Princeton Applied Research

Power and Flexibility

- Potentiostatic EIS (Single-Sine and Multi-Sine), Galvanostatic EIS (GEIS), and Mott-Schottky techniques for all your EIS needs.

- Frequency scans of 10 µHz–1 MHz (depending on hardware and technique).

- View up to four different graph styles on a single screen from a selection of 13 default graphs, or select from over 20 parameters for user-defined graphs.

- Overlay previously acquired data on specific real time plots for on the spot comparisons.

- Numerous analysis tools to easily extract information from the data including Line Fit, Circle Fit, and Graphical Impedance Math (Z Math).

- Perform data analyses during the data acquisition.

- Merge data from multiple scans into one data set for analysis, including potentiostatic EIS scans with galvanostatic EIS scans.

- Autoexecute provides unattended, sequential experiment control, even with other PowerSuite techniques (such as DC corrosion techniques).

Discover the power of a true 32-bit Windows program with the PowerSINE EIS Measurement Software module for our electrochemistry PowerSuite software platform. Take advantage of all the new features including powerful wizards, new graphics and data presentation formats and easy-to-use import/export tools for both graphs and data.

PowerSINE continues the tradition of providing world-class acquisition and analysis software for electrochemical impedance spectroscopy experiments.

When used to study electrochemical systems, electrochemical impedance spectroscopy (EIS) can provide accurate kinetic and mechanistic information using a variety of techniques and output formats. For this reason, EIS has become a powerful tool in the study of corrosion, batteries, semiconductors, coatings, electroplating, and fuel cells, to name a few.

PowerSINE, the PowerSuite module that provides EIS techniques for data acquisition and analysis with Princeton Applied Research systems, has expanded its capabilities (with version 2.40 and above), and now provides four impedance techniques; Single-Sine Potentiostatic EIS, Multi-Sine Potentiostatic EIS, Mott-Schottky, and Galvanostatic EIS.
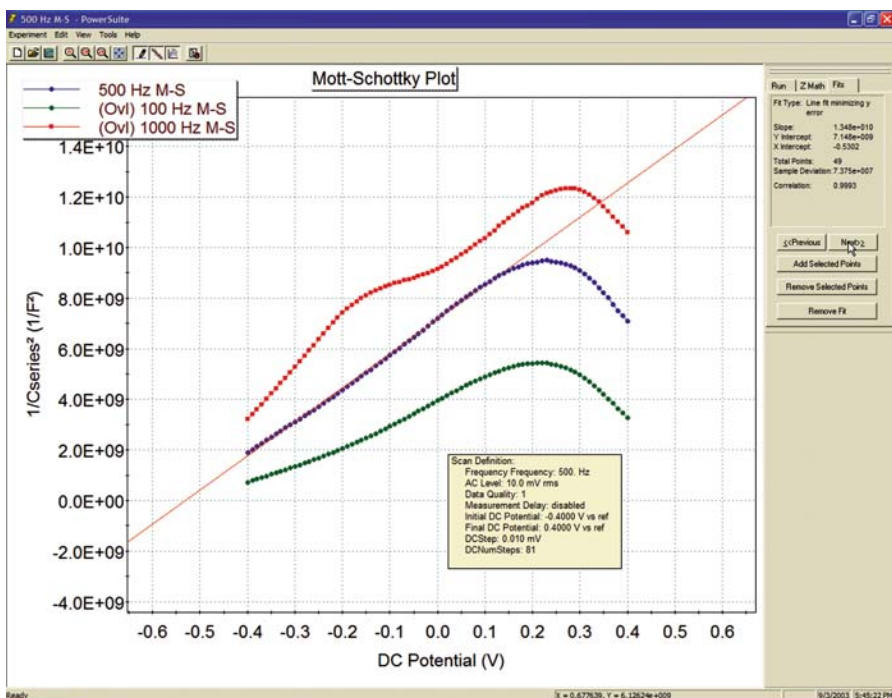
Single-Sine experiments acquire an impedance spectrum over a range of frequencies (range is instrument-dependent) with the cell under potentiostatic control in two, three, or four electrode configurations. The user can control the AC voltage amplitude, DC bias voltage, starting and ending frequencies, number of data points sampled (linear or logarithmic), and measurement delays.
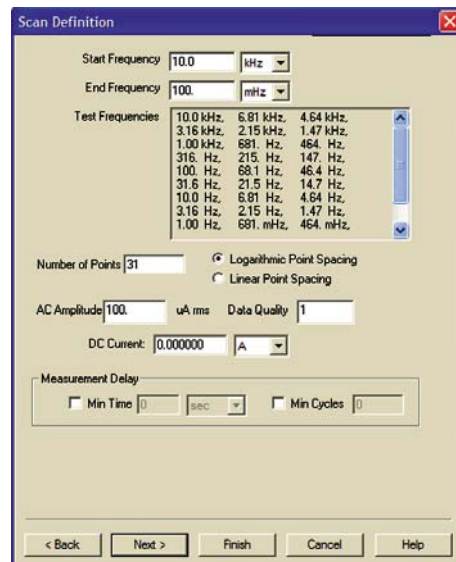
Multi-Sine potentiostat EIS technique allows experiments in the 10 µHz–10 Hz range to run in approximately half the time of the single-sine technique for the same frequency range, collecting two decades of frequency data simultaneously. This is an advantage when wanting to acquire data rapidly in a changing electrochemical system. Running multiple multi-sine scans to cover a wide frequency range is not an issue thanks to the Autoexecute capability and Merge Data function. Potentiostatic EIS (Single-Sine and Multi-Sine) is useful for coatings analyses, corrosion rate determinations, and kinetic experiments.

Mott-Schottky is a type of AC voltammetry where a single frequency ac signal is applied over a range of DC bias potentials, with the cells impedance being measured at each discrete DC potential step. The default plot for the Mott-Schottky technique of $1/C^2$ vs. DC voltage is commonly used in semiconductor and film formation (adsorption) studies.

Galvanostatic EIS (GEIS) experiments are similar to the Single-Sine technique, however, the cell is under galvanostatic control rather than potentiostatic control. The user can control the AC current amplitude and DC bias current, allowing the DC potential to "drift" over the course of an EIS experiment. For this reason, the GEIS can be useful in those experiments where the application of a bias potential is unwanted, for example, during oxide formation in a corrosion study.

Discover the right-click power in PowerSINE. Just right-click the mouse on any graph and a full complement of analysis tools and graphical options appear at your finger tips. Use the Line Fit and Z Math to determine the capacitance on a Bode Magnitude plot, and use the Circle Fit on a Nyquist plot to estimate the resistance of a time constant. To statistically test your data against an equivalent circuit, copy Z data to ZSimpWin® and obtain your results with just a few clicks of the mouse! (Note: ZSimpWin is sold separately.) Better still is the fact that you can perform all these functions during the acquisition.


With over twenty parameters available for custom graphing, one can create and save unique techniques. As an example, we have added impedance at a single frequency versus elapsed time as a technique to our Single Sine and GEIS techniques. Simply set up a new experiment with the desired parameters, create and add custom plots/graphics, save as a template, and now you have added a custom technique to PowerSINE!
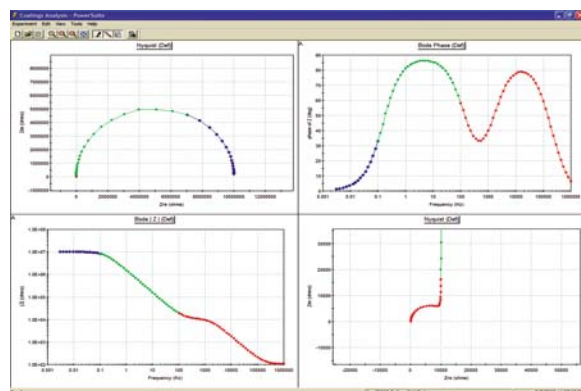
PowerSuite, our 32-bit Windows 95/98/NT/2000/XP application software, provides a simple, flexible and extremely powerful software interface to perform corrosion techniques with Princeton Applied Research Instrumentation.

PowerSuite's unique data storage format using a Microsoft® Access database makes a number of other powerful features available to PowerSuite. They include making changes to some experimental parameters on the fly, performing fits on data as it's being collected, searching data files based on comments added by the user, and exporting data and plots to other programs such as Excel or PowerPoint.
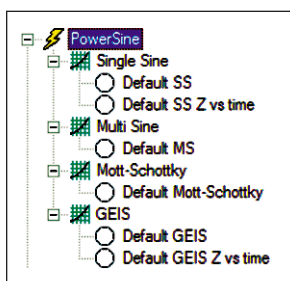
For new users, the "New Experiment Wizard" guides you through a step by step process to configure all aspects of the experiment. Once you have a setup that is to be repeated over several experiments, it can be "Saved as a Template…" , recalled, and executed without having to re-enter information with each use.

PowerSuite's dominant feature is the graphical capabilities that provide tremendous flexibility with data presentation. Up to four plots can be viewed simultaneously on the screen without opening a separate viewing program. Several default plots are available, and the user has the ability to modify each or create and save their own custom graphs according to their criteria. A wide variety of parameters are available for plotting, as well as the ability to add a second Y-axis or view the plot in 3-D. The user can select the data symbols/lines desired, and change the color of any plot.

Additional graphical features allow for the data of any axis to be modified (by choosing either +, –, /, or * the axis values) using the Data Factors feature. This feature can be used to change a reading in amps to microamps for data comparison purposes, or it can be used to convert a potential reading acquired from an ancillary component (such as a temperature probe) through the Auxiliary Input into its proper values (such as °C).

Overlaid data from prior experiments can appear on up to four different graphs simultaneously. You can even place the overlay data on the plots prior to acquiring the data, which allows the user to compare the two data sets as the experiment progresses! The
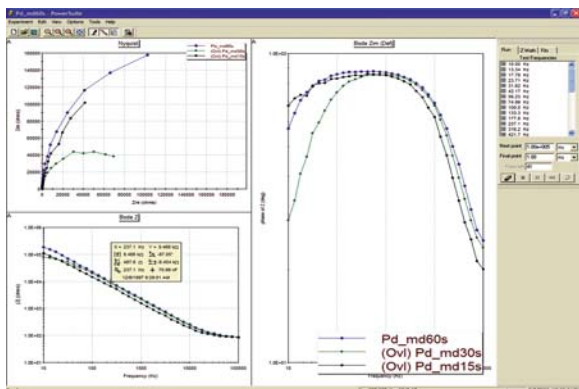

graphical properties of the overlaid data can also be modified in terms of color or plot style. Any overlaid data can be selected to become the "active" data file, at which point the current "active" file becomes an overlay, and full data analysis can be performed on what was an overlay! A number of graphical and analytical features are available by right-clicking on any graph and selecting from a full complement of options.

The "Hover" window feature in PowerSuite provides you with a unique information window for any data point, even during the acquisition. Just position the cursor near a data point and the Hover box will appear, providing detailed information on that data point determined by the type of plot being examined.

The Experiment Bar in PowerSuite provides a live interface to the experiment. The control buttons on the Experiment Bar's Run tab allow the user to start, stop, or pause an experiment. The Fits tab on the Experiment Bar provides the information on Line Fits, Circle Fits, Rp Fits, Tafel Fits, Peak Analysis, etc., depending on the data being analyzed. An Instrument Toolbar provides information on the ID of the instrument being controlled, the cell on/off status, current scale, as well as the current and potential measurements.

The Autoexecute Bar gives you even more automated control over PowerSuite. Experimental templates can be entered into control windows for execution, along with time delays, loops, and even user prompts. Any template can be added to an Autoexecute sequence, allowing a user to run, for example, both DC and AC corrosion techniques in the same sequence! An Autoexecute can be created and saved for repeated use to allow the user to work while away from the instrument, increasing productivity and throughput.
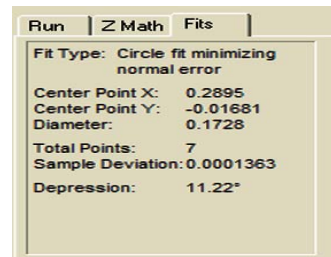
PowerSINE Specifications

Frequency Limits
Single Sine: 10 µHz – 1 MHz (with 283 and PARSTAT)
Multi Sine: 10 µHz – 10 Hz

AC Amplitude (RMS)
Single Sine: 0.1 mV – 1000 mV
Multi Sine: 0.1 mV – 700 mV
Mott-Schottky: 1 mV – 1000 mV
GEIS: 100 pA – 1 A (depending on hardware)

DC Potential: ±8000 mV

Current Range Selection: Fully Automatic/Fixed/Initial (fixed for GEIS)

Prescan Options Include:
Conditioning Potential: ±8000 mV
Initial Open Circuit Delay
Open Circuit Potential Measurement
Equilibriation Period

Electrode Types Supported
Solid
Rotating – selectable rotation rate
SMDE (303A)

Auxiliary A/D Acquisition: At each frequency point (if hardware supported)

Data Manipulation and Analysis
  Z Math (Graphical Impedance Math)
    • add/subtract series components
    • add/subtract parallel components
  Apply Constant Factor
    • multiply Z data set/selected points by constant
  Line Fit (Multiple Fits/Graph)
    • slope
    • X/Y intercepts
    • sample deviation
    • correlation
  Circle Fit (Multiple Fits/Graph)
    • center point
    • diameter
    • sample deviation
    • depression angle
  Merge Data Set
    • merge data from multiple data sets into one
    • merge potentiostatic and galvanostatic results
  Purify
    • remove constant factors, data set mergers, and accept all
      rejected points
  Copy Z Data
    • copy to paste into ZSimpWin or other modeling package
  Data Point Rejection
    • reject selectable points
    • show/re-accept rejected points

Plotting Styles (Real Time or After Experiment)
  Thirteen default styles
  User-defined options**:**
        Frequency
        Sqrt (Frequency)
        1/Sqrt (Frequency)
        Elapsed Time
        DC Potential
        DC Current
        Auxiliary Signal
        C Series
        1/C Series
        1/C Series^2
        L Series
        Impedance (Z) (choose between magnitude, real part,
              imaginary part, phase angle [rad or deg])
        AC Potential (V ac)
        AC Current (I ac)
        Admittance (Y)
        Complex Capacitance (C)

Hardware Requirements (minimum)
Potentiostat: 263A (version 2.19), 273A /92 (version 202), 283 (version 1.04), 273/92/96 (version 107), BES, 6310A, PARSTAT

Single Sine Analyzers
(required for 263A, 273/273A, and 283)
5210EC Lock-in Amplifier
1025 Frequency Response Detector
FRD100 Frequency Response Detector
FRD2000 Frequency Response Detector
Solartron 1255/1260 FRA

Recommended Computer Specifications
Pentium II
64 MB RAM
50 MB available HDD space
CD-ROM drive
Microsoft Windows® 95/98/2000/NT/XP

Interface Card (GPIB Instruments only)
National Instruments AT-GPIB/TNT, PCII/IIA, PCMCIA GPIB card and NI 488.2 Driver

Specifications subject to change
090803

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