available in the online Support Center at Princeton Applied Research.com. Please also refer to the Guide to Practical Solutions for Common Technical Questions for additional guidance on how best to proceed with troubleshooting.