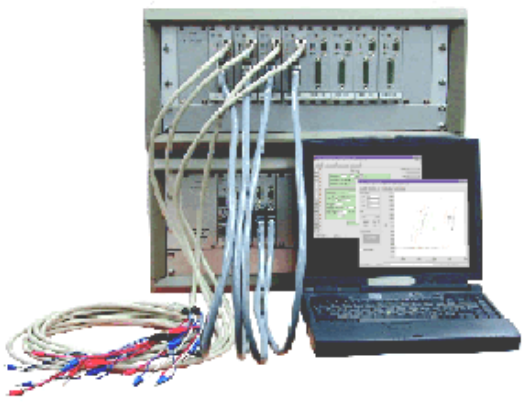
VMP2 & VMP2/Z multichannel potentiostats

- From 1 to 16 channels
- Complex impedance measurements on all channels (1-16) simultaneously and /or independently from 10µHz to 200kHz (with the EIS option)
- From 1 nA up to 400mA in standard
  - From 100 fA up to 400mA with the 'p' low current option
  - From 1 nA up to 80A with booster option
- Current autoranging
- Input impedance of 10^{12} ohm in parallel with 20pF - with the 'p' low current option: 10^{14} ohm in parallel with 1pF max
- Simultaneous measurement of potential and current
- 20 Volts Control Voltage (adjustable from ±10V to 0-20V)
- 200µSec software Timebase
- Ethernet communication
- Up to 16 electronically independent channels or 16 Working with 1 CE and 1 RE
- 2 Auxiliary Inputs per Channel
- 2, 3, 4 and 5 Terminal measurements
- Switches from potential to galvanostatic control in <10 µs
- Data channel buffers in the VMP2 retain data even if PC is disconnected
- External security input to open circuit
- **LabVIEW® Vis**



VMP2/Z with booster unit.

Specifications

Cell control	Potential measurement
Converters: 16 bits dynamic DAC + 12 bits attenuation DAC + 12 bits DC shift DACs **Control Voltage Range:** ±10V adjustable to 0-20V **Maximum applied current:** ±400mA continuous with thermal shutdown protection, ±2.4A peak (±1A peak with 'p' low current option) with a 1/10 duty cycle for GSM protocols - up to 80A with booster option **Applied potential resolution:** 300µV on 20V	**ADC converters:** 16 bits ADC + 12 bits shift DAC **Ranges:** ±2.5V, ±5V, ±10V plus ±10V adjustable DC shift level **Measured potential resolution:** 0.0015% of the range, down to 75 µV **Acquisition speed:** 200,000 samples / second **Measured potential accuracy (DC):** < 0.1% FSR **Electrometers**

dynamic range, programmable down to 3µV on 200mV dynamic range
Applied current resolution: 0.004% FSR*, down to 0.76nA - down to 76 fA with the 'p' low current option
Applied potential accuracy (DC): < 0.1% FSR
Applied current accuracy (DC): < 0.1% FSR
with the 'p' low current option:
* <1% FSR on the 1nA range
* <0.5% FSR on the 10nA range
* <0.1% FSR on the other ranges
Bandwidth control: 7 stability factors, loop compensation poles at: 680kHz, 217kHz, 62kHz, 21kHz, 3.2kHz, 318Hz, 32Hz
Frequency response: (small signal) regulation
Shunt 1kOhm / Load 1kOhm
Potentio: 300kHz (3dB)
Galvano: 100kHz (3dB)
Shunt 100kOhm / Load 100kOhm
Potentio: 100kHz (3dB)
Galvano: 10kHz (3dB)
Rise Time: <2µS (no load)
Slew Rate: >3V/µS (no load)

Current measurement

Converter: 16 bits ADC
Ranges: ±10µA(100kOhm), ±100µA(10kOhm), ±1mA(1kOhm), ±10mA(100Ohm), ±100mA(10Ohm), ±1A(1Ohm)**
** limited to 400mA DC
additional ranges with the 'p' low current option: ±1nA(1GOhm), ±10nA(100MOhm), ±100nA(10MOhm), ±1µA(1MOhm)
Maximum resolution: 0.004% of the range, down to 763 pA - down to 76.3 fA with the 'p' low current option
Acquisition speed: 200,000 samples / second
Measured current accuracy (DC) < 0.1% FSR
with the 'p' low current option:
* <1% FSR on the 1nA range
* <0.5% FSR on the 10nA range
* <0.1% FSR on the other ranges

Inputs: 3 potential measurements leads with 2 differential voltage measurements
Impedance: 10^{12} ohm in parallel with 20pF - with the 'p' low current option: 10^{14} ohm in parallel with 1pF
Bias current: < 5pA
with the 'p' low current option: 60 fA typical, 150 fA max @ 25°C (it doubles every +10°C)
Common mode rejection: > 60dB at 50kHz - with the 'p' low current option: > 60dB at 10kHz

Impedance specifications (Z version only)

Frequency range: 10µHz to 200kHz
Sinus amplitude: Programmable from 1mVpp to 1Vpp in potentio mode and 0.1% to 50% of the current range in galvano mode

Additional Inputs / Outputs

2 general purpose analog inputs: 16 bits resolution with programmable range ±2.5V, ±5V, ±10V
1 external input trigger: TTL level
1 external output trigger: TTL level
1 external security input to Open Circuit: TTL level

General Specifications

Computer interface: Ethernet (TCP/IP)
Number of channels: from 1 to 16
Cell cable length: 1.5m
with the low current option:
* board to probe: 1.3m
* probe to cell: 0.15m
'p' option probe dim: 12x7x3cm
Power requirements: 85-264 VAC, 47-440Hz

Specifications subject to change

*FSR=Full Scale Range | i.e. ±1mA range <=> FSR=2mA
Note: The max continuous applied&measured current without booster was limited to 250mA instead of 400mA for instruments delivered before April 2004.

Ordering information

For ordering information, please contact your **local representative**. Standard VMP2 units come in 1 to 16 channels configurations with a choice of Z or non-Z channel boards. 'p' low current options are also available as well as a number of booster units that can be configured for a variety of applications.

General Hardware Specifications

The VMP2 is a computer-controlled multi-channel potentiostat/galvanostat. Each channel of the VMP2 can be controlled independently or be used in conjunction with other channels (potentiostats) to perform the same experiment on different electrodes. In addition, up to 16 channels can be used with one reference and one counter electrode (N'stat mode).

Each potentiostat is capable of ± 10V scan ranges, 400 mA current capabilities with 20V control voltage, and a timebase of 200 µSec.

Each channel of the VMP2 can be impedance capable with a built-in analyzer (Z version).

The std channel board with cable

Each channel of the VMP2 can be equipped with the **'p' low current option** providing a sub pA resolution.

The VMP2 unit comes complete with Windows-based electrochemistry and battery test software **EC-Lab**. Communication is Ethernet-based.

Impedance version (Z)

The VMP2 channels can be individually ordered either in potentiostat/galvanostat version or in potentiostat/galvanostat/EIS (Z) version. The Z version has a built-in impedance analyzer capable of performing electrochemical impedance spectroscopy from 10 µHz to 200 kHz.

A VMP2 unit outfitted with multiple Z capable channels can perform simultaneous impedance experiments on each channel. A VMP2 unit can contain a mixture of Z channels and non-Z channels.

'p' low Current Option

Each channel of the VMP2 can be equipped with the 'p' low current option providing a sub pA resolution. This option extents the current ranges down to 1nA with a resolution better than 0.1 pA.

A VMP2 unit can contain a mixture of standard channels (Z or non Z) and channels equipped with the 'p' low current option.
Each 'p' low current option must be installed in one of the 16 slots of the VMP2. This limits the maximum number of channels all equipped with the 'p' low current option to 8 in the same instrument.

More information can be found following the below link:

- **'p' low current option for VMP2 & BiStat**
- **'p' low current option - measurement precautions**

Current and Voltage

The VMP2 has a maximum continuous current specification of 400 mA on each channel. Each channel can be boosted up to 80 amps, depending on which power booster is interfaced to it. The minimum current range is 10 µA, with a measurement resolution of 763 pA. With the 'p' low current option, the minimum current range is 1 nA, with a measurement resolution of 76.3 fA. Current auto-ranging, not available in the VMP, has been added to the VMP2.

The reference voltage is ± 10V. The minimum potential step is 300 µV on the 20V dynamic range. Using Adaptive Signal Generation, the resolution of the VMP2 can be as low as 3 µV depending on

the voltage scan range desired.

Programmable Control Voltage

Programmable control voltage is a new VMP2 feature. The VMP2 has a 20V control voltage specification. Because the VMP2 is a virtual ground instrument, the control voltage can be adjusted based on where the virtual ground is set. For example, one can program the virtual ground to -5V, allowing the VMP2 to operate between -5/+15 Volts.

Timebase

The data acquisition rate of the VMP2 has been upgraded to 200,000 samples per second. However, at this time, the timebase used in the software techniques has been improved to 200 µSec.

Auxiliary Input/Output

The VMP2 has two general-purpose analog inputs with programmable ranges of ±2.5V, ±5V and ±10V. These can be used to record temperature, pressure, or another variable that can be converted to a voltage. There is also a TTL signal in and TTL signal out (triggers) to enable experiments to be coordinate precisely with other instrumentation events that could be necessary in your experiment.

Computer Interface

Ethernet communication is utilized by the VMP2. This allows for fast data transfer and the ability of multiple users to interface to the unit. Each user could have one channel to do his experiments and control that channel from his own computer. The ability to monitor the progress of an experiment can be accomplished from your office desk, away from the laboratory. All the benefits of Ethernet and LAN are available to the VMP2. Also, one computer can easily control multiple VMP2 units.

Downloadable "Firmware"

The firmware for the VMP2 can be downloaded from the newest version of the software available. In this way, as new techniques are implemented in the software, the proper firmware modifications can be downloaded to the VMP2 hardware unit to allow the unit to execute the necessary commands.

Autocalibration

The VMP2 also includes automatic calibration for the individual channels that can correct for internal offset and gain errors. The user can run the calibration, when needed, simply by disconnecting the cell cable. This calibration information is stored into the channel memory. As a result, channels can be swapped without worrying about calibration and also permits the VMP2 to perform power-up tests on each of the channels.

Additional Features

The VMP2 can be configured as a Zero Resistance Ammeter, and can be used in the 3,4, or 5 terminal modes. The 5-terminal mode can be used to eliminate the ohmic drop in contacts when recording a second electrode potential with respect to the reference electrode (e.g. counter electrode potential)

The VMP2 memory buffering capability allows your VMP2 unit to continue working in the event of a computer lockup. Data will be retained in its buffer section until reconnected.

Current Power Boosters

The basic VMP2 unit has a maximum current of 400 mA available for electrochemical experiments. For applications that require higher levels of current, the VMP2 line of potentiostats/galvanostats can be interfaced to a variety of current booster units. The booster units are separate from the base VMP2 instrument. They can be purchased along with the VMP2, or they can be added to your system at any time. In most cases, there is no need to return the VMP2 for any modification to allow interfacing to the booster unit.

Boosters are available to increase each channel of your VMP2 to 2, 5, 10 and 20 amps. These can be purchased in blocks of the same current levels, but can also be purchased as separate channels that can be mixed into a booster chassis. Contact your local representative to determine the possible limitations on how many or how much current a chassis can accommodate.

A **special 80A booster** has been developed with control of the potential limited to ±3V.

Bi-Potentiostat, Tri-Potentiostat.... N'Stat Operation

The VMP2 and the VMP2/Z can be configured to operate in "N'stat" mode, which allows one reference electrode and one counter electrode to work with multiple working electrodes. For multi-electrode potentiostatic and potentiodynamic pitting experiments, this is a critical feature. Other application areas do benefit from this feature:

- **Sensors** - many sensors under development utilize multiple working electrode sites under the control of one reference electrode.
- **Batteries and Fuel Cells** - The VMP2 can be used to monitor individual cells in a fuel cell where one plate serves as both cathode and anode. The unique electronic configuration of the VMP2 potentiostat allows the VMP2 to make either the working or the counter electrode the common one.
- **Corrosion** - Studies involving localized corrosion testing usually requires multiple tests done on nominally similar electrodes to develop the statistics required for result assurance. The VMP2 can be utilized to run cyclic polarization tests on multiple corrosion specimens installed in one solution environment.
- **Basic Electrochemistry** - The VMP2 can be purchased in a two channel configuration specifically to address **Bi-potentiostat** operation. Specific protocols have been developed to address those experiments that are typically used with a computer controlled **Bi-potentiostat**.

Optional items

Auxiliary inputs/outputs cable - Several auxiliary signals are available on the DB-9 connector of each VMP2 channels. For convenience we have designed a 50 cm cable that connects to the DB-9 connector of a channel on one end and with 7 BNCs on the other end. Each connection is individually shielded.

The available signals are: Ewe monitor, I monitor, TTL input, TTL output, Analog input#1, Analog input#2, Analog output.

The reference for this cable is 091-61/9.

N'stat Box accessory - The N'stat box is a VMP2 accessory designed for cells with several working electrodes, one counter and one reference electrode floating in the same bath.

The N'stat box considerably simplify the VMP2 to cell connection.

More details **here**

The reference for this accessory is 091-61/10.

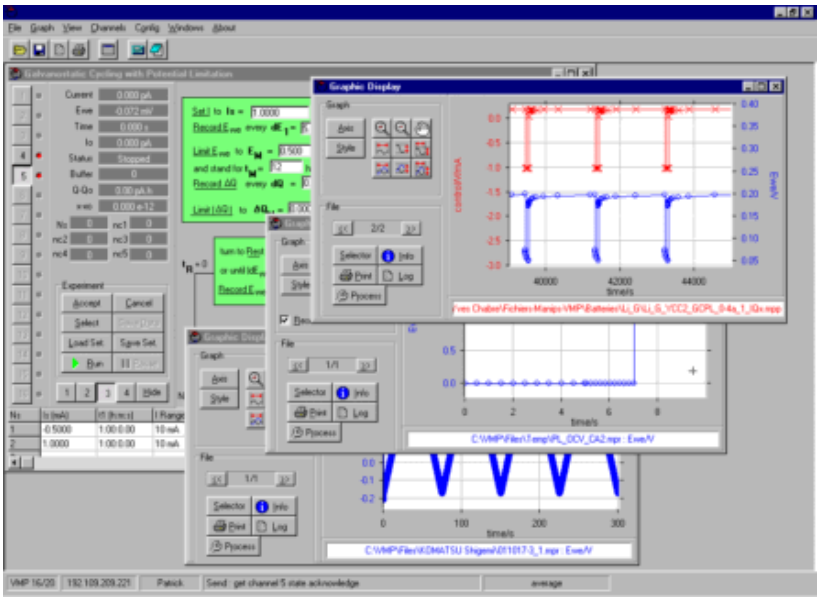
LabVIEW® Vis

Click **here**

Software

All our multichannel potentiostats are now controlled by our EC-Lab® software.

The EC-Lab® Windows-based software (95,98,ME,NT,2000 and XP) performs a variety of electrochemical techniques from basic electrochemistry to corrosion/impedance to battery test. Each of the techniques provides flexible user input, technique specific plotting formats, and data analysis tools.



Techniques

As of this writing, we offer 30 techniques for the EC-Lab®. These techniques range from Polarization Resistance and Tafel Plots for corrosion applications to Cyclic Voltammetry and Chronoamperometry for basic electrochemical research. We have a whole section of battery protocols, many designed specifically for Lithium-based batteries.

Each technique can be linked with the others allowing infinite number of combinations.

Available techniques:

- General Electrochemistry
  - Chronoamperometry / Chronocoulometry
  - Chronopotentiometry
  - Cyclic Voltammetry
  - Modular Galvano
  - Modular Potentio
  - Open Circuit Voltage
  - Polarization Resistance
  - Stepwise Potential Fast Chronoamperometry
  - Differential pulse Voltametry (DPV)
- Batteries
  - Alternate Pulse Galvano Cycling
  - Galvanostatic Cycling with Potential Limitation
  - Galvanostatic Cycling with Potential Limitation 2
  - Galvanostatic Cycling with Potential Limitation 3
  - Galvanostatic Cycling with Potential Limitation 4 (LEO - Low Earth Orbit battery satellite protocol)
  - Potentiodynamic Cycling with Galvanostatic Acceleration
  - Constant Load Discharge
  - Constant Power Discharge
- Impedance
  - Potentiostatic Impedance - VMP2 only !!
  - Potentiostatic Impedance versus time - VMP2 only !!
  - Galvanostatic Impedance - VMP2 only !!
  - Galvanostatic Impedance versus time - VMP2 only !!
- Corrosion
  - Critical Pitting Temperature - VMP only !!
  - Critical Pitting Temperature 2 - VMP only !!
  - Cyclic Potentiodynamic Polarization
  - Depassivation Potential
  - Generalized Corrosion
  - Linear Polarization

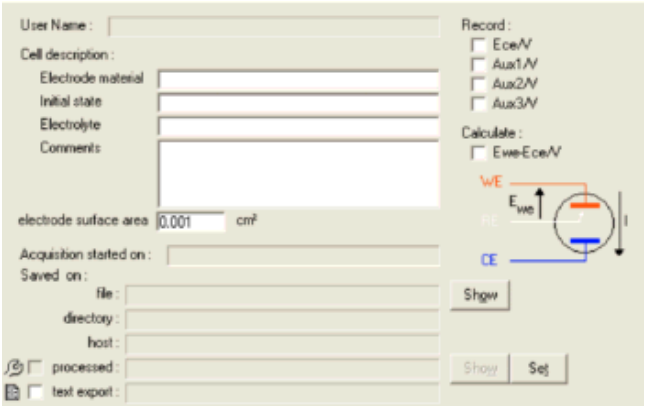
    - Multielectrode Potentiodynamic Pitting
    - Multielectrode Potentiostatic Pitting
    - Zero Resistance Ammeter
    - Zero Voltage Current
- Manual Control
    - Current Manual Control
    - Potential Manual Control
- Custom applications
    - Measure of U-I Correlation - VMP only !!

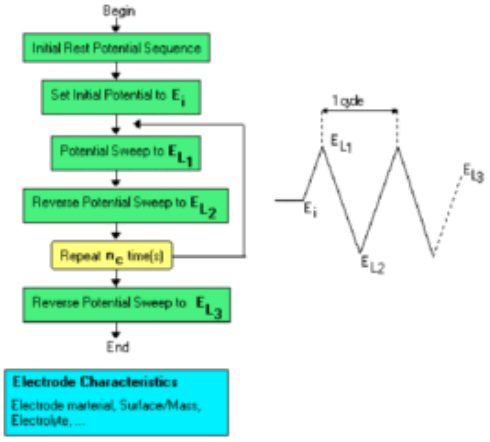
Under corrosion, there are multi-electrode techniques that utilize the "N-stat" feature of the multi-potentiostats, where multiple working electrodes are used with one reference and one counter electrode. For general electrochemistry, there are techniques for CV, CA, CE and others useful routines.

In the battery application area, there are dedicated protocols to perform accepted test procedures on fuel cells and batteries. The user has the ability to program almost any series of pulses and holds to an electrode using a unique spreadsheet format for protocol creation. This feature also benefits the electro-plating applications area where designer pulse waveforms are being used to deposit materials on substrate surfaces.

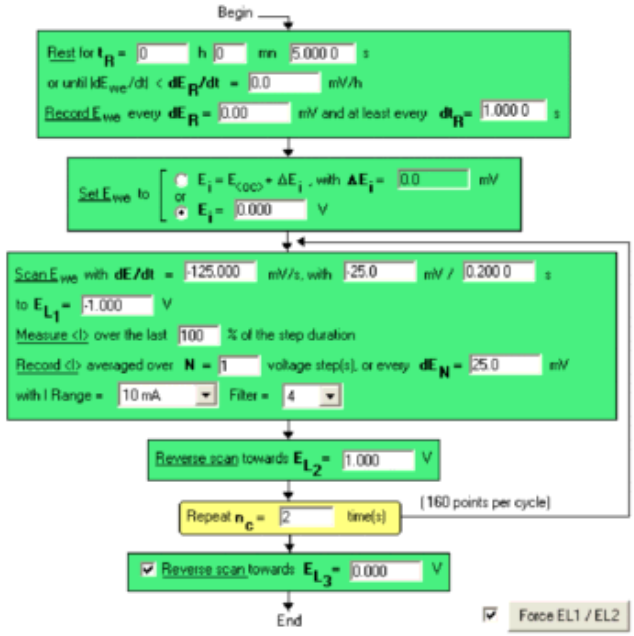
Set up Menus

Three separate menus are available to setup an experiment. Setup menus are visual in the respect that they indicate how an experiment will be executed.





General flow-diagram for Cyclic Voltammetry



Cyclic Voltammetry detailed flow diagram

Autoexecution Routines

EC-Lab® has added an auto-execution routine to allow a sequence of different experiments to be performed sequentially on a channel. This increases the flexibility of the software.

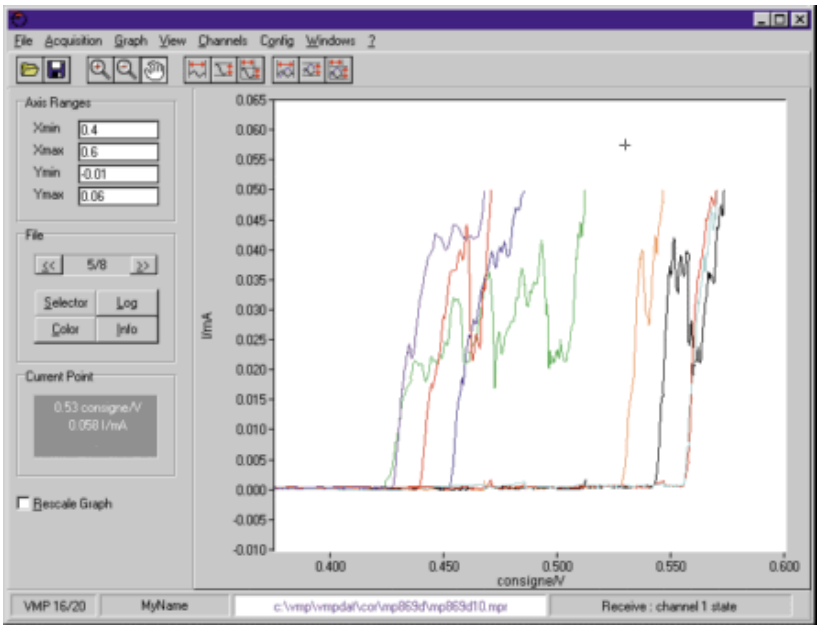
Powerful Graphics

The graphics package of the EC-Lab® software enables the user to have excellent flexibility in displaying his data. In addition to being able to see the data in the units common to the technique on the display, the user can plot many other related values, picking from a list including the charge, time, log I, and many more.

Overlays are easily shown, each overlaid plot may have a different color and point choice. Overlays are added or removed in any order.

Autoscaling is the default for the plotting routine, but one can manually scale a plot, change either axis to logarithmic, zoom and contract. Plot symbols and line types can be selected by the user.

By using the Windows tile arrangement feature, the user can display data from all actively running experiments on the screen simultaneously.



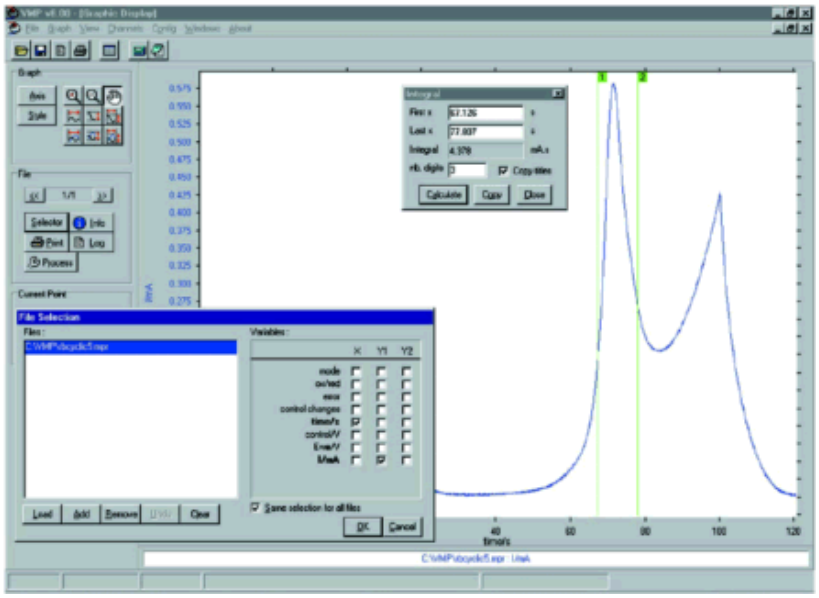
Text Exportation

The data acquired in an electrochemical experiment can be exported to a text file with the click of the mouse. In addition, a utility can be activated to implement a real time export into Microsoft Excel®, allowing the full features of Excel plotting and data manipulation to be exploited.

Data Processing

The EC-Lab® software allows for on-line and off-line data processing. The processing results will differ depending on the type of experiment. Processing allows for:

- Displaying log currents
- Tafel determinations and polarization resistance calculations
- Cycle number can be made part of the data record and can be plotted.
- Charge can be calculated
- For multi-pitting experiments, the mean value and the standard deviation of the final open circuit potentials and pitting potentials of a set of electrodes.
- Integrals can be calculated
- Smoothing
- Splitting large files



This is just a small sample of the power of the EC-Lab® software. All data files can be converted into text and are able to be imported into Princeton Applied Research's powerful PowerSuite platform for further data handling.

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