CorrWare - Tutorial

Note: This is a PDF version of the compiled help file available from the Help Menu in CorrWare Version 3.5e. One can download CorrView installation files directly from the website of Scriber Associates. This is posted here for the exclusive academic/educational use as reference material for the members of Faraday Laboratory at USC. Commercial use of this material is strictly prohibited.

Getting Started Click on the desired topic for specific help.

Setup Topics

Measurement Topics

Instrument Topics

CorrWare Menus

Select a function from the list below:

Setup Topics

- Setup Pstat/Gstat
- Setup Experiment
- Insert New Experiment
- Cut+Paste
- Replace File Names

Measurement Topics

- Starting Measurements

Instrument Topics

- New Instrument
- Modify Instrument
- Close Instrument
- Load/Save Setup

Introduction

CorrWare for Windows is an easy to learn package which maximizes the performance of both Solartron and EG&G PAR Potentiostat/Galvanostats for a variety of experiments.

CorrWare operates under Microsoft Windows providing a clear, user friendly interface. By virtue of the multitasking Windows environment, CorrWare can be run in the background allowing the computer to be used for other purposes. The CorrView companion program can be used to display, analyze and graph data from previous measurements.

Notice:
Schlumberger Technologies Instruments Division is now Solartron Instruments Limited.

All Schlumberger instruments are 100% supported by this software and by Solartron. The name Solartron will be used exclusively throughout this program. However, Schlumberger instruments with the same model number operate identically.

The name PAR is used to identify instruments manufactured by EG&G Princeton Applied Research, also known as PARC.

With CorrWare and CorrView you can:

- Setup and control all features of the Solartron 1470/80, 1287, 1286, 1285, 1284, 1280 and 1280B as well as the PAR 283, 273, 263, 263A, VersaStat2, 253(VersaStat), 276/173, and AMEL 5000 potentiostats.
- Save to disk and retrieve data files and experimental setup parameters.
- Perform experiments using any one of 16 basic formats including open circuit, constant potential or current, potential and current sweeps and square waves.
- Interleave electrochemical and impedance experiments (when used with ZPlot for Windows).
- Plot data using a wide variety of axis formats.
- Analyze data through curve fitting and linear regression in addition to polarization. resistance and Tafel slope calculation.
- Optimize experimental parameters for maximum measurement capability.
- Perform sequences of experiments as easily as a single experiment.
-

System Requirements

- Potentiostat/Galvanostat (Solartron 1470/80 1287, 1286, 1285, 1284, 1280, 1280B, or

PAR 283, 273, 263, 263A, VersaStat2, 253(VersaStat), 276/173, or AMEL 5000
- IEEE-488.2 Interface (National Instruments GPIB Board)
- CorrWare/CorrView Electrochemistry / Corrosion Software
- Microsoft Windows 95/98/NT/2000
- IBM PC/compatible computer with
- Pentium or equal processor
- 64 Meg RAM
- CD, and Parallel Port

Using This Manual

This CorrWare user's manual includes all of the information you need to install and use CorrWare on your IBM or fully compatible PC.

It is assumed that the user is familiar with Microsoft Windows and knows how to use the mouse and keyboard to access the pull-down menus.

Throughout this manual, you will be asked to select various commands from the CorrWare menu. The menu commands will be printed as **BOLD**. For example if we say select **File**, click on the word 'File' in the menu. Notice that the letter F is underlined. This indicates that the item can also be selected by holding down the 'Alt' key and pressing the F key. Selecting an item from the menu usually drops down a submenu. For example, selecting **File** drops down a submenu with items such as **New Setup** and **Open Setup...**.

We will indicate that you should select **File** and then **Open Setup...** by asking you to select **File | Open Setup...**.

CorrWare also has a 'button bar' of icons directly below the menu. Each of the icons perform the same function as an item in the menu. They are used as shortcuts for various commonly used functions.

Software Support

Program updates are available through the internet from the World Wide Web location ***http://www.scribner.com***

Before calling for support, please review the Installation and Tutor portions of the manual. Registered users of CorrWare and CorrView can receive telephone support through the following sources:

U.S.A. and Canada:

Scribner Associates, Inc.
150 East Connecticut Avenue
Southern Pines, NC 28387
Software Support: Derek Johnson (925) 862 2416 (Pacific Standard Time)
Sales and Support: (910) 695 8884 (Eastern Standard Time)
Fax: (910) 695 8886

Solartron Analytical,
a member of Advanced Measurement Technology Inc.
Division of AMETEK Inc.
801 South Illinois Avenue
Oak Ridge, Tennessee 37831-0895
United States
Toll Free: 865-482-4411
Fax: 865-425-1334

Other Areas:

Contact your Solartron Representative
or
Solartron Analytical
a member of Advanced Measurement Technology Inc.
Division of AMETEK Inc.
Unit B1, Armstrong Mall, Southwood Business Park
Farnborough, Hampshire GU14 ONR
Phone: +44 1252 556 800 Fax: +44 1252 556 899

Related Topics

Hardware Installation
Software Installation

Tutors

Software Installation

Software Protection

The CorrWare program uses a Hardware Key attached to the LPT1 (or LPT2) Parallel Port. This Hardware Key is called a "dongle" and MUST be present for the software to operate. CAUTION - Since the dongle is required for operation of the software, it is quite VALUABLE. Protect this hardware item from damage or loss! It will not be replaced without charge.

Before CorrWare starts, it checks for the presence of the dongle attached to the parallel (printer) port of the computer. This dongle gives an authorization code to enable the program to start.

The dongle has a 'pass-through' capability which makes it transparent to printers, allowing them to function normally.

To install the dongle, connect the side of the dongle labeled 'computer' to your computer, and attach your printer to the 'printer' side of the dongle.

Note: It is physically possible to connect the 'printer' side of dongle to a computers Serial (RS232) port, possibly damaging the dongle. As long as the 'computer' end of the dongle is connected to the computer, it is impossible to make this mistake.

CorrWare License Restrictions

The CorrWare software is sold as a license for use on a single computer and requires the dongle to be present every time an experiment is started.

There are versions of CorrWare for use with multiple potentiostats and a single computer. **To use CorrWare on multiple computers, contact your sales office for multiple copy pricing on CorrWare.**

The included data analysis program **CorrView, can be installed on multiple computers** for data analysis purposes only.

If you receive the message 'Product Key Not Found", check the rear of the PC at the parallel port to see that the dongle is attached.

Installation from a CD

Note for NT / Windows 2000 users:
If you are using Windows NT, 2000 or XP, you MUST log on using an account with Administrator rights. If you do not have administrator rights for the computer, the setup programs will display an error message and will not install. Consult you computer system administrator for more information on user account types.

1. Close all other applications and insert the Scribner Associates Install Disk into your CD-ROM drive.

2. Setup will begin automatically. If you have your Autorun feature turned off, choose **Start | Run....** In the command line text box, type *d:\setup* (where d: is the letter of the CD-ROM drive). Click OK.

3. Select CorrWare from the list of available programs.

4. Follow the screen directions to complete the installation. You will be asked for the drive and directory in which to install CorrWare. The default is *C:\SAI*.

6. Repeat steps 3 and 4 to install other programs from the CD. Note that CorrView and CorrWare are installed separately.

During installation, a 'Program Group' named *Electrochemistry* was created in the Windows Start menu. A CorrWare icon will appear in this program group. CorrWare is normally started by using this icon.

Related Topics

Hardware Installation
Tutors

Hardware Installation

This chapter describes the operation and installation of the National Instruments GPIB interface board for your IBM/compatible PC. In addition it describes the electrical connections used to connect the Solartron or PAR potentiostat to the electrochemical cell.

GPIB Board

The GPIB communications bus is designed to allow several instruments to be controlled by a computer over a single cable. Each GPIB device is given a unique bus address through switches on the back of the instrument. A computer can control each device on the bus by sending information to a devices address. Other instruments on the bus with different addresses will ignore the command.

It is necessary to properly install the GPIB board. The GPIB board, as furnished by National Instruments, comes with a software diskette containing the driver necessary to send commands from CorrWare to the board. CorrWare will not run unless the GPIB driver has been installed.

Important Notes:

1) National Instruments sells a wide range of GPIB interface boards (GPIB-PC2/2A, AT-GPIB, MC-GPIB, PCMCIA-GPIB, etc.). CorrWare is compatible with the current version of each of the NI boards. If you have an older version of one of these boards, it may not be compatible.

2) The GPIB board must have a driver specifically designed for Microsoft Windows and the IEEE-488.2 Protocols. If you are unsure if your board has a Windows driver, consult your National Instruments manual. If your board does not support Windows, call National Instruments to upgrade the software and/or hardware. National Instruments distributes updated GPIB drivers through its World Wide Web site: http:\\www.natinst.com, phone number: (512) 794-0100 (USA).

3) If your GPIB drivers were previously installed for use with MS-DOS programs only, you may not have installed the Windows drivers. Reinstall the drivers to make sure.

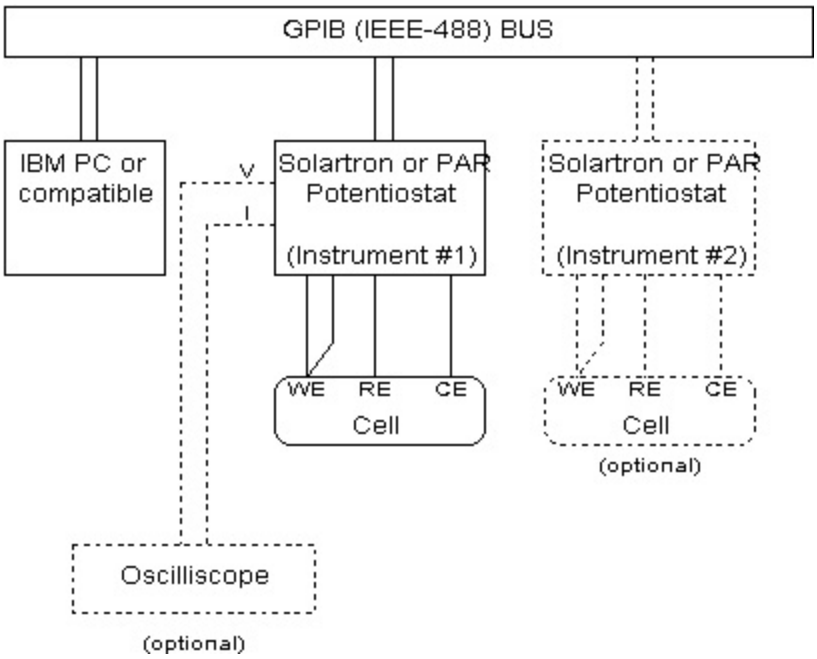
4) Carefully follow the instructions provided with the National Instruments GPIB board. Note that many boards such as the AT-GPIB/TNT-PNP require that the GPIB driver software be installed BEFORE the board is installed.

Electrical Connections

Solartron 1470/80 Users:
See Solartron MultiStat for configuration information on the Solartron 1470/80 Multistat.

The computer interface cables necessary to interconnect the computer, Solartron or PAR potentiostats, and the electrochemical cell depend on the type of equipment you have. The figure below illustrates the electrical connections. The following pages contain a written description of the connections.

Note: E &I Noise measurements require different connections between the Potentiostat and the Cell. See Tutor #2 - E & I Noise for a description of these connections.



Related Topics

- Gpib Connections/Addresses
- Analog Signals
- Software Installation
- Tutors

Setup Solartron MultiStat (1470/80)
(Solartron 1470 and 1480)

Accessed by: **Experiments | Setup Pstat/Gstat...** 

The Solartron 1470 Multichannel Battery Test System and 1480 MultiStat are quite different from traditional potentiostats.

This appendix has been designed to help CorrWare and ZPlot users to install and connect the Solartron 1470/1480 and 12xx frequency response analyzers and to configure the applications software.

Definition of Terms:

Important: Several new terms are introduced in this appendix, and the user should be familiar with these terms in order to understand the operation of the instruments, and particularly CorrWare.

Each **1470/1480 unit** contains 8 potentiostats. Throughout this appendix, the term ***UNIT*** will be used to refer to a full **physical instrument** (each unit contains 8 potentiostats).

The term ***CHANNEL*** refers to a **single potentiostat** within a unit. A channel may be connected to a single electrochemical device under test.

A ***VIRTUAL INSTRUMENT*** is a collection of one or more channels that are all performing the same list of experiments. A virtual instrument may encompass all 8 channels on a single unit, or a subset of channels from a unit, or a collection of channels from several different units. While these channels may have no physical connection to each other, they may all be assigned to the same list of experiments.

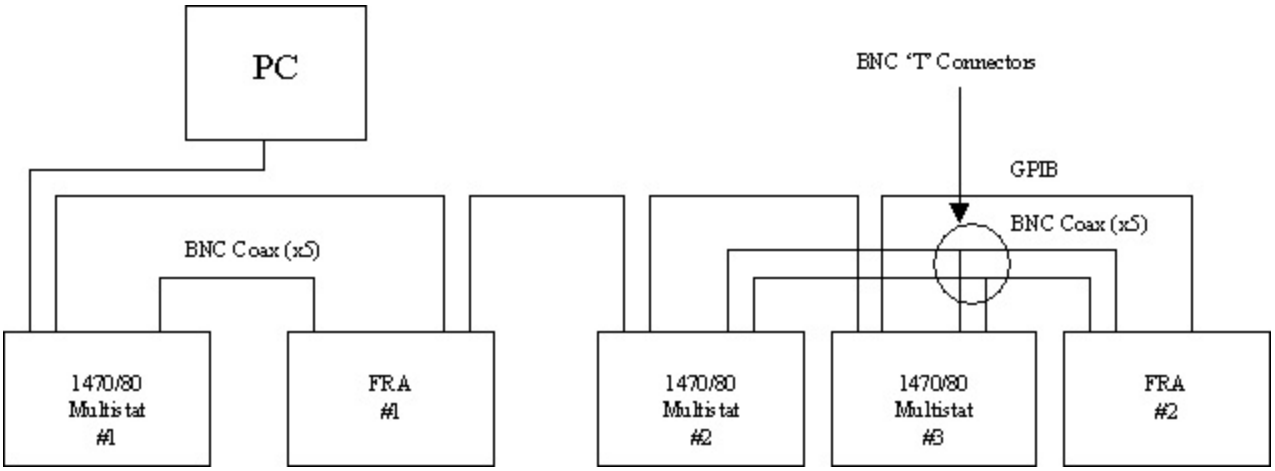
Electrical Connections:

CorrWare and ZPlot can be used to control up to four Model 1470 or 1480 MultiStat units (32 channels total).

Impedance measurements (using ZPlot) require *at least* one Solartron Frequency Response Analyzer (FRA). One FRA may be used with several MultiStats or separate FRAs can be connected to each MultiStat.

A single National Instruments GPIB interface card in the PC may be used to control all MultiStats and FRAs under the control of CorrWare and Zplot.

The following diagram shows the connections between the PC, MultiStats, and FRAs. Note that the first FRA is connected to a single MultiStat unit and the second FRA is connected to several MultiStat units.



GPIB Cables

The GPIB cable is connected from the PC to each of the MultiStat and FRA units. A separate cable may be connected from the PC to each unit, or the PC can be directly connected to one unit and additional cables daisy chained to additional units. All equipment is under the control of a *single* PC with *one* GPIB card and appropriate CorrWare and Zplot software.

GPIB Addresses

Each 1470/1480 MultiStat unit and FRA must have a unique address. The GPIB addresses are set by switches on the rear panel of each instrument. To prevent potential conflicts, it is suggested that only even numbered addresses be used. Turn off the AC power to the unit when changing its address settings.

Any GPIB address between 1 and 31 may be used. The switches are organized in an additive binary configuration. Three examples are shown below. Note that switches in the Up position are OFF and the Down position are ON.

GPIB Address = 2

GPIB Address = 8

GPIB Address = 10

FRA Connections

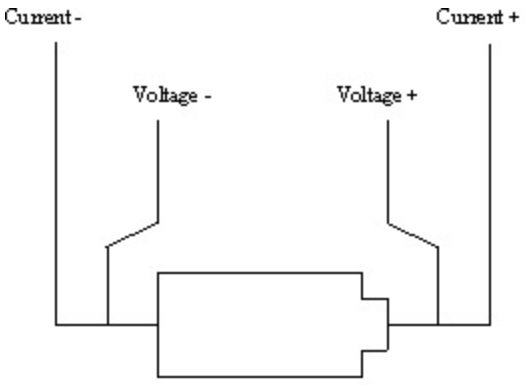
In order to measure impedance, an FRA must be connected to the MultiStat(s). Five BNC coaxial cables are used for each MultiStat unit. If an FRA is connected to several MultiStat units, BNC & T connectors are used on each of the connectors. The generator, V_1 and V_2 signal must be connected to all MultiStat units by using T connectors.

Cell Connections and Connection Conventions

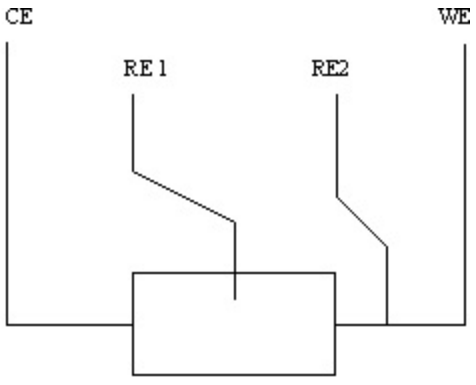
Important: Read this section carefully before selecting a cell wiring and sign convention. CorrWare must be configured to match the selection.

Each channel of a 1470/1480 has 4 cell leads. There are two different labeling conventions that may be used to describe the cables. Because the compliance voltage limits of the unit is asymmetric, the two configurations will have a similar effect on the overall limits of the instrument compliance voltage, and therefore the experiment.

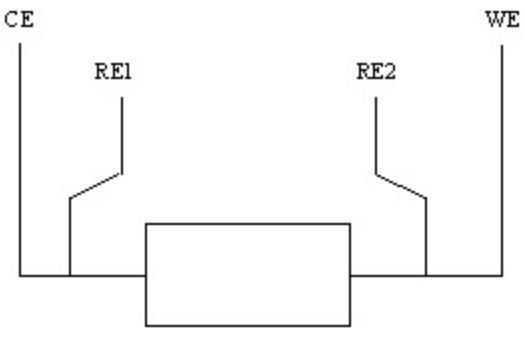
Note: The Battery labels (Current+, Current -, Voltage +, Voltage-) and the Electrochemistry labels (CE, RE1, RE2, WE) on the cell cables use opposite polarity conventions.



Battery



3 Terminal Electrochemical Cell



2 Terminal Electrochemical Cell

The compliance voltage limit is the maximum available voltage between Working and Counter electrodes. When using a 3 terminal cell, solution or other resistance between the Reference and Counter electrodes can make the voltage required between Working and Counter electrodes much larger than the applied Polarization voltage (between Working and Reference).

If large positive voltages are required, Convention 1 must be used.
If large negative voltages are required, Convention 2 must be used.
If more than one channel with a common counter electrode (all Counter electrodes shorted together), will be used, Convention 2 must be selected.

Convention 1. The Current+, Current-, Voltage+, Voltage- labels on the cell cables match this convention.

Cable Color	Battery	Electrochemistry
Red	Current(+)	WE (Working)
Blue	Voltage(+)	RE2 (Working Sense)
Green	Voltage(-)	RE1 (Reference)
Black	Current(-)	CE (Counter)

The applied voltage range is +10 Volts to -3 Volts.
The compliance voltage is +12.5 Volts to -4.3 Volts.
The Counter Electrode/Current(-) (Black) is grounded by the instrument.

Convention 2. The CE, RE1, RE2, WE labels on the cell cables match this convention.

Cable Color	Battery	Electrochemistry
Black	Current(+)	WE (Working)
Green	Voltage(+)	RE2 (Working Sense)
Blue	Voltage(-)	RE1 (Reference)
Red	Current(-)	CE (Counter)

The applied voltage range is -10 Volts to +3 Volts.
The compliance voltage is -12.5 Volts to +4.3 Volts.
The Working Electrode/Current(+) (Black) is grounded by the instrument.

CorrWare Configuration

A special Multiple Instrument version of CorrWare is required to operate a Solartron 1470/1480. CorrWare is available configured in multiples of 8 potentiostats, 16 channels are required for two 1470/1480 MultiStat units, 24 for three 1470/1480, and 32 for four 1470/1480 units.

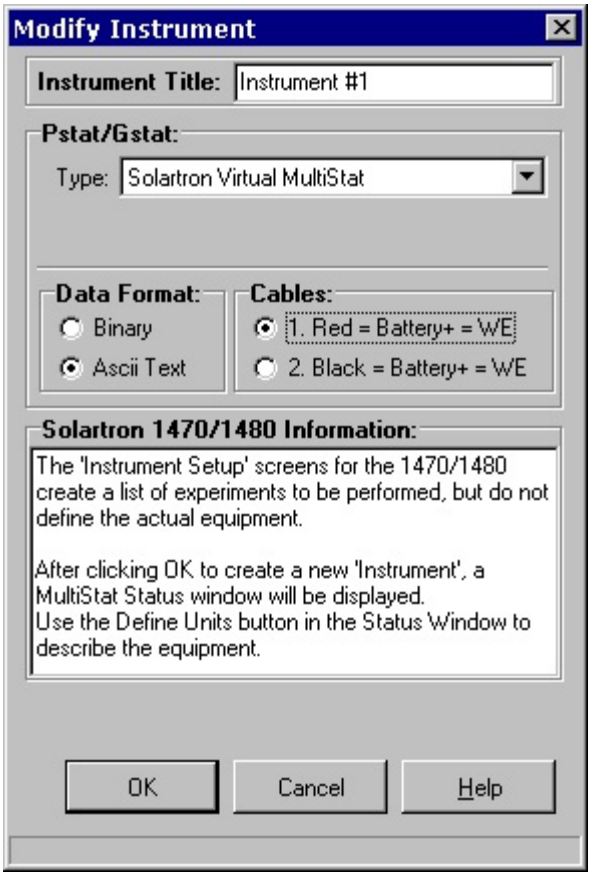
Three steps are required to configure CorrWare for use with 1470/1480 MultiStats.

I. A ***Virtual Instrument*** is created and designated as a MultiStat. Initially, a Virtual Instrument does not define the actual physical 1470/1480 MultiStat units or any channel assignments.

II. Next, the physical ***MultiStat units*** are then identified to the software. This includes specifying the GPIB addresses of the units, and specifying if an FRA is connected to the unit.

III. Finally, a "map" is then created in the software to define which physical **MultiStat units** and **channels** are to be assigned to a **Virtual Instrument**.

I. Create a *Virtual Instrument*



In CorrWare, select **File | New Instrument...**.

Select an Undefined instrument and click **Modify Instrument**.

Select *Solartron Virtual MultiStat* as the **Pstat/Gstat type**.

Very Important: Select the **Cell Cable** configuration. The choices are described in a previous section of this appendix. Make sure you understand the choices. The leads may need to be re-labeled in order to match this setting.

Click **OK** to exit the Modify Instrument screen.

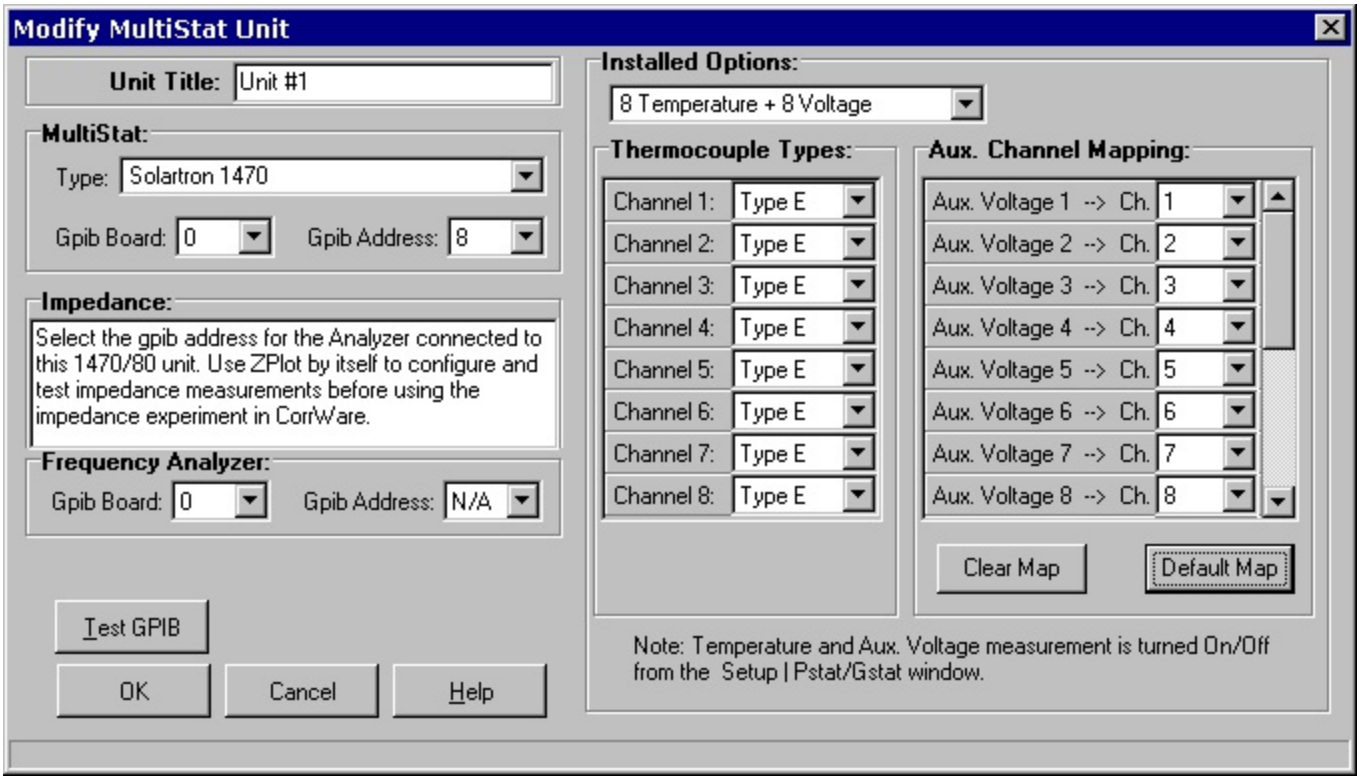
Click **OK** to exit the Select Instrument screen. This will create the new Virtual Instrument.

Note: More than one Virtual Instrument can be defined. If it is desired to run one set of experiments on 3 cells, and a different set of experiments on 5 other cells, two Virtual Instruments would be required.

II. *Define* the 1470/80 MultiStat Units.

In the **MultiStat Status** Window, click on **Define Units**. Each physical 1470 or 1480 unit must be defined using this process..

Select an Undefined line and click **Modify Unit**.



Select the correct **Pstat/Gstat Type**.

Select the GPIB address of the unit. Each unit must have a unique address. GPIB Address settings are described previously in this appendix.

If an Solartron 12xx Frequency Response Analyzer (FRA) will be connected to this unit, select the GPIB address for the Frequency Analyzer. If no Analyzer is available, select N/A.

Note: If an Analyzer will be used to measure impedance, ZPlot must also be configured and tested before impedance measurement may be performed from within CorrWare.

Note: A single Frequency Analyzer can be connected to several MultiStat Units. In this case, the same GPIB address would be given for the Frequency Analyzer when each unit is defined.

Important: If more then one FRA is used with a group of 1470/1480 MultiStat units, all FRAs controlled by the Zplot software **MUST** be of the same model.

Select the Installed Options available for this unit. If you do not know what options are installed, click **Test GPIB** and the options will be selected automatically.

Thermocouple Types are used to specify the type of thermocouples used. Each main potentiostat/galvanostat channel has a single temperature input.

Aux. Channel Mapping defines how the auxiliary voltage inputs are mapped to the main

pstat/gstat channels. **Default Map** configures the auxiliary voltage inputs so that one aux. input is used for each main channel. If desired, several aux. inputs can be mapped to a single main channel. The aux. inputs will be measured at the same time and rate as the main voltage and current measurements.

NOTE: To record and save auxiliary temperature and voltage signals, see the **Measure** setting in the Pstat/Gstat setup screen described later in this chapter.

Click **Test Gpib** to test the communications with the instrument. **Note:** Communications with the Frequency Analyzer are not tested. Use ZPlot to configure and test GPIB communication with the Analyzer.

Click **OK** to exit the Modify Unit screen,

Click **OK** to exit the Select MultiStat Units screen.

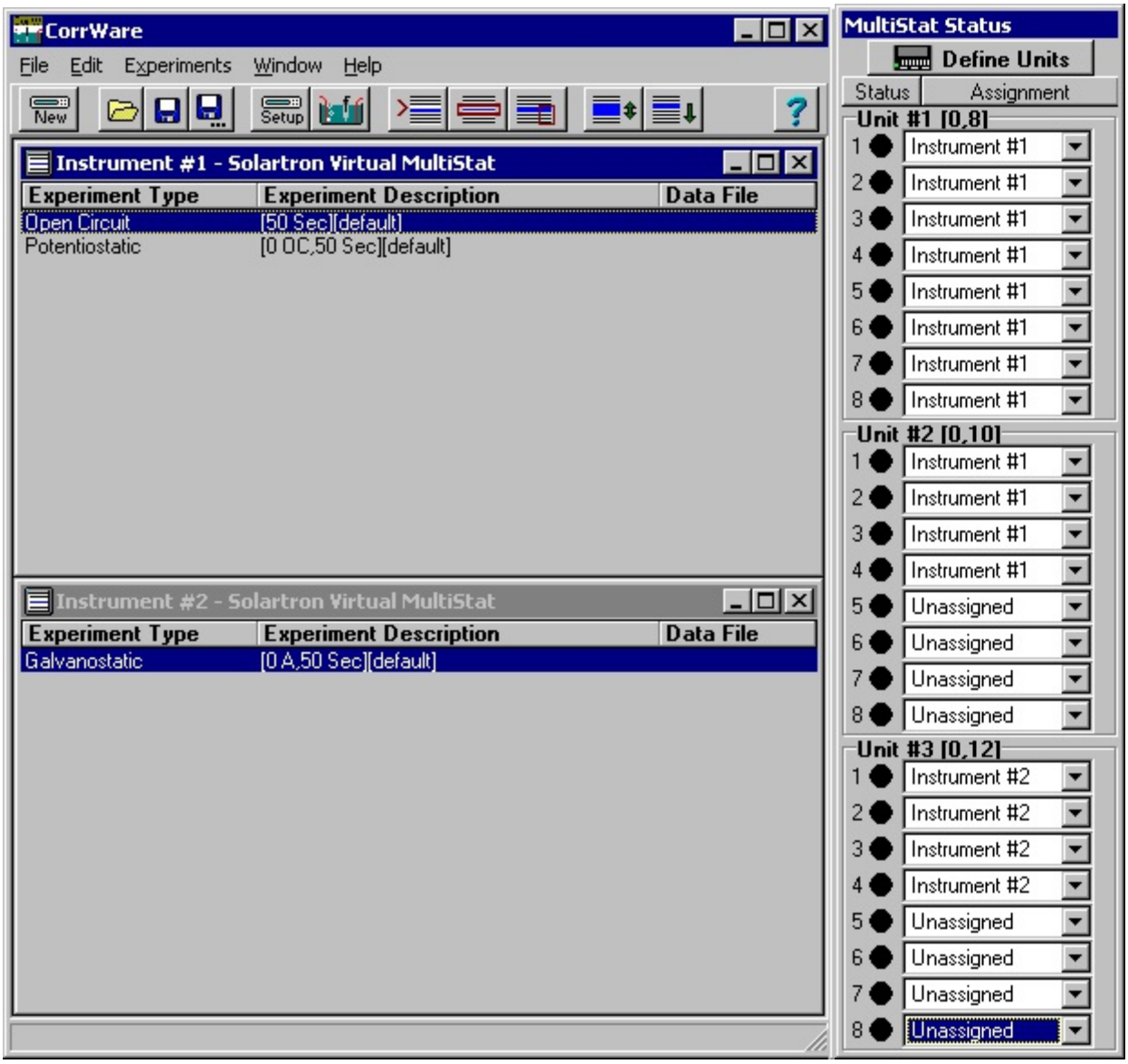
Note: If more than one 1470 or 1480 is to be used, repeat this procedure for each physical unit.

III. *Map* the desired Channels to the Virtual Instrument.

The MultiStat Status window displays a list of every channel in each of the defined units.

The Virtual Instrument window(s) contains the lists of experiments to be performed by this group of channels. The channels must be assigned to a Virtual Instrument before they can be used.

In the following illustration, two Virtual Instruments and three (physical) MultiStat Units have been defined.



When the *Instrument #1 - Virtual MultiStat* is used, it will sequentially perform an Open Circuit test followed by a Potentiostatic (constant voltage) test on 12 different channels (cells).

When the *Instrument #2 - Virtual MultiStat* is used, it will perform a Galvanostatic (constant current) test on 4 different channels (cells).

The unassigned channels, of which eight remain, are not used in this example.

The process of adding experiments to an experiment list is described in *Chapter 2 - Tutor #1* of the CorrWare manual. The available experiment types are described in *Chapter 7 - CorrWare Experiments*.

Potentiostat Settings

The potentiostat specific settings are accessed by the **Setup | Pstat/Gstat** menu.

The **Current Range** parameter selects the full scale current range to be used during experiments. Selecting 'Auto' allows the instrument to select the current range based on the actual current being measured. When measuring signals that are changing very quickly, for example, a Square-Wave or fast Cyclic Voltammagram, a fixed current range may be necessary to correctly measure the current.

Min. Current Range may be used to select the smallest current range that will be used when the **Current Range** is set to 'Auto'. If the Current Range is fixed (not 'Auto'), the **Min. Current Range** has no effect. If **Min. Current Range is 'Auto'**, all current ranges will be used.

The **Potential Range** selects the maximum voltage that can be measured. Generally 'Auto' is the best choice. When measuring signals that are changing very quickly, for example, a Square-Wave or fast Cyclic Voltammagram, a fixed voltage range may be necessary to correctly measure the voltage.

The **Low Pass Filter** may be used to reduce high frequency noise. Except when high sampling rates are required, **On** (10Hz filter) is preferable. If 'Auto' is selected, the filter is automatically selected based on the sampling rate selected within the Experiment configuration.

The Bandwidth selections allow one to optimize the stability and performance of the instrument. In general, 100kHz is stable with most cells. If stability problems are encountered, lower bandwidth settings may be used. See your instrument manual for a description of each bandwidth.

Point Averaging % is used to control the averaging of data between data acquisition points. The instrument typically samples the 10000 times per second. If data is acquired at a slower rate, the 10000/second samples can be averaged to produce a lower noise level. For example, if data is acquired (displayed and saved by CorrWare) 1 time per second and **Point Averaging** is 100%, all 10000 samples are averaged into 1 data point. If the Point Averaging is 50%, only the second half of the 10000 points (5001-10000) are averaged. If Point Averaging is 0%, only the final sample (sample 10000) is used for the data point.

OverSampling controls the potentiostats transfer rate. CorrWare cannot acquire data faster than this rate. The instrument always samples internally at 10000 points/sec. The instrument averages the data down to the rate set by the **OverSampling**, and is transferred to the computer at the **OverSampling** rate. CorrWare itself then averages the data down to the data acquisition rate specified by the experiment.

Higher **Oversampling** rates allow finer averaging by CorrWare, but require larger data transfer rates between the instrument and the computer. The total throughput of the system is approximately 30000 points/second. This means that no more than 3 channels can measure simultaneous at 10000 points/second.

Cell Connection selects how the cell is grounded. If Grounded is selected, the black cell cable is grounded. If the cell is grounded by a alternate method (for example, the counter electrode is a metal container that is electrically connected to a pump).

Measure selects which signals will be measured. Cell Voltage and Cell Current are always measured. If you unit contains the 14701 or 14702 options, additional **Auxiliary Temperature** and **Auxiliary Voltages** may also be recorded. See *CorrWare Configuration*, earlier in this chapter form more information on configuring the optional signals.

The **Experiment #** saves the number of the experiment (relative to the start of the experiment list) in the data file. This may be useful if multiple experiments are appended to the same data file because it allows the data from each experiment to be separate. **Current Range** records the current measurement range used for each data point. The current range may be useful in diagnosing stability or noise problems.

Safety Limits are used to shut off the cell and end experiments if an unexpected condition

is encountered.

SAFETY NOTE - The Solartron 1470/80 Multistats contain internal Safety Limit settings to stop the instrument if predetermined cell voltage or current limits are exceeded. These limits should be used during any experiments with energy producing or storage devices to limit operation to safe values for the device.

Click on the Voltage, Current and Charge or Temperature check boxes to activate one or more limit. The Charge limits are based on the charge passed within a particular experiment. They do not accumulate charge from an entire list of experiments. The Temperature limits are only available on 1470/80 units equipped with the Auxiliary Input Option.

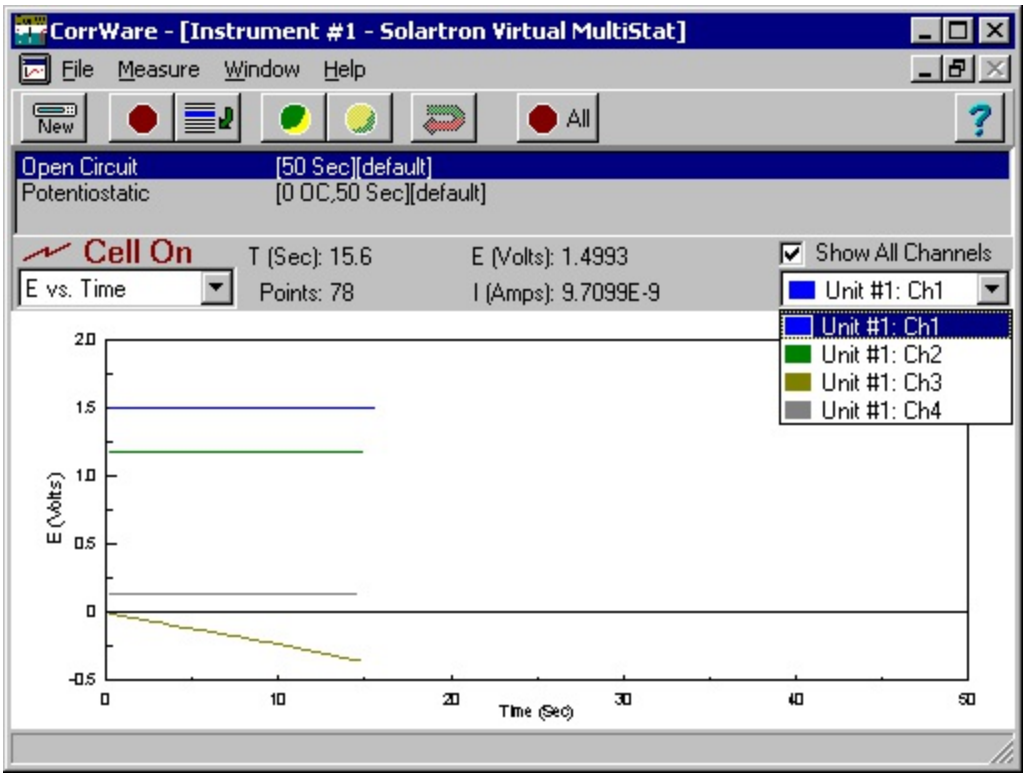
The **OK** button exits the setup menu and saves any changes you may have made.

Cancel exits the setup menu. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this Pstat/Gstat.

Running Experiments

Because a Virtual Instrument may be running an experiment on multiple channels, the CorrWare measurement screen contains several parameters to control how the data is displayed.



By default, CorrWare displays the data from one channel at a time. The drop-down list shows all of the channels used by the Virtual Instrument. Only the selected channel will be displayed.

To display all of the channels, click the **Show All Channels** box. Note that since all channels may not be (time) synchronized, different channels could be performing different experiments in the list. Because the data from all channels are displayed on the same axes, the data from some channels may have no meaning on the selected display axes - for example, Potentiostatic data has little meaning on Cyclic Voltammagram (E vs I) axes.

The measurement status and numerical current, voltage and time values apply to the selected channel. To display the values for a different channel, use the channel selection drop-down box to choose the desired channel.

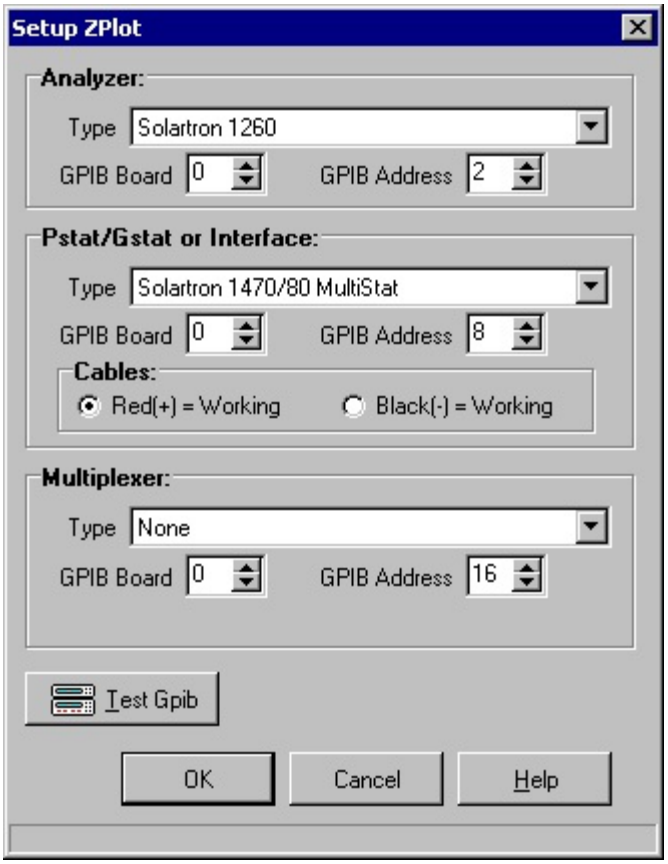
ZPlot Configuration

Zplot for use with the 1470/1480 must be part of a 1470/1480 multi instrument combo (combination) package.

ZPlot must be configured to match the available instruments before impedance measurements may be performed. Test GPIB for the FRA must be done from ZPlot.

When used by itself, a standard ZPlot controls a single channel on a single 1470/80 MultiStat unit in conjunction with a single Frequency Analyzer. If more than one MultiStat and/or Frequency Analyzer will be used, the configuration can be manually changed to test all available combinations of instruments.

The first time ZPlot is used, a Welcome screen will be displayed. Click **OK** to enter the instrument selection screen. If the installed ZPlot, has been previously used (no "Welcome" screen), select **Setup | ZPlot...**.



Select the Frequency Analyzer type that is connected to the MultiStat unit and set the GPIB Address to match the switch settings on the rear panel of the Analyzer.

Note: Gpib switch settings are further described at the beginning of this chapter. Each instrument connected to the gpib bus must have a unique gpib address.

Select *Solartron 1470/80 MultiStat* as the **Pstat/Gstat** type and set the GPIB Address to match the switch settings on the rear panel of the unit.

Very Important: Select the **Cell Cable** configuration. The choices are described in a previous section of this appendix. Make sure you understand the choices. The leads may need to be re-labeled in order to match this setting.

Click **Test Gpib** to test the communications with the instrument.

Click **OK** to exit the Setup ZPlot screen and to save the new settings.

Using Multiple MultiStat Units Connected to a Single Analyzer

Several MultiStat units may be connected to a single Frequency Analyzer as described in the *Electrical Connections* portion of this Appendix. This configuration is fully supported when using ZPlot and CorrWare together to perform impedance measurements. ZPlot is used by itself to test the configuration and to optimize the measurement parameters. ZPlot

can only control one Analyzer and one MultiStat channel at a time.

To fully test the system, setup ZPlot to match the Analyzer and the first MultiStat unit. Perform measurements on this unit until you are satisfied that all connections are correct.

Enter the Setup ZPlot screen described above and change the MultiStat GPIB Address to match the second MultiStat unit. Test this configuration to confirm that all connections are correct.

Note: While ZPlot actively controls only one MultiStat unit, other units may be turned on and connected to the Computer and the Analyzer during these tests.

Using Multiple MultiStat Units Connected to Multiple Analyzers

Several MultiStat units may each be connected to separate Frequency Analyzers as described in the *Electrical Connections* portion of this Appendix. This configuration is fully supported when using ZPlot and CorrWare together to perform impedance measurements. ZPlot is used by itself to test the configuration and to optimize the measurement parameters. ZPlot can only control one Analyzer and one MultiStat channel at a time.

To fully test the system, setup ZPlot to match the first Analyzer and the first MultiStat unit. Perform measurements on this unit until you are satisfied that all connections are correct.

Enter the Setup ZPlot screen described above and change the MultiStat GPIB Address to match the second Analyzer/MultiStat combination. Test this configuration to confirm that all connections are correct.

Note: While ZPlot actively controls only one Analyzer and one MultiStat unit, other units may be turned on and connected to the Computer during these tests.

Note: ZPlot supports may different Solartron Frequency Analyzer models, however when using CorrWare to control multiple copies of ZPlot operating multiple Analyzers simultaneously, all Analyzers must be of the same model number.

Performing Measurements

The general operation of ZPlot is described in the Tutorial section of the ZPlot manual.

When a ZPlot measurement is initiated with a MultiStat unit, you will be asked which channel of the unit should be used. By using a single channel of the MultiStat, the operation of the unit may be tested. After testing and optimizing ZPlot, save the settings in a ZPlot

Setup File, using the **File | Save Setup As...** menu selection. Multiple configurations may be saved in this manner and later accessed when using CorrWare to perform impedance measurements.

If similar measurements on similar cells are used with several MultiStat units, the same setup file may be used.

Related Topics

- Setup Pstat/Gstat
- Setup Experiment
- Setup Cell Information
- Load/Save Setup

Gpib Connections/Addresses

GPIB Connections

GPIB connections are unique in that all of the instruments are 'daisy chained' together on a common set of wires. Since each equipment item has its own address, communication between the computer and each instrument takes place directly, while the other instruments ignore commands not directly addressed to them. The order in which the equipment is chained together does not matter. One cable will be required for each instrument.

Connect the Solartron or PAR potentiostat to the computer. The GPIB interface is different from any other type of connectors (e.g. serial port, parallel port) so it is impossible to connect to the 'wrong' connector.

GPIB Addresses

The GPIB address switches can be set to any even number. For ease of use the following Addresses are suggested.

Solartron 1470/80 Users:
See Solartron MultiStat for configuration information on the Solartron 1470/80 Multistat.

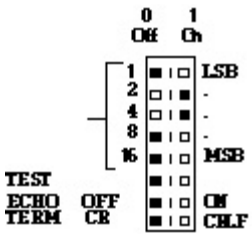
Solartron 1287, 1286, 1285, 1280, or 1280B **Address = 6**

If you have a Solartron 1287, 1286, 1285 or 1280, set the device address switch on the back panel of the instrument as shown below.

PAR 273/273A, VersaStat2, 253(VersaStat) or 276/173 **Address = 6**

If you have a PAR 273 or 273A, set the device address switch on the back panel as shown below.
The address switches for the 253(VersaStat) are inside the potentiostat and are accessed by removing its top cover. The address switches for the 276/173 are on the 276 plug-in module and are accessed by removing the module from the 173 mainframe.

Note: The black side of the switches should be pressed down.



PAR 283 or 263/263A **Address = 6**

The GPIB address is set using the controls on the front panel of the instrument. First press the <SYSTEM> button until the display shows 'System Interface'. Use the <Next> key until 'GPIB ADDR' is displayed. The GPIB address may be set to 6 using the <VALUE> knob. After the address has been set, press the <SYSTEM> function key to exit the menu.

PAR 6310 **Address=14**

The 6310 GPIB address is factory set to address 14. It can only be changed by removing the instruments case. Leave the instrument at its default address (14) and select this address in CorrWare when configuring the software as described in Software Installation.

AMEL 5000 **Address=6**

The GPIB interface must be reconfigured to be compatible with CorrWare. Follow the directions in the technical note "*Configuring the AMEL 5000 Potentiostat for use with CorrWare and ZPlot*". After reconfiguration, the GPIB address will be set to 6. Select this address in CorrWare when configuring the software as described in Software Installation.

The instrument should come with a short GPIB to RS-232 cable. This must be connected between the connectors labeled RS-232' and Auxiliary on the rear panel of the instrument.

Related Topics

- Hardware Installation
- Tutors

Analog Signals

If the potentiostat is also used for impedance measurements, the connections between the impedance analyzer and the potentiostat may remain connected when using CorrWare. They will not interfere in any way with DC electrochemical measurements.

Note: E & I Noise measurements require different connections between the Potentiostat and the Cell. See Tutor #2 - E & I Noise for a description of these connections.

Solartron 1470/80 Users:
See Solartron MultiStat for configuration information on the Solartron 1470/80 Multistat.

Three Terminal Cells:

The connections between potentiostat and the test cell depending on the type of potentiostat being used. Most electrochemical cells use three electrodes: Working, Reference, and Counter.

Solartron 1287, 1286, 1285, and 1280 users:

Plug the 'banana' jack on the end of RE2 cable into the side of the WE cable. Label the cables as follows:

Cables	Label
WE+RE2	Working
RE1	Reference
CE	Counter

PAR Users:

The cell cables are color coded as follows:

Color	Label
Green	Working
White (or Yellow)	Reference
Red	Counter

AMEL 5000 Users:

The Cell cables are labeled **Working**, **Reference**, and **Counter**.

Note: Make sure there are 2 jumper cables on the front panel of the instrument. One should go from **+Input** to **A**, the other from **-Input** to **B**. If these are not present, consult page 2 of the AMEL 5000 manual.

Two terminal Cells:

If you wish to connect the potentiostat to a two terminal cell (such as a battery or galvanic couple), connect the Reference and Counter electrodes to one side of the cell and the Working electrode to the other side.

Solartron 1287, 1286, 1285 and 1280 users:

Plug the 'banana' jack on the end of RE2 cable into the side of the WE cable. Label the cables as follows:

Cables	Label
WE+RE2	Working (+)
CE+RE1	Counter (-)

PAR Users:

The cell cables are color coded as follows:

Color	Label
Green	Working(+)
Red+White(or Yellow)	Counter(-)

AMEL 5000 Users:

Connect the cell cables as follows:

Cables	Label
Working	Working (+)
Counter+Reference	Counter (-)

Related Topics

Hardware Installation
Tutors

Instrument Performance Limitations

The various potentiostat/galvanostats supported by CorrWare have quite different capabilities. Rather than make each instrument act the same by limiting the experimental parameters to the lowest common denominator, CorrWare may accept parameters which exceed the abilities of an instrument. When experiments are performed, CorrWare adapts the parameters to match the instrument.

For example, the Solartron potentiostats are limited to a data acquisition rate of about 12 points/second. This rate will be used even if a much higher rate is requested. Scanning experiments on the PAR instruments may be limited to 3072 or 2048 points depending on the instrument. Data acquisition rates will be automatically reduced to fit these limits.

Solartron 1286, 1287, 1280B:

The maximum data acquisition rate is 12 pts/sec. when no filtering is used, 8 pts/sec. with the 8Hz filter and 2 pts/sec with the 2 Hz filter.

All experiments can use an unlimited number of data points (practical limit: 500000). Limited by computer RAM.

The minimum scan rate is 0.1mV/sec. for analog scans, and 1e-5 mV/sec. for stepped scans. Scans can cover the entire range of the instruments (1286,1280: ±12.8 V; 1287,1285,1280B:±14.5 V)

Solartron 1470/80:

The maximum data acquisition rate is 10000 pts/sec. This rate is only guaranteed when a single channel is used. 16 channels can be measured simultaneously at 1000 pts/sec.

All experiments can use an unlimited number of data points (practical limit: 500000). Limited by computer RAM.

The minimum scan rate is 1e-5 mV/sec. Scans can cover the entire range of the instruments (-3 to +10 or -10 to +3, depending on cell cable type)

PAR Instruments:

The maximum acquisition rate is 2500 pts/sec. When current and voltage autoranging is

used, the maximum acquisition rate is reduced to 1000 pts/sec.

The maximum number of data points in a swept experiment depends on the model. (273, 273A, 263, 263A w/o Option 94, VersaStat2: 3072; 253(VersaStat), 276/173: 2048; 283, 263A w/Option 94: 6144)

Cyclic Voltammetry and Square Wave experiments may use the limits listed above for each cycle.

The number of data points per file is unlimited (practical limit: 500000). Limited by computer RAM.

For all instruments except the 283 or 263 w/Option 94, the maximum scan range is 4 Volts. The 283 and 263 w/Option 94 can use 8 Volt scans.

When exceeding the instrument specific limits listed above, CorrWare must continuously reuse the instruments internal memory. Fast data acquisition may overwrite this memory before it can be transferred to the computer, resulting in gaps in the data. The speed limit is dependant many factors including instrument and computer CPU speed as well as the GPIB speed. For a 50MHz 486 computer and NI PC2 gpib board, a sustained speed of 500 pts/sec is usually achievable. Faster computers will not increase this speed. The transfer speed is limited by the rate at which the instrument can put data on the GPIB bus, not the computers CPU or GPIB boards ability to process the data.

Because of its internal design, the PAR 273/273A cannot perform the E & I Noise experiment.

AMEL 5000:

The maximum acquisition rate is 10000 pts/sec. When current and voltage autoranging is used, the maximum acquisition rate is reduced to 1000 pts/sec.

All experiments can use up to 16380 data points.

The maximum data transfer rate from the instrument to the computer is 100 points/second. Using faster acquisition rates may cause the graphs of data to fall behind the actual cell conditions.

Multiple Instruments:

The use of multiple instruments simultaneously is only recommended for slow, long term

experiments such as anodic polarizations or battery charge/discharge cycles. Multiple fast experiments with high data acquisition rates may cause loss of data.

When using multiple instruments simultaneously, the total throughput of all instruments combined is limited to that available for single instruments listed above. The transfer speed is limited by the rate at which the instrument can put data on the GPIB bus, not the computers CPU or GPIB boards ability to process the data.

Tutors

The following tutors are available:

Tutor #1 - This chapter takes the user step by step through the first use of CorrWare. It describes how to use the menus as well as the basic functions of setting parameters and taking measurements of a simple dummy cell.

Tutor #2 does not define the use of CorrWare or its various control parameters. Instead, it describes why it works it the way it does and shows the reasoning behind the parameters. Select from the topics listed below:

Tutor #2 - 'vs. Open Circuit', 'vs. Reference' and 'vs. Previous' Potentials

Tutor #2 - Termination and Reversal Parameters

Tutor #2 - Polarization Scan Limits

Tutor #2 - IR Correction Techniques

Tutor #2 - Using Multiple Instruments Simultaneously

Tutor #2 - Noise Measurement Techniques

Tutor #2 - Polarization Resistance Calculations

Tutor #1 - Using CorrWare

This tutor is designed to guide the user though their first use of CorrWare. No additional programming of the Solartron or PAR potentiostat/galvanostat is necessary. The result of this tutor is illustrated by the graph shown on the following page.

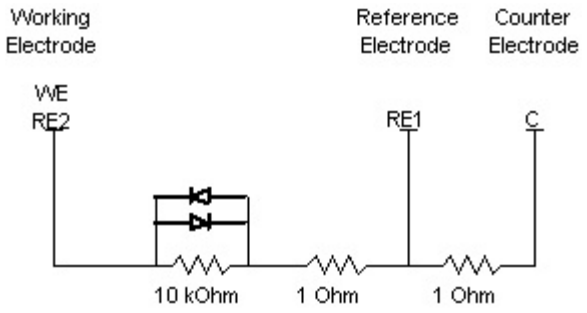
For further information on the procedures used, consult CorrWare Menus in this manual or the potentiostat manuals.

We strongly suggest that all users complete Tutor #1 even if the test is not directly of interest to you. Tutor #1 contains very specific step by step instructions while the other tutors assume you are familiar with the menu structure.

CorrWare is available in both single instrument and multiple instrument versions. Tutors #1 uses only a single instrument. Tutor #2 describes how to use multiple instruments simultaneously.

With the single instrument version, you may configure experiments for multiple instruments but measurements can only be performed on one instrument at a time.

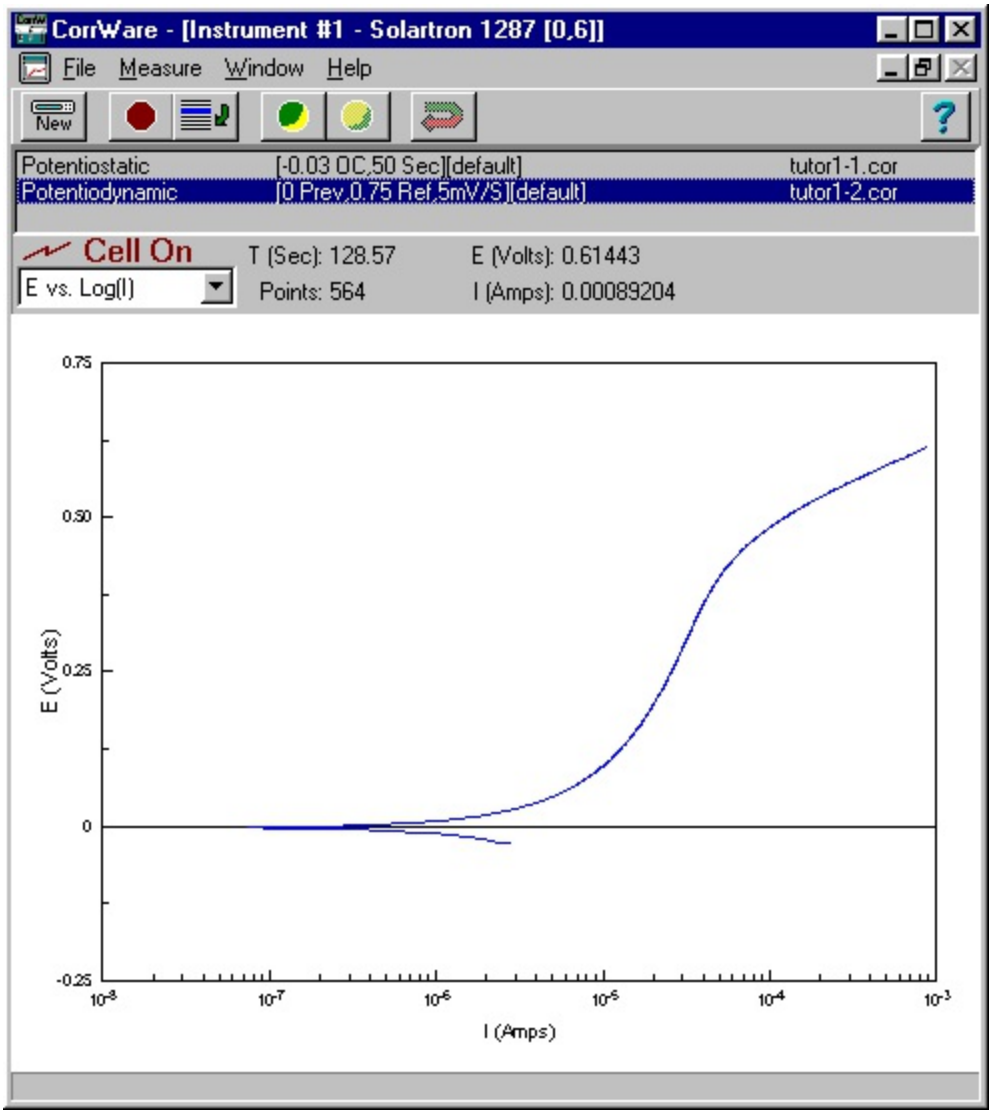
Tutor #1 consists of a potentiostatic pretreatment followed by a potentiodynamic scan on a dummy cell consisting of a simple diode and resistor combination as shown below.



CorrWare Test Module

Connect the dummy cell to your potentiostat. If you are unsure how to properly connect the cables, review the 'Analog Signals' portion of Hardware Installation and label the cables as described.

The result of tutor #1 is illustrated shown below:



Setting Parameters

Start the CorrWare program and connect the dummy cell if you have not done so already.

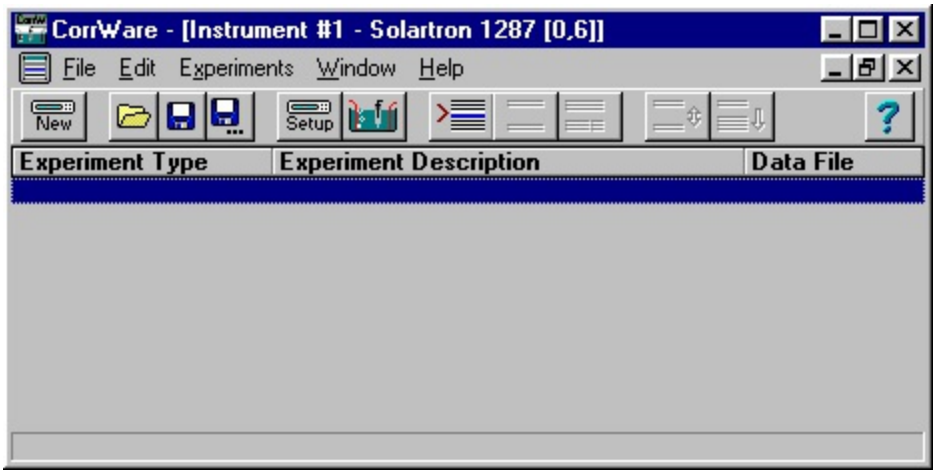
Throughout this tutor, you will be asked to select various commands from the CorrWare menu. The menu commands will be printed as **BOLD**. For example if we say select **File**, click on the word 'File' in the menu. Notice that the letter F is underlined. This indicates that the item can also be selected by holding down the 'Alt' key and pressing the F key. Selecting an item from the menu usually drops down a submenu. For example, selecting **File** drops down a submenu with items such as **New Setup** and **Open Setup...**.

We will indicate that you should select **File** and then **Open Setup...** by asking you to select **File | Open Setup...**.

CorrWare also has a 'button bar' of icons directly below the menu. Each of the icons perform the same function as an item in the menu. They are used as shortcuts for various commonly used functions. If an icon appears 'grayed out', its function is unavailable under the current settings (for example, it is impossible to start a measurement when no

experiments have been defined.) If the mouse is positioned over any icon, a box will appear describing the icons function. All icon functions are also available through the menus.

CorrWare opening menu:



Note: If your screen does not show the **Instrument #1** list, select **File | Select Instrument...** and follow the **Configuring CorrWare** instructions in Software Installation.

CorrWare has 3 different types of information which control how an experiment will be performed.

Potentiostat Information defines how the potentiostat is configured. Items such as the current range, filtering, and iR compensation are contained in this menu. The **Potentiostat Information** is instrument specific. The potentiostat information applies to **ALL** experiments within the experiment list.

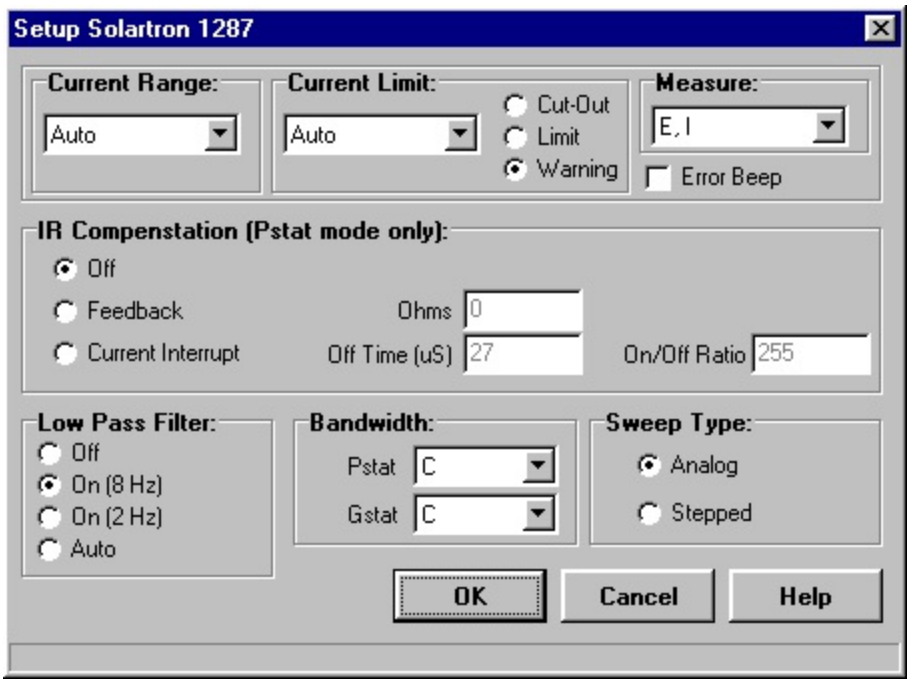
Cell Information is used to specify electrode parameters such as surface area and reference electrode type. The Cell Information applies to **ALL** experiments in the experiment list.

The **Experiment List** defines the actual experiments. Each item in the list is a separate experiment. The list can hold up to 1000 independently defined experiments.

To setup the **Potentiostat Information**, select **Experiments | Setup Pstat/Gstat...** or click on the **Setup Pstat** icon ( ).

The following menu should be displayed. For a complete description of all Potentiostat

parameters, see CorrWare Menus.



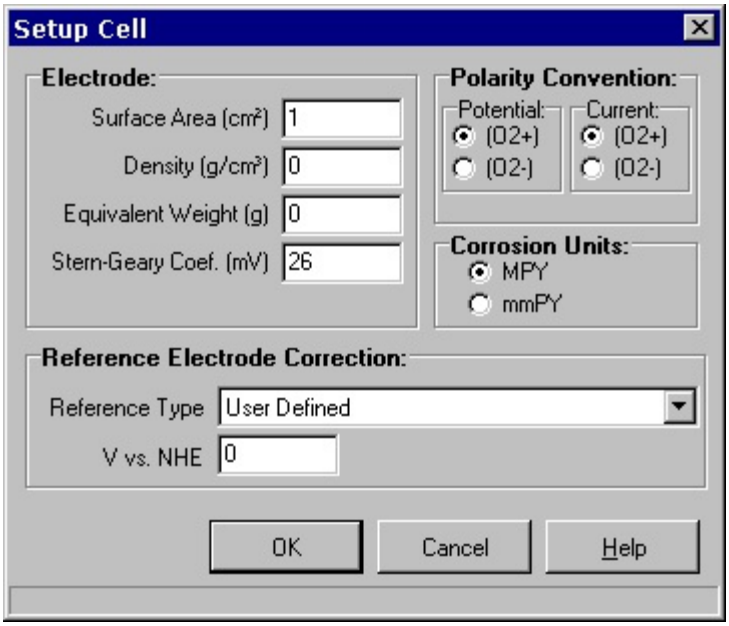
The available choices depend on the potentiostat model you are using. For example, the Solartron potentiostats have a choice of Sweep Types. However, the PAR and AMEL potentiostats can only produce a Stepped Sweep (digital stairstep waveform) so this item is not shown. Also, the iR Compensation format depends on how iR Compensation is implemented by a particular instrument. The PAR 276 does not have computer controlled iR compensation so the items are shown as gray text.

The **Help** button can be used to get a full description of all available parameters.

If you are using a Solartron potentiostat, change the **Sweep Type** to Analog. Otherwise you do not need to make any changes to the potentiostat settings at this time so click on the **OK** button to exit this menu.

To setup the **Cell Information**, select **Experiments | Setup Cell...** or click on the **Setup Cell** icon ( ).

The following menu should be displayed. For a complete description of all Cell Information parameters, see CorrWare Menus.



The **Electrode** parameters are used to define the working electrode characteristics. These values do not affect the raw data measured or saved by CorrWare but are saved in the data file and used by CorrView to calculate corrosion rates. For a full description of the parameters, see CorrWare Menus.

The **Reference Electrode Type** is used to define the reference electrode used. The settings do not affect the data measured or saved by CorrWare but are saved in the data file and can be used by CorrView to translate the data from one reference electrode type to another (for example, you may wish to measure data using a Saturated Calomel (SCE) reference and later display it as if it were measured using a Normal Hydrogen (NHE) electrode). Most of the standard electrode types are predefined, but if you use a reference electrode which is not in the list, you may select 'User Defined' and enter a voltage describing how it varies from a Normal Hydrogen electrode.

Polarity Convention selects how positive and negative potentials and currents are interpreted. When using **Normal (O2+)**, a more positive potential produces a larger driving force for oxidation and oxidation produces a positive current. In an aqueous environment (at pH=0) oxygen is produced at the working electrode when the potential is approximately +1.23 Volts vs. a Hydrogen Reference. When using **Reversed (O2-)**, a more negative potential produces a larger driving force for oxidation and oxidation produces a negative current. In an aqueous environment (at pH=0) oxygen is produced at the working electrode when the potential is approximately -1.23 Volts vs. a Hydrogen Reference.

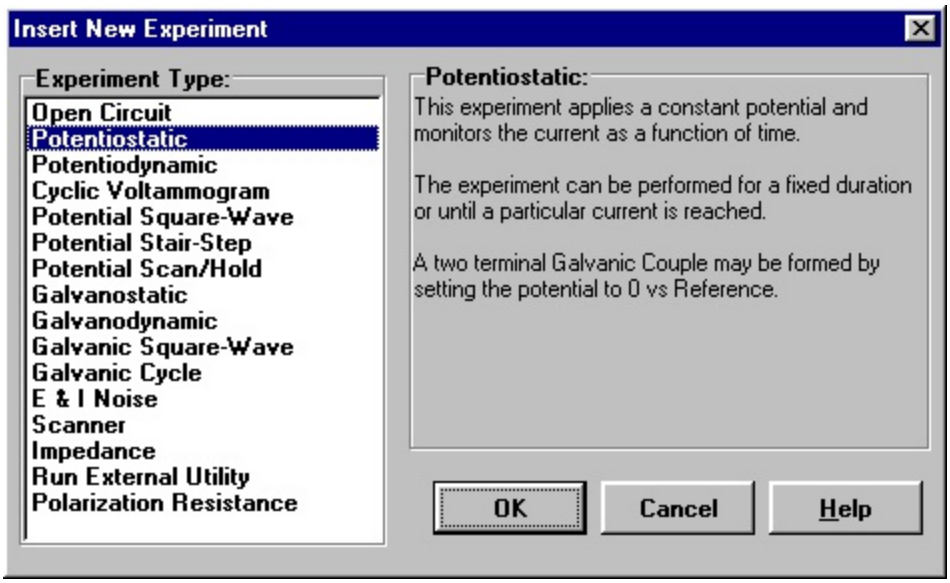
Since we are using a dummy cell, we will leave these settings at their default values. Select **OK** to exit this menu.

In this tutor, will be defining a 2-part experiment. A potentiostatic (constant potential)

pretreatment at -0.03 V below the open circuit potential, followed by a potentiodynamic (potential sweep) experiment from -0.03 V to +0.75 V. (note: CorrWare does not specifically label any experiment as a pre or post-treatment. The experiment list is completely free form - any sequence of experiments may be performed.)

We will start by defining the first portion on the experiment - the potentiostatic pretreatment.

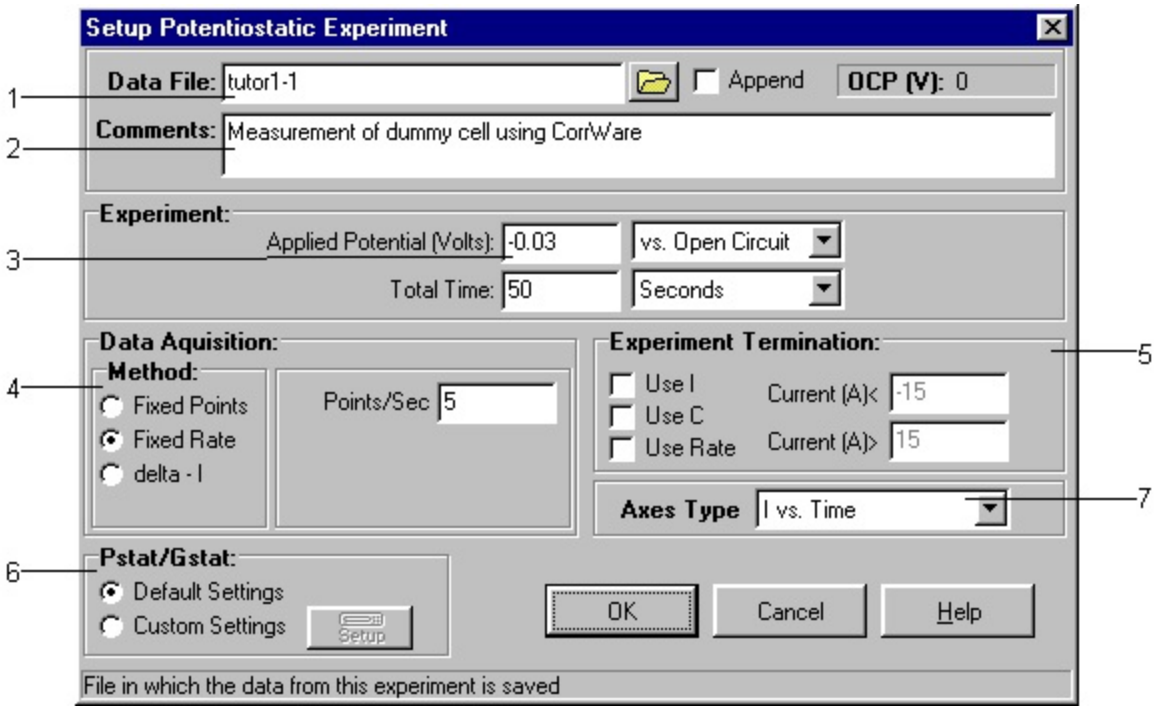
To create an experiment segment, select **Experiment | Insert New Experiment...** (you could also press the <Insert> key on the keyboard, or click on the **Insert New Experiment** icon).



Using the up and down cursor keys, select 'Potentiostatic' from the displayed list. (Note: you may wish to scroll through the entire list and read the short description of each experiment type.)

Select 'Potentiostatic' and click on **OK**, or double click on 'Potentiostatic'.

The following window should be displayed. For a complete description of all Experimental parameters, see CorrWare Experiments.



Notice the **OCP** value. This is the Open Circuit Potential of the cell. It is measured by the potentiostat every 2 seconds. The dummy cell should have a potential very close to zero. If it is more than 1 or 2 mV, the dummy cell is not connected correctly. Real cells should have a more meaningful Open Circuit Potential.

Move the mouse over the experiment parameters displayed on screen (without clicking on them). When the mouse is over a parameter, a short description of the parameter will appear at the bottom of the window. If the parameter contains a number, the lower and upper limit of the value is also displayed. For example, 0 < x <=1000' means that the value must be greater than zero, and less than or equal to 1000.

1. For the **Data File** enter *tutor1-1*. The **Folder** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used.

   After the experiment, the data will be stored in the file *tutor1-1.cor* for later use with CorrView. Note that CorrWare automatically appends the suffix '.COR' to the data file if you don't enter one.

   If no data file name is specified, the experiment will be performed, but the data will be lost.

   Press <Tab> after entering the file name.

2. Enter a comment about the experiment. For example:
Measurement of dummy cell using CorrWare for Windows

Note: The time, date, and type of experiment are automatically saved in the data file so you don't need to write these into the comment lines.

Press <Tab> until you reach the **Applied Potential** setting.

3. For the **Applied Potential**, enter -0.03. Leave the potential type as 'vs. Open Circuit'. Leave the Total Time as 50 seconds.

4. The **Data Acquisition** can be specified as either a 'Fixed number of points' spread evenly over the entire experiment, a 'Fixed Rate' of points per second, or as 'delta - I'. The 'delta - I' setting allows CorrWare to vary the data acquisition rate depending on how fast the current is changing. For example, you may want to take data quickly at the beginning of an experiment when the current is changing rapidly, but very little data is required toward the end of the experiment when the current is very stable. For this tutor, select 'Fixed Rate' and 5 Points/Second.

5. We will not be using **Experiment Termination** in this experiment. It can be used to stop an experiment before the **Total Time** has expired if the current goes above or below a certain level. This is commonly used to end a battery charge or discharge when the current reaches a certain level, or to stop a corrosion experiment when the current becomes large enough to indicate that pitting is occurring. When the termination conditions are met, the experiment is stopped, and the next experiment in the Experiment List is started immediately. Alternately, the experiment could be terminated after CorrWare determines that the cell current has become stable. The termination techniques are further described in Tutor #2 - Termination and Reversal.

6. The **Potentiostat** settings allow a particular experiment to have its own 'private' settings for the Pstat/Gstat parameters. Normally the settings we saw at the beginning of this tutor (using **Experiments | Setup Pstat/Gstat...**) apply to all the experiments in the experiment list. Using the 'Custom Settings' choice, a particular experiment can be designed with Pstat/Gstat settings which are different from the rest of the experiments.

   We will use the 'Default Settings' during this tutor.

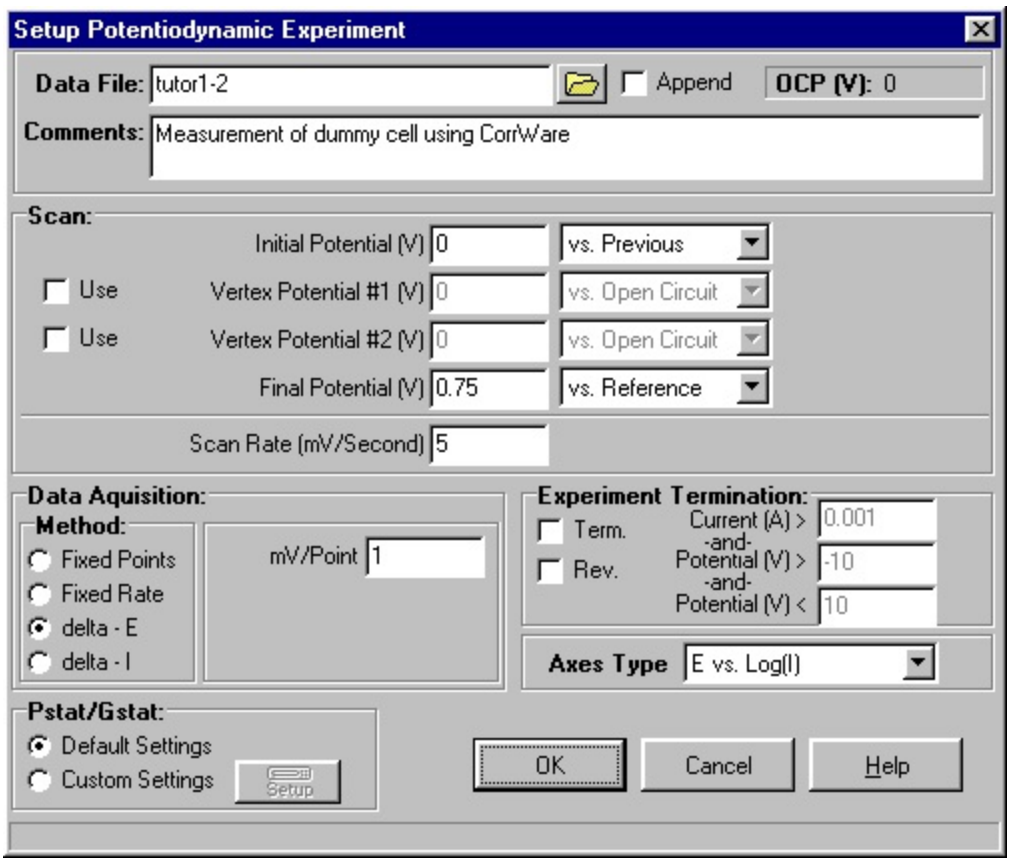
7. The **Axes Type** selects the type of axes used to display the data. Normally the default settings are correct for each type of experiment. When later examining the data with CorrView, the **Axes Type** will be the default axis for the data file, but other axes types can be used as well. (for example, a file measured with 'Current vs. Time' might later be displayed as 'Charge vs. Time'.)

Select **OK** to save the settings we have specified.

Notice that the Experiment List now contains a short description of the experiment. It indicates the first experiment is a Potentiostatic experiment at -0.03 Volts vs. Open Circuit for 50 seconds, the default Pstat/Gstat settings are being used, and the data will be saved in *tutor1-1.cor*.

We are now ready to define the potentiodynamic experiment. Notice the blank line at the end of the experiment list is highlighted. This indicates that the next experiment will be inserted after the Potentiostatic experiment.

To create another experiment segment, select **Experiment | Insert New Experiment...** (or press the <Insert> key on the keyboard, or click on the **Insert New Experiment** icon) and choose the **Potentiodynamic** Experiment.



Set the parameters as shown above.

The **Scan** parameters are used to define the sweep. The sweep can consist of 1, 2 , or 3 segments. The **Initial** and **Final** Potentials are always used. If neither of the **Use** boxes for **Vertex #1** and **Vertex #2** are checked, one segment is used (from initial to final). If one of them is checked, two segments are used (from initial, to vertex, to final). If both **Vertex** potentials are used, three segments are used (from initial, to vertex #1, to vertex #2, to final).

For this experiment, we want the scan to start at the same potential used by the Potentiostatic pretreatment. We could use the same setting used in the pretreatment (-0.03 vs. Open Circuit), but if we wanted to later change this value, we would have to change it in two places (in both the Potentiostatic and Potentiodynamic experiments). Instead, we can set the **Initial Potential** to '0 vs. Previous'. This starts the sweep at whatever potential was present at the end of the previous experiment. Thus, if the potential in the previous experiment (Potentiostatic) is changed to a new value, the sweep automatically starts at the new potential. These methods are more fully explained in Tutor #2 - Potentials.

The **Data Acquisition** method is set to 'delta -E'. This setting automatically calculates the acquisition rate based on the **Scan Rate**. Since the Scan Rate is 5 mV/Second, CorrWare will sample 5 Points/Second resulting in the requested 1 mV/Point spacing.

The Sweep could be terminated or the sweep direction reversed based on certain current and voltage conditions. See Tutor #2- Termination and Reversal for more information on these techniques.

Click on **OK** to save these settings.

Starting an Experiment

We are now ready to make measurements.

Notice that the 'Measure' icons are grayed, and under the **Experiments** drop down menu, the 'Measure' items are grayed. This is because an undefined line is currently selected in the Experiment List. Press the <Up Arrow> cursor key (or the <Home> key) to highlight the first experiment in the list. The 'Measure' icons should now be visible. There are two choices for making measurements. **Measure Selected ...to End** starts measuring with the highlighted experiment and performs all the experiments until it gets to the end of the list. **Measure Selected Lines** is used to measure only the highlighted experiments, allowing a subset of experiments to be measured. Other techniques to manipulate the experiment list will be described later in this tutor.

Make sure the dummy cell is connected and select **Experiments | Measured Selected ...to End**.

Measure Selected ...to End can also be started using **Ctrl+M** or by clicking on its icon ( ). To start experiments using **Measure Selected Lines**, use **CTRL+S** or its icon ( ).

The 'button bar' will change to reflect the options available during measurements. The list of experiments is also displayed. The experiment currently being measured is highlighted.

Let the experiments run until both the Potentiostatic and Potentiodynamic test have been completed. The data obtained during the Potentiodynamic experiment is illustrated in the beginning of this chapter.

The menus change to reflect the options available during a measurement. **Measure | Stop** (also accessible by clicking on the **Stop** icon) will immediately stop the measurements and turn off the potentiostat. **Skip to Next**( ) will stop the current experiment and immediately start the next experiment in the list. The other measurement options are described in CorrWare Measurements.

During a measurement, the displayed axes can be changed using the list box below the **CELL ON** indicator. The default axes for each experiment is defined in the experiment setup menu. When vs. Time axes are displayed, the axis may be rescaled during the experiment. This may be helpful if a stray data point causes the axis to scaled so that the rest of the data is difficult to
see clearly. To rescale the axis, hold down the **Ctrl** key and drag the mouse over the graph to
indicate to desired scaling range. This method rescales only the vertical axis and not the horizontal (Time) axis. Return to the original autoscaling by reselecting the axes using the axes selection box below the **CELL ON** indicator.

When the experiments are finished, click the **OK** box that appears.

We have now completed the first set of experiments. The experiment list should now be saved for later use. Select **File | Save Setup As...** ( ) and enter the file name *tutor1*. The experimental setup is now saved in the file *tutor1.cpw*. Note that CorrWare automatically appends the suffix '.CPW' to the setup file if you don't enter one.

Experiment List Tricks & Techniques

The experiment list has a variety of techniques that speed manipulation of the list.

Inserting New Experiments

We have previously seen than a new experiment can be inserted by simply pressing the <Insert> key. Experiments can be added to the middle of the list in the same manner. The

new experiment will be inserted at the highlighted line and the current line will be moved down the list. To see how this works, use the up and down cursor keys on the keyboard to highlight the 'Potentiodynamic' experiment, press <Insert>, and select the 'Open Circuit' experiment type. Click **OK** or press <Enter> to add the new experiment.

Modifying an Experiment

Modifying an experiment is as easy as inserting a new one. To modify an experiment, highlight the experiment you wish to modify and press <Enter> (you could also double-click on the experiment or select **Experiments | Setup Experiment...** or click on the **Setup Experiment** icon). You will now see the complete experiment setup window. After making changes, click **OK** or press <Enter> to save the changes. Click **Cancel** or press <Esc> to avoid saving any changes.

Changing File Names

It is very easy to change the data file names in each of the experiments within the **Experiment List**, allowing a series of experiments to be repeated with new data files.

Press the <Home> to make sure you are at the top of the list.

Select **Experiments | Search/Replace File Names...** or click on the **Replace Files** icon ( ).

Enter **Replace** *tutor1*
With *tutor2*

and click **OK**.

Notice that the file names have been changed from *tutor1-1.cor* and *tutor1-2.cor* to *tutor2-1.cor* and *tutor2-2.cor*. We are now ready to start a new set of experiments and save the data in new files.

Selecting Multiple Lines

A series of experiments in the experiment list can be highlighted simultaneously. The cut and paste techniques described below, as well as **Experiments | Measure Selected Lines** will perform their functions equally well on either single or multiple experiment lines.

To highlight more than one line, click the mouse on one item in the list and, while holding down the mouse button, move the mouse to include other lines.

There is also a standard Windows method to highlight multiple lines using the keyboard. Hold down the <Shift> key and press the Up and Down cursor keys.

Cut+Paste Techniques

CorrWare is quite similar to a word processor in its ability to cut and paste experiments from one portion of a list to another. Although commonly called 'Cut+Paste', there are actually four methods: Cut, Copy, Paste, and Delete. These methods are accessed through the **Edit** drop down menu. Windows has standard shortcut keystrokes for these functions. For example to 'Cut', use **Edit | Cut**, or press **Ctrl+X**. The shortcut keystrokes are listed in the **Edit** menu.

Cut (Ctrl+X): Removes the highlighted lines from the list and stores them so they can later be 'pasted'.

Copy (Ctrl+C): Stores a copy of the lines in memory so they can later be 'pasted'. Unlike **Cut**, the current lines are left in place.

Paste (Ctrl+V): Inserts, at the currently highlighted line, the lines that were last **Cut** or **Copied**.

Delete: Removes the highlighted lines from the list. The information in the lines is deleted and cannot later be pasted.

To move an experiment from one location in the list to another, highlight the line and select **Cut**, then move to the new location and select **Paste**.

To duplicate an experiment multiple times, highlight the line and select **Copy**. Use **Paste** repeatedly to insert multiple copies of the original.

Related Topics

Tutors

Tutor #2 - 'vs. Open Circuit', 'vs. Reference' and 'vs. Previous' Potentials

Whenever a potential is mentioned, it raises the question 'compared to what'. A reference electrode is typically used to provide a standard to which an electrode can be compared.

When a potential in one of the CorrWare experiments is specified as '**vs. Reference**' this is exactly what happens. The potentiostat is instructed to create the desired potential between the Working Electrode and the Reference Electrode.

If a two terminal cell (such as a battery) is used, the Working Electrode is connected to one terminal of the cell and the Reference Electrode cable and Counter Electrode are connected to the other terminal. Thus, when '**vs. Reference**' produces a potential between the Working and Reference, it is effectively producing this potential across the entire cell.

The Open Circuit Potential (also known as the free corrosion potential) is the potential that exists between the Working and Reference electrodes when no current is flowing through the potentiostat (i.e. the potentiostat is turned off). The Open Circuit Potential (OCP) is dependent on a great number of variables such as ion concentration, surface preparation, and pretreatment. These variables often make the OCP a moving target. If one had to manually determine the OCP and enter these values, it would be very inconvenient. In addition, the OCP may have changed by the time the experiment is actually started.

The obvious solution is to be able to say 'start the experiment at the OCP' and let CorrWare figure out its value. If you let CorrWare determine the OCP, you must understand **when** CorrWare measures the value. In the simplest terms, CorrWare uses the potential at the last time the system is uncontrolled by the potentiostat. CorrWare always measures the OCP just before starting measurements, but it will remeasure the OCP if given the opportunity.

For example, a potentiostatic experiment is followed by a potentiodynamic experiment starting at the OCP. The OCP used by the sweep is the OCP measured at the very start of the measurements (i.e. **before** the potentiostatic experiment).

On the other hand, if you use a potentiostatic experiment followed by an open circuit vs. time experiment followed by the potentiodynamic experiment starting at the OCP, CorrWare will remeasure the OCP during the open circuit vs. time experiment (and just before the sweep) and start the sweep at this new OCP value.

In each case, the OCP is measured at the end of the last time the system was allowed to be at an open circuit.

Specifying **'0 vs. Open Circuit'** would start a sweep at the OCP. One can also specify other values. For example, if '-0.1 vs. Open Circuit' were specified, the experiment would start 0.1 Volts **below** the OCP.

It should be noted that the OCP will often drift over time, particularly after the cell has been polarized in some way. If an open circuit vs. time experiment is used to redetermine the OCP, but the duration of the open circuit vs. time is too short, the system may not have stabilized by the time the next experiment is started. It is up to the user to determine the appropriate length of time to allow the system to stabilize, and when he or she wants the OCP measured.

The '**vs. Previous**' method is another alternative in setting a potential. This setting is used to control the potential based to the last potential present in the cell.

For example, suppose you want to apply 0.1 Volts for 50 seconds and then start a sweep from 0.1 to 0.5 Volts. You also know that in the future you will be repeating the same experiment, except that you will be using 0.2 Volts instead of 0.1. If '0.1 vs. Reference' were used, you would have to change the values in both the potentiostatic and potentiodynamic experiment. If '0 vs. Previous' were used for the start of the sweep, the sweep would start at whatever potential was present during the potentiostatic experiment.

If **'vs. Previous'** follows an open circuit experiment, the potential in the cell is the OCP thus **'vs. Previous'** would act the same as **'vs. Open Circuit'**.

Although rarely used, 'vs. Previous' can also be used between controlled current and controlled potential experiments. If a galvanostatic (constant current) experiment is followed by a potentiostatic experiment set to '0 vs. Previous', the potentiostatic experiment would start at whatever potential was present at the end of the galvanostatic experiment.

Related Topics

Tutors

Tutor #2 - Termination and Reversal Parameters

Each experiment type contains some sort of termination or reversal parameters. These parameters can be used to end an experiment earlier than would otherwise take place.

Terminate at Potential or Current Limits

The controlled potential experiments can terminate or reverse when a specified current is reached, while the controlled current experiments can terminate when a specified potential is reached. When the experiment is terminated, CorrWare saves the data and immediately moves on to the next experiment in the experiment list.

A very simple example involves the discharge of a battery at a constant current (galvanostatic). You may know that the battery is fully discharged when it reaches 0.9 Volts, but not know exactly how long this will take. The discharge time can be set to longer than necessary and the termination potentials used to stop the experiment when the potential is less then 0.9 Volts.

An experiment could also be designed which discharged at a constant potential (potentiostatic) until the current dropped below a certain level.

Terminate when Potential or Current is Stable

The static experiments (potentiostatic, galvanostatic and open circuit vs time) experiments can also terminate when the cell becomes stable. These techniques require two parameters, a delta-I or delta-E value and a time value. The experiment is terminated when the average current or voltage over the specified time changes less the delta-I or delta-E amount. The only way to determine the appropriate values is from experience with your particular electrochemical system.

For example, a potentiostatic (constant potential) could be applied and the experiment terminated when the current stabilizes. From other measurements, you know that it typically takes 30 to 60 minutes for the current to stabilize. From close examination of previous data, you decide that the current is stable when it changes by less than 2% over a 5 minute period. Thus you set the Total Time for the experiment to 100 minutes (to provide some extra time if a cell is slower than normal), the Termination delta-I value is 2% and the Termination delta-T value is 5 minutes.

When the experiment is performed, CorrWare averages the current for 5 minutes. It then compares this value to the averaged current for the previous 5 minutes. Because it

requires 2 5-minute segments before they can be compared, it would never terminate earlier than 10 minutes.

Note: 2% over 5 minutes is NOT the same as 0.4% over 1 minute. Because of noise in the signals (and resolution limits of the instruments), using a very small change over a short period of time may produce unexpected results. In general, the delta-T time should be at least 5% of the anticipated total time.

Terminating a Scanner Loop

The scanner experiment, which can be used to repeat a series of experiments multiple times, also has termination parameters. Because the experiments inside the repeated loop may contain both controlled current and controlled potential experiments, the loop may be ended if either the current or potential exceed specified limits. Note that the scanner termination limits are only checked at the end of each loop. They do not force an experiment inside the loop to terminate, but rather, they decide whether or not the loop should be repeated additional times.

For example, you might wish to discharge a battery at 0.1 A for 10 minutes and then take an impedance measurement, repeating this procedure until the battery potential is below 0.9 Volts. The scanner experiment would be set to repeat more times than necessary and the potential termination would be turned on.

Another example would involve a corrosion system where, starting with the OCP, the impedance is measured, the potential is increased by 0.1 Volts and the impedance is measured again. The potential increase (performed as an '0.1 vs Previous' potentiostatic experiment) and impedance measurement could be repeated until a particular potential was reached.

Terminating a Potentiodynamic Experiment

A potentiodynamic experiment can be terminated (or reversed) if the current goes above a particular level but does so quite differently from other experiments. This situation is discussed in *Section III - Polarization Scan Limits*.

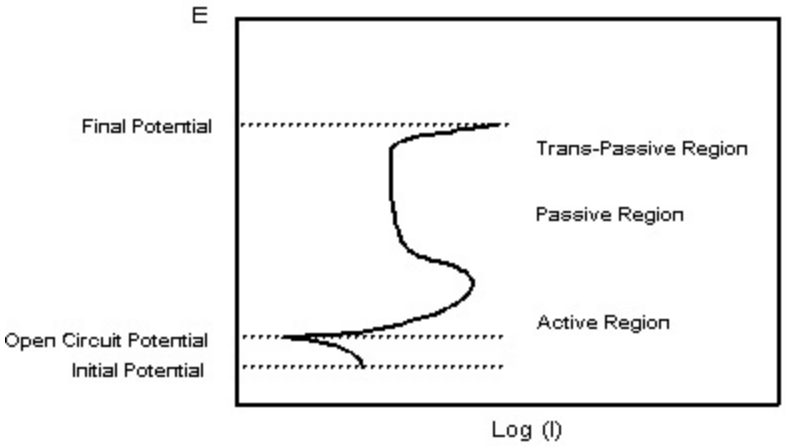
Related Topics

Tutors

Tutor #2 - Polarization Scan Limits

One of the most common corrosion experiments is the Anodic Polarization Scan, where the potential is scanned from at or near open circuit to some more anodic potential where the material is corroding at a fast rate.

The following figures show an idealized polarization curve for an active/passive metal. It will be referenced throughout this discussion.



Selecting Sweep Rates

The sweep rate can vary from microvolts/second to several volts/second. A value of 0.1667 mV/second (0.6 Volts/hour), which corresponds to several ASTM standards (ASTM Standard Practice G 61), is one of the most commonly applied rates.

Generally, one wants to sweep as quickly as possible without removing the system from steady state. In other words, you want to get the same results as if you did the sweep infinitely slow, and your sample had plenty of time to decide how it wants to react. For example, if your sample exhibits a pitting potential and you sweep to fast, the pitting potential will be shifted to more anodic potentials because it takes time for the pits to initiate.

Faster scans, however, can be useful in avoiding problems such as localized corrosion around gaskets and masks. Faster scans also allow more samples to be measured in a given amount of time.

Choosing an Initial Potential

Most polarization scans are started at the sample's open circuit potential (or free corrosion potential). As a modification to this, it may be helpful to start an anodic scan 5 to

30 mV on the **cathodic** side of open circuit. This is particularly useful if you wish to calculate the polarization resistance from the slope of the I vs. E plot at open circuit. By starting slightly cathodic, the sample will pass through open circuit allowing the determination of both the polarization resistance and the anodic tafel slope from a single data set.

If a scan is started at a potential other than open circuit, you may wish to use some sort of pretreatment prior to the scan. Otherwise, the potential will jump straight from open circuit to the initial potential at the start of the scan. This can result in current spikes which may distort the data at the beginning of the scan. Typically a Potentiostatic experiment will be used to hold the potential at the initial scan potential prior the Potentiodynamic experiment.

When Should a Scan be Reversed

Depending on the sample material, one may want to reverse the scan at some point in the test and scan back to (or near) the starting potential. A reverse scan is most often useful with materials which exhibit active/passive behavior. In such a case, the passive film is broken down on the forward (anodic) scan and may reform at some point in the reverse scan. The difference between the potential at which the passive film breaks and reforms can be a useful parameter in comparing materials.

Reverse scans also produce useful data on materials which de-alloy. Because different elements are removed from the material at different rates, the composition of the surface will be different during the forward and reversed scans resulting in different characteristics for the two segments.

A reverse scan is used less often on materials which do not form a passive film because the forward and reverse scans are often very similar. Using a reverse scan may just double the total time required for a test without yielding any additional information.

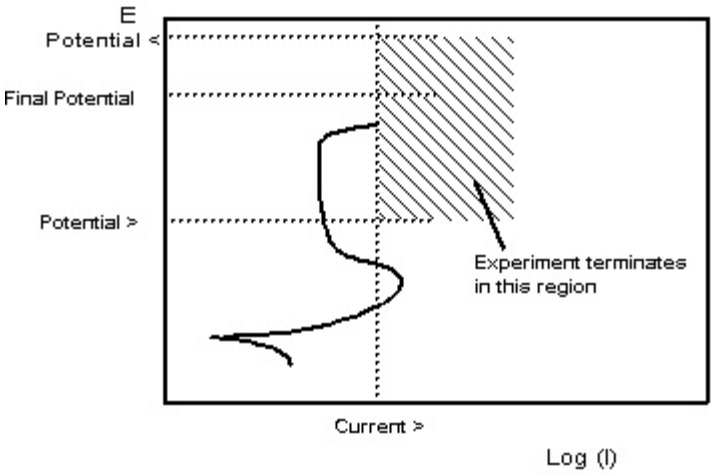
Selecting an Anodic Scan Limit

There are no fixed rules on how to determine the anodic limit of the experiment. In general, it is chosen at a point where further scanning would not result in significant data and would simply cause further destruction of the sample.

The limit can be chosen as a particular potential or current. It is also possible to specify both types of limits and have the scan stop (or reverse) when either one is reached.

To use the potential limit, simply enter the desired potential as the Final Potential (for single direction sweeps), or as the Vertex Potential (for reversed sweeps).

The termination/reversal current is useful if you don't know exactly what potential limit to use. For example, you may wish to reverse the sweep when the passive film breaks down, but the potential at which this happens may vary from sample to sample. By specifying a **Current >** value, you can have the scan terminate/reverse when the current gets large enough to indicate depassivation (often ~1 mA/cm2 of surface area). When using the current limit, you should try to set the vertex or final potential just slightly more anodic than necessary. If you choose an unrealistically large vertex potential (i.e. 10 Volts) and assume that the scan will be reversed at the current limit, data accuracy and sampling frequency will be sacrificed. This occurs because CorrWare must initially setup the instrument for the full voltage scan and the instruments generally produce poorer quality scans over wide potential ranges.



In addition to the termination current, two termination potentials (**Potential >** and **Potential <**) are necessary. CorrWare will use the termination current only when the cell potential is between these two values. When measuring active/passive materials, the reverse is usually performed in the 'transpasive' region. However, if the current in the active region is very large, the termination current might be reached in the active region and the scan would be reverse before it even got to the passive region. By using the termination potentials, you can effectively say 'don't worry about the termination current until you have reached this potential'.

Related Topics

Tutors

Tutor #2 - IR Correction Techniques

IR Correction refers to methods used to compensate for unwanted resistances in an electrochemical system. If left uncorrected, these resistances can distort data or make it impossible to perform the desired experiment.

The resistance of the electrolyte between the working electrode and the reference electrode is the most common cause of errors; however, contact resistance or long electrode leads can also create errors.

As an example, consider an electrolyte of 1E-5 Molar KCl with a specific resistance of 770 Ohm-cm. The resistance between the working and reference electrodes will depend on cell geometry, but let's assume a resistance of 100 Ohms if the reference is placed a few millimeters away from the working electrode. If 1 mA is passed through the electrode, a potential drop of
IR = (100 Ohm) x (1 mA) = 100 mV will occur between the working and reference electrodes. Thus, the potential measured by the reference is 100 mV **different** than the potential actually applied to electrode-electrolyte interface. The purpose of IR compensation is to correct for this current-dependent error.

There are two compensation techniques which will be discussed: Current Interruption (sampled IR correction), and Feedback compensation.

Current Interruption

Current Interruption uses a very brief interruption of the electrode current to measure and compensate for IR potential drop errors. This requires the potentiostat to momentarily stop the cell current and then measure the electrode potential. With no current flowing, the potential drop in the resistive component of the electrolyte between the reference electrode and the electrode surface drops to zero, allowing measurement of the true electrode potential. The potential applied between the working and counter electrodes is increased until the interrupt-measured value agrees with the desired potential.

This method is the most powerful technique because it is not necessary to determine (or guess) the solution resistance. This is particularly important if the solution resistance changes while the test is in progress.

The technique also has drawbacks in that it is very sensitive to the potentiostat bandwidth used. Before using this technique, one should always use an oscilloscope to examine the interrupt waveform to determine the correct bandwidth selection. See your potentiostat manual for more information on using an oscilloscope with your potentiostat.

The current interrupt process can also increase the level of noise in your data because of the need to measure the potential during the very short interrupt period.

Feedback IR Correction

This method requires the user to enter a value for the electrolyte resistance between the reference and the electrode surface. It then increases the applied potential by multiplying the chosen resistance value times the cell current.

It may be difficult to determine the correct electrolyte resistance. In addition, the potentiostat will go into wild oscillations if the chosen resistance value is equal to or greater than the actual resistance; thus, one can usually compensate for only 95-98% of the solution resistance.
Electrochemical Impedance Spectroscopy is generally the best technique for determining the solution resistance. Alternately, one can manually use the current interruption technique using an oscilloscope to determine the value or slowly increase the feedback resistance value until oscillations just start to occur and then back off slightly.

Related Topics

Tutors

Tutor #2 - Electrochemical Noise Techniques

Noise Measurement is accomplished using the E & I Noise experiment.

Very Important - Read This!

The E & I Noise experiment requires a different configuration of the cell cables from all other experiments. Using the E & I Noise configuration with other experiments could potentially damage the instrument or expose the user to a dangerous electrical shock!

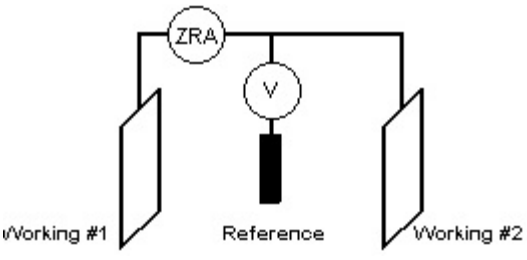
Using the Normal cable configuration with an E & I Noise measurement will not cause damage but will result is incorrect and useless data. CorrWare will not allow E & I Noise and Normal experiments to be run from the same experiment list, but cannot warn of incorrect cables because it has no way to determine if the cell cables have been configured correctly.

It is up to the user to assure that the correct connections are made for a particular experiment.

Note: Because of the electrical design of the PAR 273/273A and AMEL 5000, these instruments are unable to perform E & I Noise experiments properly.

Connecting the Cell

E & I Noise measurements are performed by shorting together two identical Working electrodes. The current flowing between the two Working electrodes, as well as the potential between the Working electrodes and a reference electrode is monitored.

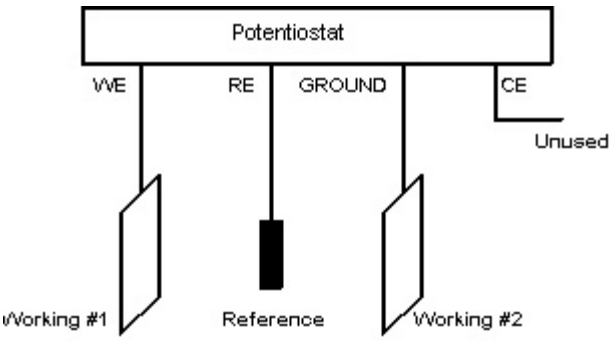


The potentiostats which can perform this experiment actively hold their working electrode connection at the ground potential by a small amplifier circuit. If one Working electrode is directly connected to ground and the other is connected to the working electrode cable, they are both held at the same potential and are, in effect, shorted together. Any current which flows between the two electrodes is measured by the instruments current

measurements circuits thus creating a Zero Resistance Ammeter (ZRA).

The potential is measured between the Working electrodes (since they are shorted together, both Working electrodes are at the same potential) and a reference electrode.

These connections are shown below, on the following page is a description of the connections.



Solartron 1287, 1286, 1285 and 1280 users:

Plug the 'banana' jack on the end of RE2 cable into the side of the WE cable. Label the cables as follows:

Connect a Ground wire to the chassis ground provided by the instrument. On the 1287 and 1286, the ground is a banana jack on the front panel near the WE and RE2 connectors. On the 1285 and 1280, the ground is a green banana jack on the rear panel.

Cables	**Label**
WE+RE2	Working #1
RE1	Reference
GROUND	Working #2
CE	*Unused*

PAR 263/263A, VersaStat2 and 253(VersaStat) Users:

The cell cables are color coded as follows:

Color	**Label**
Green	Working #1
White (or Yellow)	Reference
Black (Ground)	Working #2
Red (Counter)	*Unused*

PAR 283 Users:

Connect a Ground wire to the chassis ground provided by the instrument. The Ground connection is a banana jack near the Dummy Cell connectors.

Cable	Label
Working +Sense	Working #1
Reference	Reference
GROUND	Working #2
Counter	*Unused*

Performing Noise Measurements

A Noise experiment measures the potential and current at a fixed rate for a fixed number of points. Often, noise data is measured for days or weeks in an attempt to identify a change in the noise which corresponds to a change in the electrodes (such as the onset of accelerated corrosion). If the data is measured continuously, the number of data points may soon become overwhelming. For example, measuring 5 points/second for 1 week would result in over 3,000,000 data points.

Instead, the data may be measured in bursts. For example, data could be measured for 20 minutes at 5 points/second (6000 points). For the next 100 minutes no data be measured, followed by another 20 minutes of data collection. Each 20 minute segment could then be analyzed to calculate a single noise level value. The result would be a single noise point for every 2 hours.

To perform the sequence described above, the Scanner experiment would be used to repeat a series of E & I Noise experiments. For example:

Scanner Begin [repeat cycles: 84]
  E & I Noise [6000 points, 5 points/sec, save data] (20 minutes)
  E & I Noise [6000 points, 1 points/sec, do not save data] (100 minutes)
Scanner End

would run for 7 days (84 cycles x 2 hours/cycle) and save data for 20 minutes every 2 hours.

Noise Data

There are numerous calculations which may be performed on noise data including calculating frequency spectrums using FFT or MEM. To successfully use these methods, it is generally necessary for a large amount of user intervention in the calculation and are not directly supported by CorrWare or CorrView. Noise data may however be saved in ASCII text format (saved directly for CorrWare, or converted using CorrView) such that it is easily accessible by spreadsheet or user written programs.

The RMS values of the Potential and Current Signals can be calculated by both CorrWare and CorrView. They are calculated by first subtracting any linear background drift to the signal and then using the equation

RMS = sqrt {{SUM from {i=1} to n {X sub n}^2} over n}

where: n = number of data points
Xn = value of the nth data point

In CorrWare the RMS values are calculated at the end of each noise experiment and are saved in the file specified by the **RMS File** parameter in the E & I Noise setup menu. In the example given previously, after 1 week, the RMS file would have 84 lines in it - one line corresponding to each 20 minute measurement.

The RMS values can be saved even if the full data set (the potential and current values) are not. The previous example made no use at all of the data acquired during the 100 minute experiments. Instead, we could use the experiment list:

```
Scanner Begin              [repeat cycles: 84]
  E & I Noise      [6000 points, 5 points/sec, save data,      save RMS]      (20 minutes)
  E & I Noise      [6000 points, 5 points/sec, no data,      save RMS]      (20 minutes)
  E & I Noise      [6000 points, 5 points/sec, no data,      save RMS]      (20 minutes)
  E & I Noise      [6000 points, 5 points/sec, no data,      save RMS]      (20 minutes)
  E & I Noise      [6000 points, 5 points/sec, no data,      save RMS]      (20 minutes)
  E & I Noise      [6000 points, 5 points/sec, no data,      save RMS]      (20 minutes)
Scanner End
```

If these experiments were performed, there would be 504 RMS values (every 20 minutes). The full data sets would still be saved for 20 minutes ever 2 hours.

The RMS file is in a tab delimited ASCII text file which can be read by any word processor or spreadsheet program such as Excel or 1-2-3. A sample file is shown below.

```
CORRW RMS NOISE
CorrWare for Windows: Version 2.0
E & I Noise      [512pts, 20pts/sec, temp.txt][default]      temp.cor
```

Date: 06-29-1995 Time: 15:04:51

"Description"	"Time(Seconds)"	"E_RMS(V)"	"I_RMS(A)"	"I_RMS(A/cm2)"	"E_RMS/I_RMS(V/A)"	"E_RMS/I_RMS(V/ A/cm2)"
"512 points, 20.00 pts/sec"	0	1.8583E-0003	6.5915E-0008	6.5915E-0008	2.8192E+0004	2.8192E+0004
"512 points, 20.00 pts/sec"	27	1.7349E-0003	5.1165E-0008	5.1165E-0008	3.3909E+0004	3.3909E+0004
"512 points, 20.00 pts/sec"	53	2.2144E-0003	5.0882E-0008	5.0882E-0008	4.3520E+0004	4.3520E+0004
"512 points, 20.00 pts/sec"	80	1.3114E-0003	4.9576E-0008	4.9576E-0008	2.6452E+0004	2.6452E+0004
"512 points, 20.00 pts/sec"	106	1.2648E-0003	4.4468E-0008	4.4468E-0008	2.8443E+0004	2.8443E+0004
"512 points, 20.00 pts/sec"	132	1.6489E-0003	4.9762E-0008	4.9762E-0008	3.3136E+0004	3.3136E+0004
"512 points, 20.00 pts/sec"	159	1.2466E-0003	4.3012E-0008	4.3012E-0008	2.8982E+0004	2.8982E+0004

The **Time** value is the starting time of each experiment. The I_RMS are saved as both total current: I_RMS(A) and surface area corrected: I_RMS(A/cm2). In addition Voltage/Current values are calculated.

Related Topics

Tutors

Tutor #2 - Polarization Resistance Calculations

This section only applies to the Polarization Resistance experiment.

The polarization resistance (Rp) is calculated as the inverse of the slope of the I vs. E data near the Open Circuit potential.

Rp (Ohms) is the inverse of the slope of the I vs E data.

ECorr (Volts) is the potential at which the current changed polarities. This usually corresponds to the open circuit potential of the system.

Estimated ICorr(Amps/cm2) is based on the Stern-Geary relationship (Stern and Geary, J. Electrochem. Soc. 104 56, 1957):

Icorr(A/cm^2) =(Ba * Bc) / (2.3*(Ba+Bc) * Rp)

Since the Tafel slopes (Ba and Bc) cannot be calculated from this data, 0.12 V/decade are often used, resulting in the approximation (Mansfeld, Advances in Corrosion Science and Tech., 6 Ed. Fontana and Staehle, Plenum Press, p. 163, 1976):

Stern Geary Coef. = (Ba * Bc) / (2.3*(Ba+Bc)) = 0.026

Icorr (A/cm^2) = 0.026 / Rp

The Stern-Geary Coefficient is specified in the **Setup | Cell...** window.

Corrosion Rate is calculated from:

MPY = (Icorr(A/cm^2) * EquivWeight(g/equivalent) * 393.7(mils/cm)) / (Density(g/cm^3) * 96500(coulomb/equivalent))

or

mmPY = (Icorr(A/cm^2) * EquivWeight(g/equivalent) * 10(mm/cm)) / (Density(g/cm^3) * 96500(coulomb/equivalent))

The Corrosion Rate calculations are only possible if Density and Equivalent Weight values were entered in the **Setup | Cell...** window.

Important Note: The calculated values depend on the proper selection of data to be used by this function. In addition, data artifacts or improper experimental technique may cause

large discrepancies in the results. The user must depend on there own knowledge of electrochemistry or corrosion to determine if the values are valid.

Related Topics

- Tutors
- Setup Cell Information

Tutor #2 - Using Multiple Instruments Simultaneously

CorrWare has the ability to run experiments on multiple instruments with each instrument having its own completely independent experiment list. CorrWare is sold in versions which support 1, 6, or more instruments. The single instrument version will allow you to set up multiple instruments but you will only be allowed to perform measurements on one instrument at a time.
The instruments do NOT have to be the same model. One could perform 6 measurements on 6 different types of potentiostats at the same time.

To determine how many instruments are supported by your current version, select **Help | About CorrWare...**. The serial number will be followed by the multiple count. For example *1234-6* would indicate that you can use 6 instruments simultaneously. The multiple instrument count is contained on the software protection 'dongle'. If you wish to increase the instrument count, the 'dongle' can be reprogrammed without disrupting your work or even installing any software.

Creating Experiment Lists for Multiple Instruments

To create a new Experiment List for an additional instrument, use the **File | New Instrument...** function described in CorrWare Menus. Select one of the 'Undefined' instruments and use the **Modify Instrument** button to define the instrument. Each instrument must have a separate address on the GPIB bus. You will have to determine which addresses are not currently being used by other instruments and configure the potentiostat to the unused address.

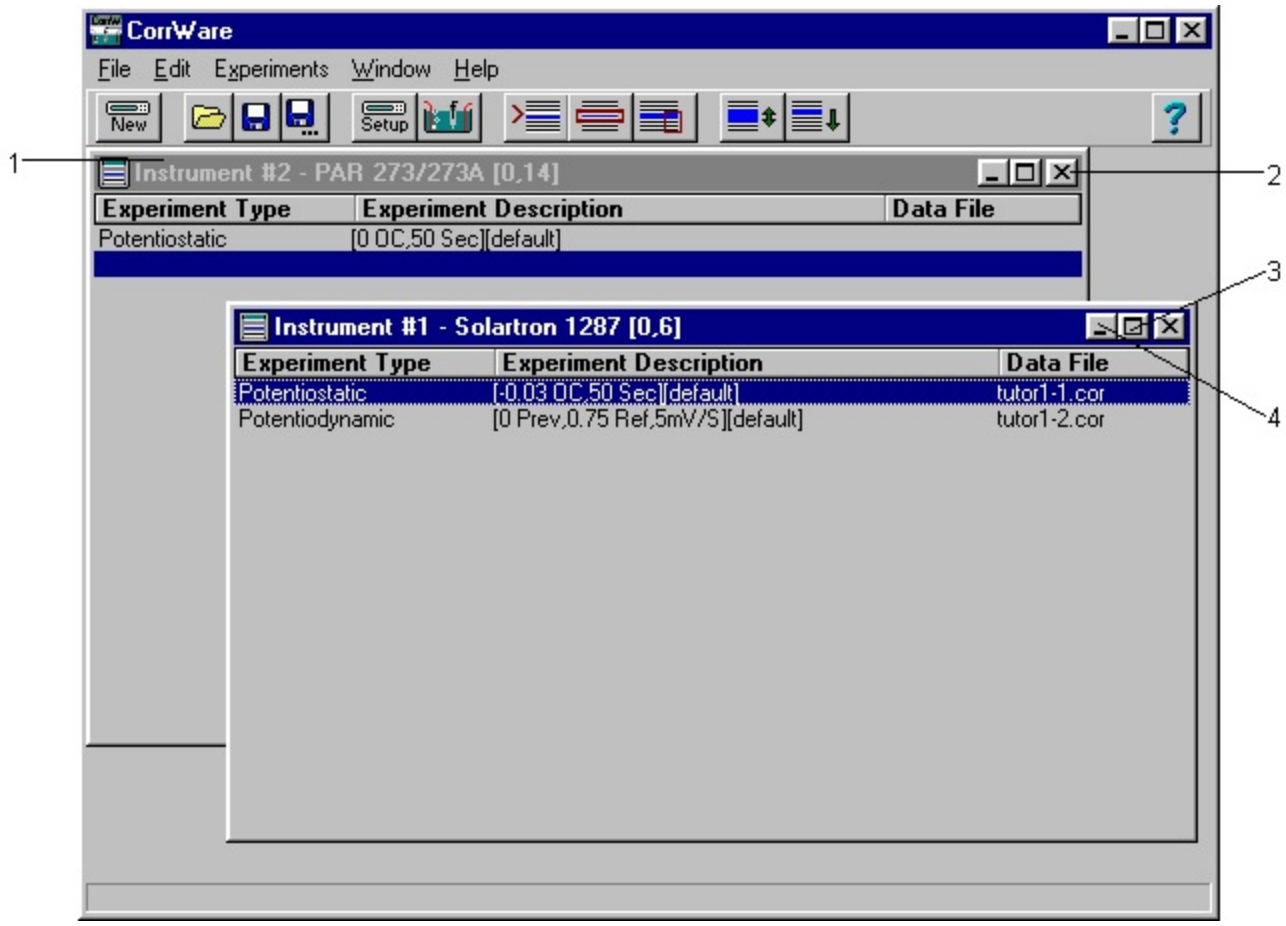
Note: The Solartron instruments actually use 2 addresses, the address set by the switches on the rear of the instrument as well as the next higher address. For example, if the switches are set to an address of 2, both address 2 and 3 are being used.

When defining the instrument, you may also want to choose your own **Instrument Title**. This name is displayed above each instruments Experiment List to help you keep track of each instrument. It is a good idea to put a label showing this name on the front of each instrument.

When multiple instruments are being used, one of them has its title highlighted designating it as the 'active' instrument. The other instruments are still operating, and measurements will continue even if the instrument has been minimized to an icon. The 'active' instrument, however, receives all keyboard inputs. To 'activate' another instrument, click on its title bar

or choose **Window** and select the desired instrument from those listed.

When multiple instruments are being used, they can appear as a stack of windows with one on top of each other (using **Window | Cascade**), side by side (using **Window | Tile**), iconized, or displayed with one window occupying all of the space and the others hidden.



1. Click on the title bar to 'activate' an instrument. Instruments are also listed in the **Window** menu. This is useful if the instrument you want is hidden behind other windows.

2. Double click on the 'control-menu' box to close the instrument. An instrument may also be closed using **File | Close Instrument**. If experiments are in progress on an instrument, the measurements must first be stopped before the instrument may be closed.

3. The 'maximize' box will expand the instrument to fill the entire CorrWare window. The other instruments will be hidden behind this window but will continue to operate.

4. The 'minimize' box changes the instrument to an icon. The instrument will continue to operate when minimized.

Related Topics

Tutors

Setup Pstat/Gstat

Accessed by: **Experiments | Setup Pstat/Gstat...** 

The options available depend on the model of the instrument. Select Setup Solartron Pstat/Gstat or Setup PAR Pstat/Gstat.

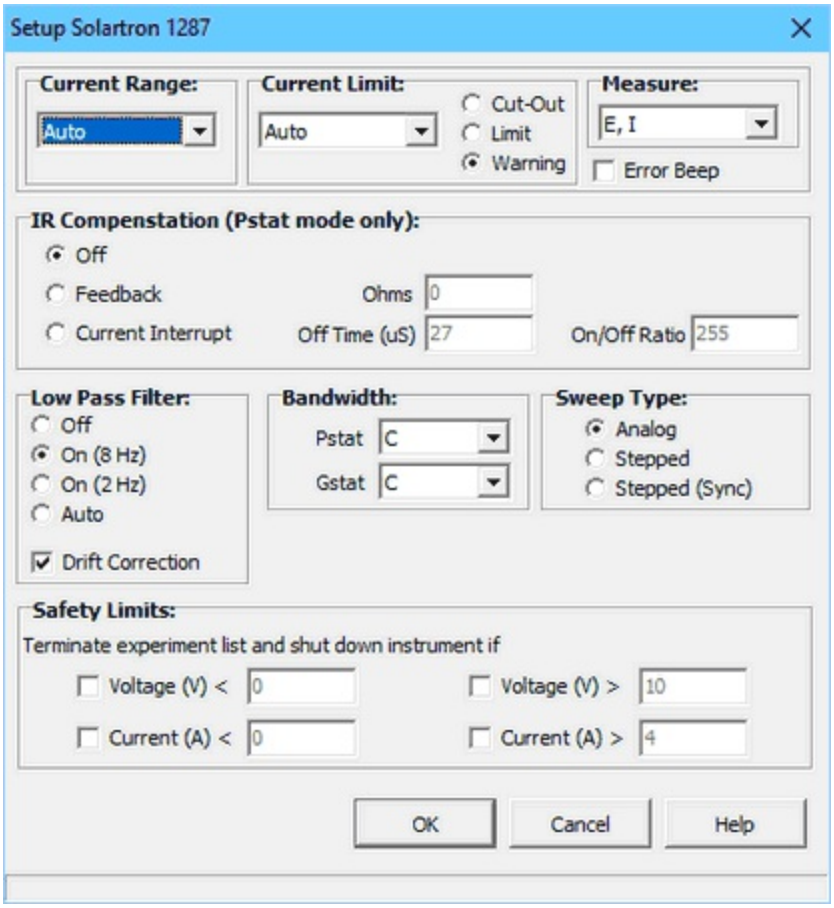
Note: The Schlumberger 1286 and 1280 operate identically to the Solartron 1286 and 1280.

Related Topics

- Setup Solartron Pstat/Gstat
- Setup PAR Pstat/Gstat
- Setup AMEL Pstat/Gstat
- Setup Experiment
- Setup Cell Information
- Load/Save Setup

Setup Solartron Pstat/Gstat
(Solartron 1287, 1286, 1285 and 1280)

Accessed by: **Experiments | Setup Pstat/Gstat...** 



The **Current Range** parameter selects the full scale current range to be used during experiments. Selecting 'Auto' allows the instrument to select the current range based on the actual current being measured.

Current Limit may be used to cause an action if the current exceeds a set value. If **Warning** is chosen, the instrument will beep and display 'Current Overload'. If **Limit** is used, the instrument will prevent the current from exceeding the set value. **Cut-Out** causes the instrument to disconnect from the cell if the current limit is exceeded. When the **Current Limit** is set to 'Auto' the current limit is set to the same value as the **Current Range**. If both are set to 'Auto', the Current Limit is 2 Amps.

Measure selects which signals will be measured. The Solartron 1286 and 1287 have a DVM Input connector on the rear panel of the instrument. This auxiliary signal can be measured instead of either Potential or Current. It is not possible to measure all three signals (Potential, Current, Auxiliary).

The **Error Beep** checkbox determines if the instrument makes an audible beep when an error condition (such as current overload) occurs. Uncheck the box to silence the sound.

IR Compensation is only used during Potentiostatic (controlled voltage) operation. The **Feedback** compensation method may be used to boost the cell voltage to compensate for voltage drops cause by the cell geometry and solution resistivity. **Feedback** may only be used with a fixed (not 'Auto') **Current Range**. The maximum allowable Feedback value (in ohms) for each current range is as follows:

Current Range	Maximum Feedback
2A	1 Ohm
200mA	10 Ohms
20mA	100 Ohms
2 mA	1k Ohms
200uA	10k Ohms
20uA	100k Ohms
2uA	1M Ohms
200nA	10M Ohms

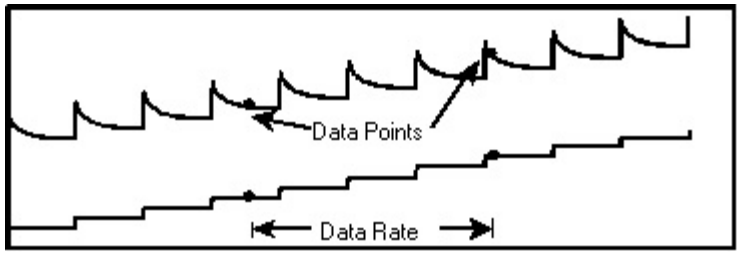
The **Current Interrupt** method periodically interrupts the current to measure and compensate for the actual IR drop. **Off Time** and **On/Off Ratio** control the duration and frequency of the current interrupts.

The **Low Pass Filter** may be used to reduce high frequency noise. Unless high sampling rates are required, the 8 Hz or 2 Hz are preferable. If 'Auto' is selected, the filter is automatically selected based on the sampling rate selected in the Experiment configuration.

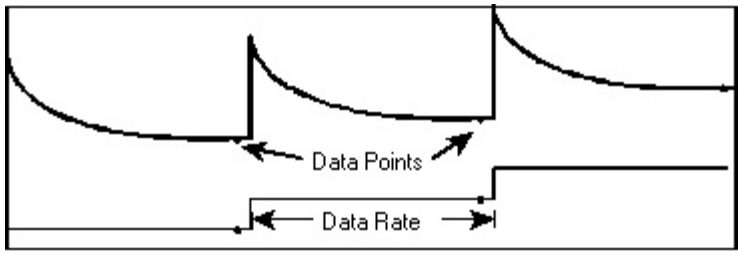
When in Potentiostat mode, the instrument has 10 different **Bandwidths** available. In Galvanostat mode 3 **Bandwidths** are available. These selections allow one to optimize the stability and performance of the instrument. In general, Bandwidth 'C' is appropriate for most cells, however you may wish to select one of the very limited bandwidths ('F' - 'J') to reduce noise. See your instrument manual for a description of each bandwidth.

The **Sweep Type** selects how a potential or current sweep is performed. The **Analog** sweep produces a continuous, smooth sweep while the **Stepped** sweep uses a series of small (usually <0.1 mV) steps to produce a sweep.

The **Analog** sweep has the advantage of producing perfectly smooth sweeps but cannot produce sweeps slower than 0.1 mV/Second. Because of its analog nature, the actual sweep rate may vary somewhat from the specified value.



Stepped sweep rates can be used as low as 1e-5 mV/Second (0.01 uV/Second), and the sweep rates are exact. However, this method must use a series of small steps to approximate a smooth sweep. Because data acquisition can occur at any time during a voltage step, this scan method may exhibit noise created by the double-layer capacitance.



Stepped (Sync) uses a modified version of the Stepped sweep where the voltage steps are synchronized with the data acquisition rate. A data point is measured just before a voltage step occurs. Because of the timing, most of the double-layer charging current is not included in the data point. This effect may be either good or bad, depending on the type of data desired. Noise created by current range changes is also reduced because current range changes typically occur at a voltage step. The full synchronizing effect only occurs at very low data acquisition rates (acquisition rates <1.9 points/second when no low pass filter is used, <1.2 points/second when the 8 Hz filter is used, and <0.45 points/second when the 2 Hz filter is used).

Safety Limits are used to shut off the cell and end experiments if an unexpected condition is encountered.
If a Safety Limit Type is checked and the Safety Limit Value is exceeded, the cell is turned off, the experiment list is stopped, and an error message is displayed.
The safety limits are created by CorrWare, not the instrument. If communications is lost between CorrWare and the instrument, the limits will not function.

The **OK** button exits the setup menu and saves any changes you may have made.

Cancel exits the setup menu. Any changes you may have made to the parameters are lost.

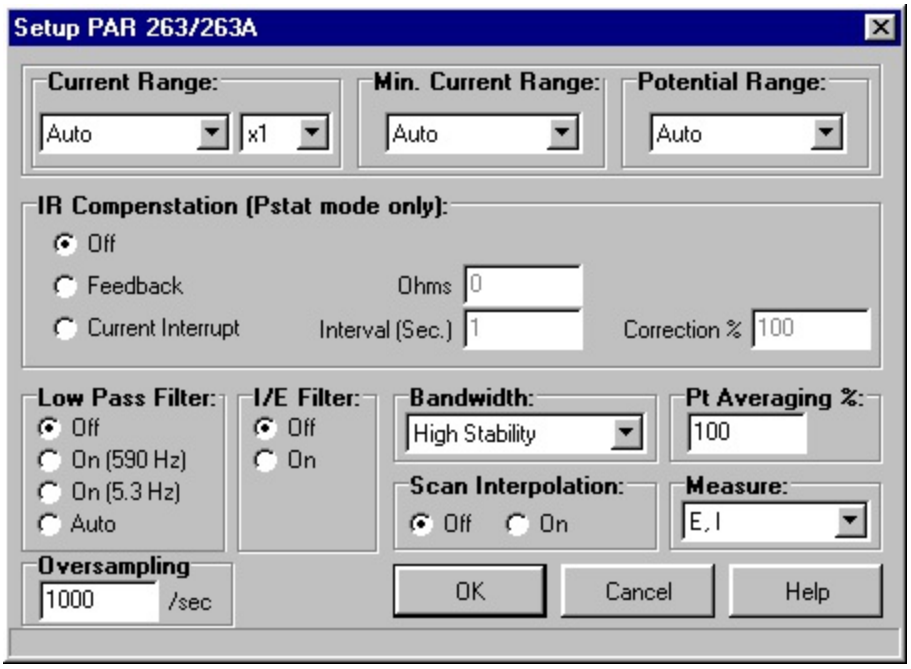
Help accesses the on-line help information on the setting up of the Pstat/Gstat.

Related Topics

Setup Pstat/Gstat
Setup Experiment

Setup PAR Pstat/Gstat
(PAR 283, 273, 263, 253(VersaStat), and 173/276)

Accessed by: **Experiments | Setup Pstat/Gstat...** 



The **Current Range** parameter selects the full scale current range to be used during experiments. Selecting 'Auto' allows the instrument to select the current range based on the actual current being measured. Additional gain settings (x1, x5, x10, x50) amplify the signal before it is measured for higher resolution.

Min. Current Range may be used to select the smallest current range that will be used when the **Current Range** is set to 'Auto'. If the Current Range is fixed (not 'Auto'), the **Min. Current Range** has no effect. If **Min. Current Range** is 'Auto', all current ranges will be used.

The **Potential Range** selects the maximum voltage that can be measured. Generally 'Auto' is the best choice, however if you use a PAR 253 (VersaStat) or 173/276 to perform Galvanostatic experiments on cells with voltages greater than 2V, you may have to manually select the 10 Volt range.

Note: IR Compensation options depend on the model of instrument you are using. Their differences will be noted below. **IR Compensation** is only used during Potentiostatic (controlled voltage) operation.

The **Feedback** compensation method may be used to boost the cell voltage to compensate for voltage drops cause by the cell geometry and solution resistivity. **Feedback** may only be used with a fixed (not 'Auto') **Current Range**. The maximum allowable Feedback value (in ohms) for each current range is as follows:

Current Range	Maximum Feedback
1A	2 Ohm
100mA	20 Ohms
10mA	200 Ohms
1 mA	2k Ohms
100uA	20k Ohms
10uA	200k Ohms
1uA	2M Ohms
100nA	20M Ohms

Note: Feedback is not available on the PAR 253 (VersaStat). With the PAR 276, the **Feedback** may be set using a knob in the front panel of the instrument. See the instrument manual for further details.

The **Current Interrupt** method periodically interrupts the current to measure and compensate the actual IR drop.

PAR 283, 273A, 273 with Option 96 or 97, and PAR 263:
Interval and **Correction%** control the frequency of the current interrupts as well as how much of the measured IR is corrected. The instrument also has separate parameters for each current range which determine how the interrupt is measured. These parameters must be set through the front panel of the 273. See your instrument manual for further details. The parameters are listed in the index under Functions 18 and 19.

PAR 253 (VersaStat):
Duration and **Correction%** control the length of the current interrupts as well as how much of the measured IR is corrected.

PAR 273 and PAR 173/276:
The Current Interrupt method is not available with these instruments.

The **Low Pass Filter** may be used to reduce high frequency noise. Except when high sampling rates are required, **On** (a 5 Hz filter) is preferable. If 'Auto' is selected, the filter is automatically selected based on the sampling rate selected within the Experiment configuration.

Some PAR models have an additional **I/E Filter** which places a capacitor in parallel with the current measurement circuit. The effect of this capacitor depends on the current range, with stronger filtering achieved with smaller current ranges.

Important Note: The Filters can sometimes cause problems when used in combination with Current AutoRanging or when used with galvanic (controlled current) experiments. The

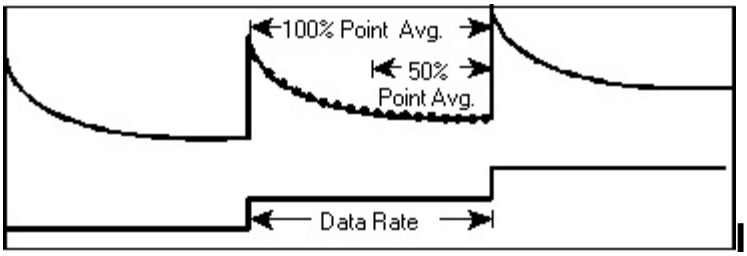
Filters distort the current signal for a short time after a transient. If the instrument requires an accurate signal shortly after a transition such a change in current range or change in applied current, the filters can cause the instrument to loose proper control of the cell. See your instrument manual for a further description of the filters effects.

All PAR 283, 273 and 263 models have a **Bandwidth** control, while all other PAR models have a fixed bandwidth. These selections allow one to optimize the stability and performance of the instrument. In general, 'High Stability' is appropriate for most cells as some electrochemical systems may be unstable with the 'High Speed' setting. See your instrument manual for a description of each bandwidth.

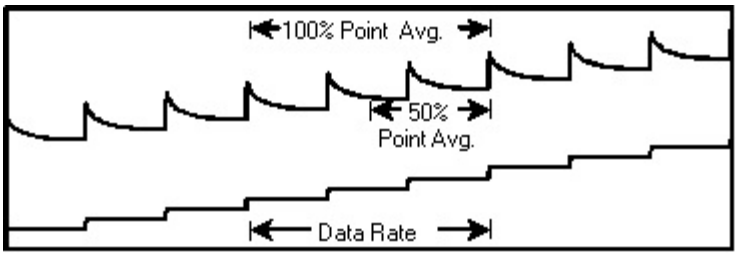
Point Averaging % is used to control the averaging of data between data acquisition points. The instrument typically samples the current and voltage 250 times per second. If data is acquired at a slower rate, the 250/second samples can be averaged to produce a lower noise level. For example, if data is acquired (displayed and saved by CorrWare) 1 time per second and **Point Averaging** is 100%, all 250 samples are averaged into 1 data point. If the Point Averaging is 50%, only the second half of the 250 points (126-250) are averaged. If Point Averaging is 0%, only the final sample (sample 250) is used for the data point.

Point Averaging can have a strong effect on noise levels, but can also change the measured values and interact with the **Scan Interpolation** setting as described below.

Scan Interpolation controls how voltage scans are produced. All PAR potentiostats create a voltage scan using a series of small steps. When Interpolation is On, the instrument uses the smallest possible steps. This will often produce several small steps within a single acquired data point. When Interpolation is **Off**, voltage steps only occur between data points.



Interpolation Off: When Point Averaging is 100%, the double-layer charging current (current spike after each step) is averaged into each data point. When 50% Point Averaging is used, most of the double-layer charging current is not included in the data point. This effect may be either good or bad, depending on the type of data desired. A Point Averaging value < 100% can also reduce noise created by current range changes because current range changes typically occur at a voltage step.



Interpolation On: A smoother scan is created, but noise may be introduced because current range changes will often occur in the middle of a data point. Because voltage steps may occur at any time within a data point, double-layer charging current cannot be removed from the data using Point Averaging < 100%.

Measure selects which signals will be measured. Many PAR instruments have a A/D Input connector on the rear panel of the instrument. This auxiliary signal can be measured in addition to the Potential and Current. Potentiostats which perform Current Interrupts can also save the actual voltage drop during the interrupt. This choice is called EiR.

OverSampling controls the potentiostats internal measurement rate. The **OverSampling** parameter sets the maximum internal sampling rate. Typically the potentiostat will sample at 250 points/second as described in **Point Averaging %**. Setting the OverSampling rate to 240/second may help cancel 60 Hz noise.

The **Instrument Overload** setting determines what action is taken if a voltage or current overload occurs. **E Overload** occurs if the voltage between the Working and Counter electrodes exceeds the compliance voltage of the instrument. **I Overload** occurs if the current exceeds the limit of the current range. Momentary I Overload signals can occur when changing current ranges which could lead to unintentional shutdown.

The **OK** button exits the setup menu and saves any changes you may have made.

Cancel exits the setup menu. Any changes you may have made to the parameters are lost.

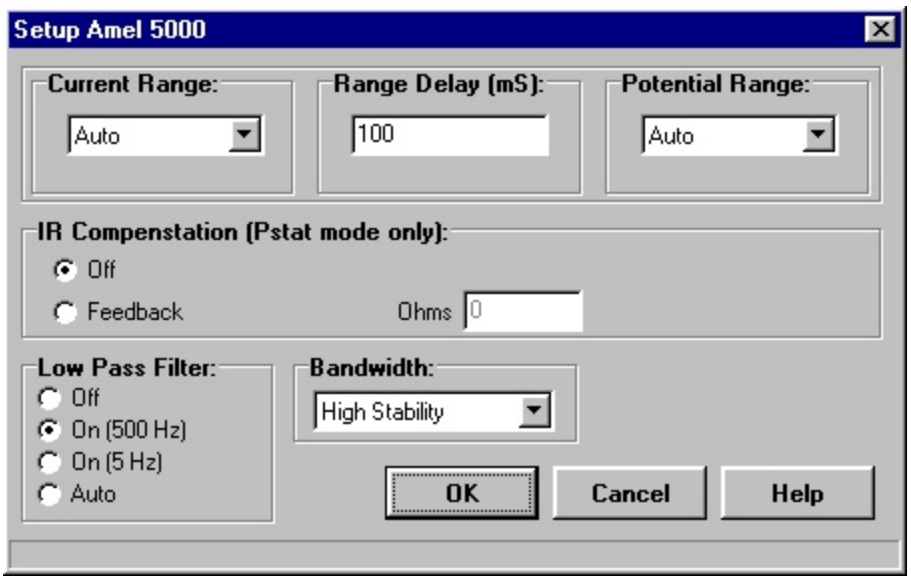
Help accesses the on-line help information on the setting up of this Pstat/Gstat.

Related Topics

- Setup Pstat/Gstat
- Setup Experiment
- Setup Cell Information
- Load/Save Setup

Setup AMEL Pstat/Gstat

Accessed by: **Experiments | Setup Pstat/Gstat...** 



The **Current Range** parameter selects the full scale current range to be used during experiments. Selecting 'Auto' allows the instrument to select the current range based on the actual current being measured.

The **Range Delay** determines how long the instrument waits before changing ranges after it sees that the current is large or small enough to indicate that a range change should be performed. This is use to prevent range changing from noise spikes.

The **Potential Range** parameters selects the maximum cell voltage which can be measured. Generally Auto is the best choice unless the signal is changing very fast. In this case, data points can be lost as the instrument uses time autoranging.

The **Feedback** compensation method may be used to boost the cell voltage to compensate for voltage drops cause by the cell geometry and solution resistivity. **Feedback** may only be used with a fixed (not 'Auto') **Current Range**. The maximum allowable Feedback value (in ohms) for each current range is as follows:

Current Range	Maximum Feedback
1A	2 Ohm
100mA	20 Ohms
10mA	200 Ohms
1 mA	2k Ohms
100uA	20k Ohms
10uA	200k Ohms
1uA	2M Ohms
100nA	20M Ohms

The **Low Pass Filter** may be used to reduce high frequency noise. Except when high sampling rates are required, **On** (a 5 Hz filter) is preferable. If 'Auto' is selected, the filter is automatically selected based on the sampling rate selected within the Experiment configuration.

The **Bandwidth** selections allow one to optimize the stability and performance of the instrument. In general, 'High Stability' is appropriate for most cells as some electrochemical systems may be unstable with the 'High Speed' setting. See your instrument manual for a description of each bandwidth.

The **OK** button exits the setup menu and saves any changes you may have made.

Cancel exits the setup menu. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this Pstat/Gstat.

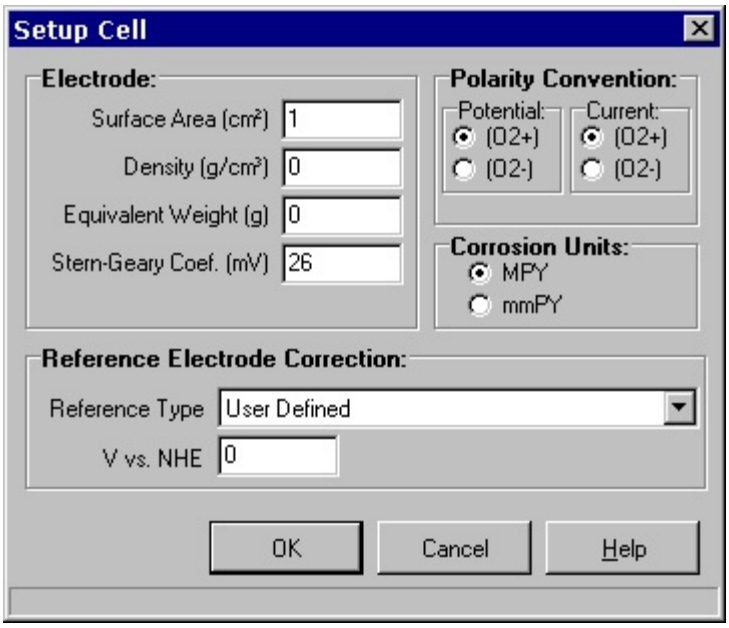
Related Topics

Setup Pstat/Gstat
Setup Experiment
Setup Cell Information
Load/Save Setup

Setup Cell

Accessed by: **Experiments | Setup Cell...** 

These parameters are used to define the type of cell being measured.



The **Surface Area** specifies the exposed surface area of the sample. This parameter is not used during measurements (CorrWare always displays the total current), but is saved in the data file and can be used by CorrView to display current density.

The Density, Equivalent Weight, and Stern-Geary Coefficient are saved in the file for use by CorrView where they are used to help calculate corrosion rates. The Equivalent Weight is the Atomic Weight divided by number of electrons transferred per reaction. For example, for the reaction Fe --> Fe2+, Iron has an atomic weight of 55.847 and transfers 2 electrons so the Equivalent Weight is 55.847/2=27.92. Equivalent Weight can also be interpreted as mass lost per electron transferred. This definition is particularly helpful when using alloys. The values are also used by the Polarization Resistance experiment to calculate corrosion rates. The application of these values is described in Tutor #2 - Polarization Resistance Calculations.

The **Surface Area** specifies the exposed surface area of the sample. This parameter is not used during measurements (CorrWare always displays the total current), but is saved in the data file and can be used by CorrView to display current density.

Polarity Convention selects how positive and negative potentials and currents are interpreted. When the potential is set to **(O2+)**, a more positive potential produces a larger driving force for an anodic/oxidation reaction an a more negative voltage produces a cathodic/reduction reaction. When using **(O2-)**, a more negative potential produces a larger driving force for and anodic/oxidation reaction. A more positive potential produces

cathodic/reduction reaction.
If the Current polarity convention is set to **(O2+)**, positive current is anodic/oxidation and negative current is cathodic/reduction. When using **(O2-)**, positive current is cathodic/reduction and negative current is anodic/oxidation.

Note: The display on the front panel of the Solartron 1286 and 1287 always uses the **(O2-)** convention independent of the convention used by CorrWare. If you use the **(O2+)** convention in CorrWare, the potentiostat and the computer will display opposite potentials. To avoid confusion, always read the potential from the computer and not the instrument.

The **Reference Type** saves information on the reference electrode for later use by CorrView. This parameter is not used during measurements (CorrWare always displays and stores the actual cell potential). Most common reference types are predefined. If your reference electrode is not in the list, you may wish to enter the 'User Defined' value. Once the reference electrode type is selected, CorrView will be able to translate data from one reference type to another.

The **OK** button exits the setup menu and saves any changes you may have made.

Cancel exits the setup menu. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the parameters.

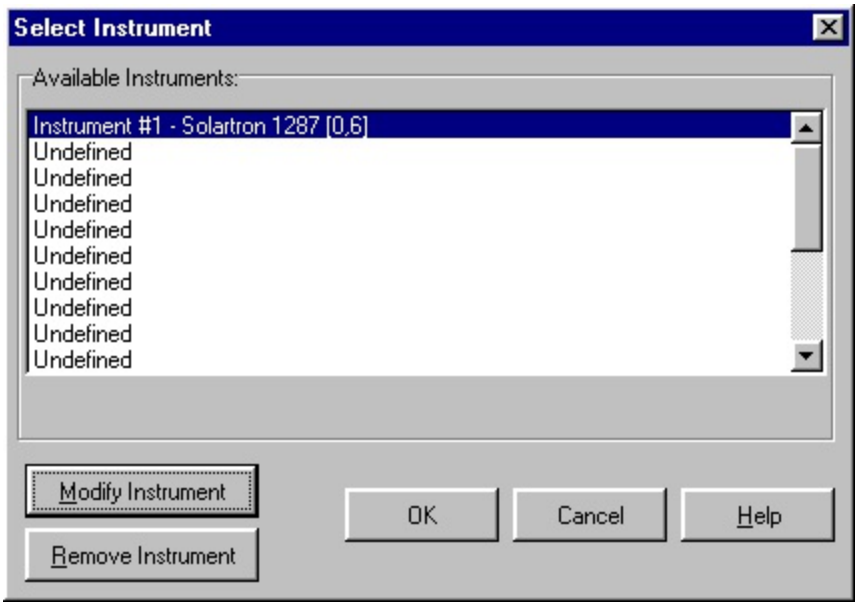
Related Topics

Setup Pstat/Gstat
Setup Experiment
Load/Save Setup

New Instrument

Accessed by: **File | New Instrument...** 

Creates a new Instrument Definition. The Instrument Definition describes the type of instrument as well as its GPIB address.



Currently defined instruments can be modified or removed from the list.

Note: An instrument that is currently in use cannot be modified or removed.

SAFETY NOTE - The Solartron 1470/80 Multistats contain internal Safety Limit settings to stop the instrument if predetermined cell voltage or current limits are exceeded. These limits should be used during any experiments with energy producing or storage devices to limit operation to safe values for the device.

Use **OK** to create an Experiment List for the highlighted instrument.

Cancel exits the window without creating a new instrument.

Help accesses the on-line help information on defining an instrument.

To create a new instrument definition, highlight one of the 'Undefined' instruments and click on the **Modify Instrument** button.

Remove Instrument resets the highlighted instruments definition to 'Undefined'.

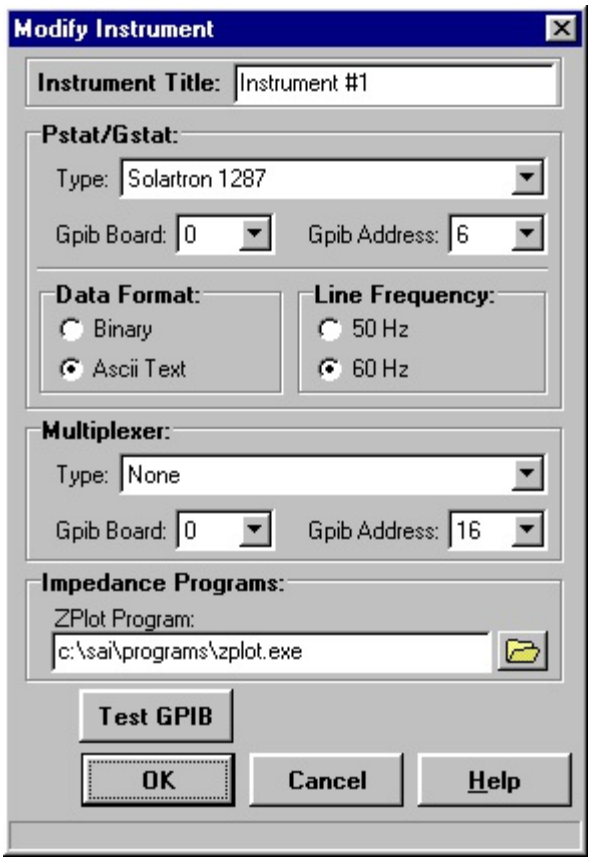
Related Topics

- Modify Instrument
- Close Instrument
- Hardware Installation
- Software Installation
- Load/Save Setup

Modify Instrument

Accessed from: File | New Instrument...

This menu is used to create a new instrument definition.



Solartron 1470/80 Users:
See Solartron MultiStat for configuration information on the Solartron 1470/80 Multistat.

The **Instrument Name** is used to help you keep track of multiple instruments. You may use any descriptive text you wish. If you are using multiple instruments, it is a good idea to put a label on the front of each instrument showing the instrument name.

Set the **Pstat/Gstat Type** to the model of instrument used.

The **GPIB Board** should always be 0 (zero) unless your computer contains multiple GPIB boards.

The **GPIB Address** correspond to the address switch settings on the rear panel of the instrument. If you don't know how to select addresses with switches, use address 6 and set the switches as shown in the **Hardware Installation** section of this manual.

PAR Users: even and odd numbered GPIB addresses can be used, but even numbered addresses are preferable.

Solartron Users: Use only even numbered GPIB addresses for the Solartron 1287, 1286, 1285 and 1280 potentiostats.

The **Multiplexer** installation is described in the CorrWare scanner support package. If a scanner in not used, set the scanner **Type** to 'None'.

If ZPlot is installed on the same computer, and you wish to intermix DC electrochemical and impedance experiments, confirm that the **ZPlot Program** is the correct location of the ZPlot program files. Use **Dir** to search drives and directories for the *zplot.exe* file.

The **Test Gpib** button is used to confirm that the potentiostat and GPIB addresses are correctly configured. If the instrument cannot be found, CorrWare will examine the GPIB bus and attempt to determine which addresses are being used by instruments. It cannot, however, determine which instruments are at each address. Try using the active addresses reported.

The **OK** button exits the setup menu and saves any changes you may have made.

Cancel exits the setup menu. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of the instrument.

Related Topics

New Instrument
Hardware Installation
Software Installation
Load/Save Setup

Close Instrument

Accessed by: **File | Close Instrument...**

Closes the current instrument Experiment List. The instrument definition still exists and the Experiment List can be recreated using the File | New Instrument... command.

Related Topics

- New Instrument
- Software Installation
- Hardware Installation
- Load/Save Setup

Load/Save Setup

File | New Setup

Resets all parameters to their 'factory defaults'. All experiments are deleted from the Experiment List and the Pstat/Gstat and Cell Information parameters are reset to their defaults.

Note: This function resets only the active(highlighted) instrument. If several instruments are being utilized simultaneously, only one of them will be reset.

File | Open Setup... 

Loads a CorrWare setup file. The Experiment List, Pstat/Gstat, and Cell Information is set to the values found within the setup file. A setup file holds information for a single instrument. If you use multiple instruments at the same time, use **Open Setup...** once for each of the instruments.

Note: This function loads the setup file only for the active (highlighted) instrument. If several instruments are being utilized simultaneously, only one of them will be changed.

Note: If a setup file is saved by one instrument and then loaded by a different instrument, you will be warned that some parameters may be lost. All of the Experiment List and Cell Information will be loaded but some Pstat/Gstat parameters will not be loaded. For example, when moving between Solartron and PAR potentiostats, some parameters may be lost due to differences in available options, as previously described.

File | Save Setup 

Saves the current Experiment List, Pstat/Gstat, and Cell Information under the last used setup file name. If you have not saved the setup file since creating the instrument, **Save Setup As...** (described below) is used instead.

Note: This function saves the setup only for the active (highlighted) instrument. If several instruments are being utilized simultaneously, only one of them will be saved.

File | Save Setup As... 

Saves the current Experiment List, Pstat/Gstat, and Cell Information under a user specified file name. The suffix '.CPW' is automatically appended unless you specify one.

Note: This function saves the setup only for the active (highlighted) instrument. If several instruments are being utilized simultaneously, only one of them will be saved.

File | Exit

Exits CorrWare.

Related Topics

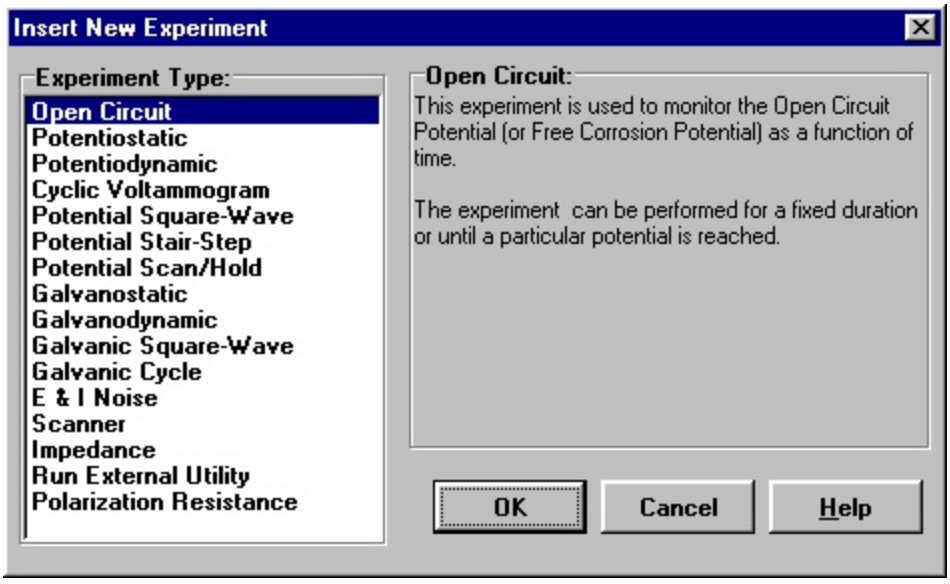
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information

Insert New Experiment

Accessed by: **Experiments | Insert New Experiment...** 

or: press <Insert> key

Inserts a new experiment at the currently highlighted line in the Experiment List and moves the highlighted line down. This function can also be performed by pressing the <Insert> key or by clicking in the **Insert New Experiment** icon. The type of experiment is selected from the following list:



Select an experiment and click **OK (**or press <Enter> or double-click on the selected experiment) to insert the experiment. Click **Cancel** to avoid inserting a new experiment.

After an experiment has been selected, the configuration screen for that experiment will be displayed. The configuration of experiments is described in CorrWare Experiments.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Cut+Paste

Edit | Cut

Removes the highlighted lines from the list. The lines are saved so that they can later be 'pasted'.

Edit | Copy

Puts a copy of the lines in memory so they can later be 'pasted'. Unlike **Cut** the current lines are left in place.

Edit | Paste

Inserts the lines that were last **Cut** or **Copied** at the currently highlighted line. If multiple instruments are used, experiments may be **Cut** or **Copied** from one instrument to another. If the instruments are different model numbers, you may be warned that some Pstat/Gstat information was not transferred. This occurs because the different models may have different options available and a direct translation may not be possible.

Edit | Delete

Removes the highlighted lines from the list. The information in the lines is lost.

Related Topics

Setup Experiment
Insert New Experiment
Replace File Names
Load/Save Setup

Replace Files Names

Accessed by: **Experiments | Search+Replace File Names...** 

Search and Replace File Names is used to change all data file names at once.

Search and Replace will change the data file names for all of the applicable experiments within the Experiment List starting with the currently highlighted line.

For example, suppose the experiments in your experiment list have the file names *test1-1.cor*, *test1-2.cor*, *test1-3.cor*, etc. You have just made measurements using these files and now wish to repeat the measurements on a new sample using the file names *test2-1.cor*, *test2-2.cor* and *test3.cor*.

- highlight the first line in the experiment list
- select Search+Replace File Names...
- for **Replace**, enter *test1*
- for **With,** enter *test2*
- click the **OK** button

Click on **Cancel** to avoid making any changes.

Related Topics

Setup Experiment
Load/Save Setup

Setup Experiment

Accessed by: **Experiments | Setup Experiment...** 

or: press <Enter> key

This function is used to change the parameters of a experiment which has previously been created using
Insert New Experiment....

The parameters available depend on the experiment type:

Setup Experiment - Open Circuit

Setup Experiment - Potentiostatic

Setup Experiment - Potentiodynamic

Setup Experiment - Cyclic Voltammogram

Setup Experiment - Potential Square-Wave

Setup Experiment - Potential Stair-Step

Setup Experiment - Potential Scan/Hold

Setup Experiment - Polarization Resistance

Setup Experiment - Square-Wave Voltammetry

Setup Experiment - Galvanostatic

Setup Experiment - Galvanodynamic

Setup Experiment - Galvanic Square-Wave

Setup Experiment - Galvanic Cycle

Setup Experiment - E & I Noise

Setup Experiment - Scanner

Setup Experiment - Impedance

Setup Experiment - Run External Utility

Setup Experiment - Comment

Related Topics

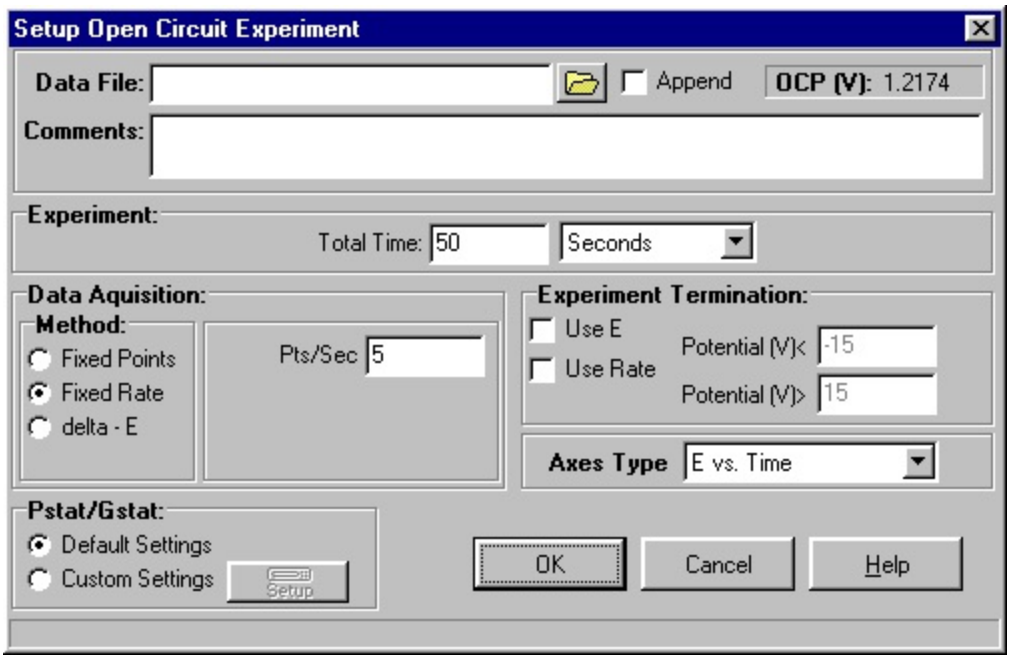
- Insert New Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Open Circuit

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment is used to monitor the Open Circuit Potential (or Free Corrosion Potential) as a function of time. The experiment can be performed for a fixed duration or until a particular potential is reached.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

The **Total Time** determines the total length of the experiment.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell potential changes (compared to the last point saved) by more than the **mV/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at the rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-E**, you may wish to use a **Fixed Rate** experiment to get a feel for the noise level of the cell. This will help in selecting an appropriate value for **mV/Point**.

Experiment Termination:

If the **Use E** box is checked, the experiment is automatically terminated if the potential goes below the **Potential (V) <** value or above the **Potential (V) >** value.

If the **Use delta-E** box is checked, the experiment is automatically terminated when the cell potential changes by less than **delta-E** (mV) over the specified delta-T (seconds).

The Termination methods are further described in Tutor #2 -Termination and Reversal.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually

used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

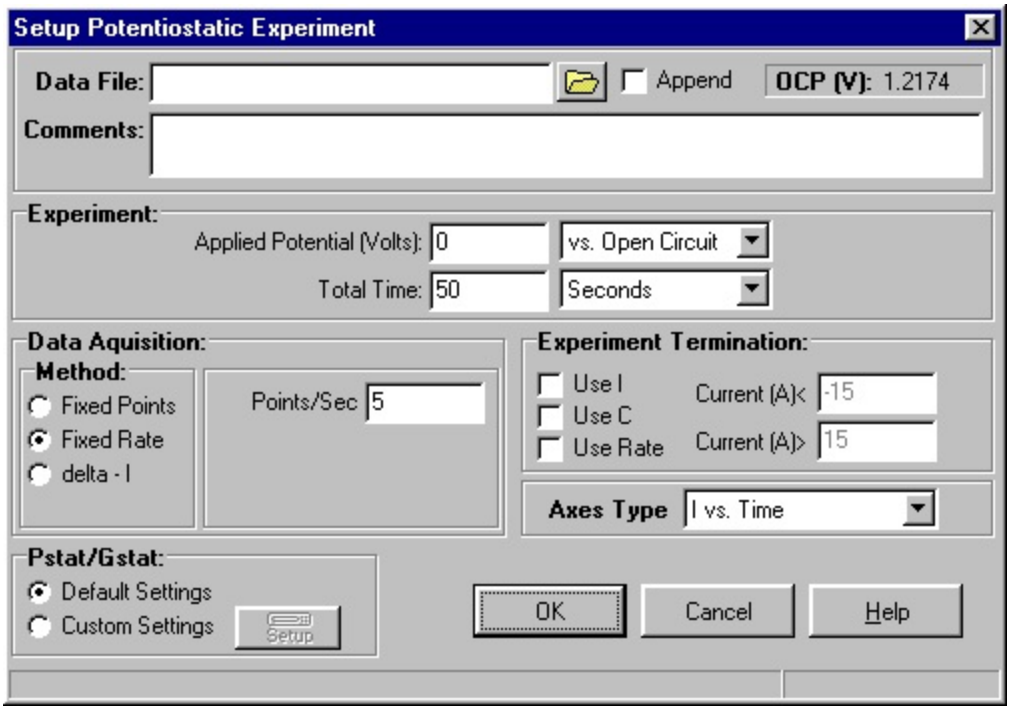
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Potentiostatic

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment applies a constant potential and monitors the current as a function of time. The experiment can be performed for a fixed duration or until a particular current is reached. A Galvanic corrosion can be performed by setting the applied potential to 0 (zero) vs Reference.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't

need to write these into the comment lines.

Applied Potential specifies the potential applied during the experiment. A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the open circuit potential of the cell. For example 0.1 vs Open Circuit would apply a potential 0.1 Volts above the measured open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list. For example, if the previous experiment was a Potentiostatic experiment applying 0.45 V vs. Reference, and the next experiment was set as 0.1 V vs. Previous, 0.55 Volts would be applied.

The **Total Time** determines the total length of the experiment.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-I** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell current changes (compared to the last point saved) by more than the **mA/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at a rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-I**, you may wish to use a **Fixed Rate** experiment to get a feel for the amount of current and the noise level of the cell. This will help in selecting an appropriate value for **mA/Point**.

Experiment Termination:

If the **Use I** box is checked, the experiment is automatically terminated if the current goes below the **Current (A) <** value or above the **Current (A) >** value.

If the **Use C** box is checked, the experiment is automatically terminated if the total charge (in Coulombs) goes below the **Charge (C) <** value or above the **Charge (C) >** value.

If the **Use delta-I** box is checked, the experiment is automatically terminated when the cell current changes by less than **delta-I** (%) over the specified delta-T (seconds).

The Termination methods are further described in Tutor #2 -Termination and Reversal.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

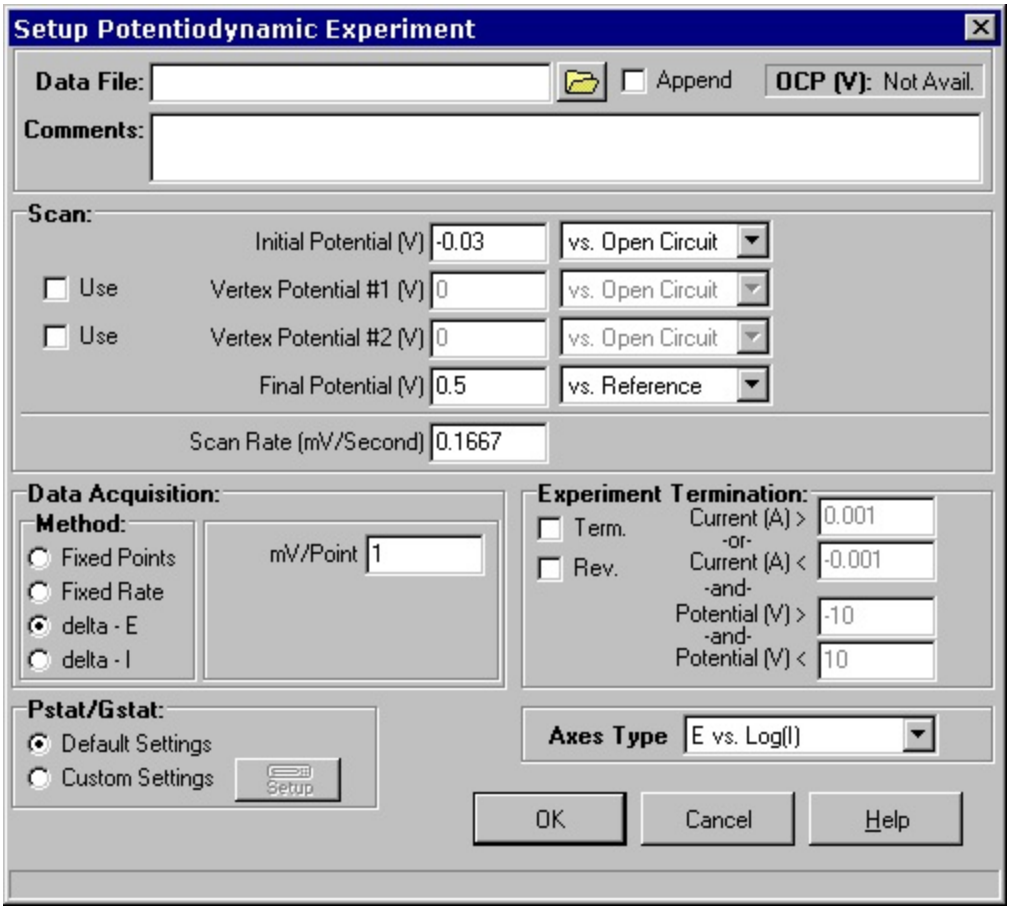
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Potentiodynamic

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

A potential sweep between up to 4 separate potential setpoints is applied and the current response is measured. The sweep can be terminated or the sweep direction reversed if a particular current is reached. This can be configured to obtain either Polarization Resistance or Tafel data.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc*

the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate potentials can be applied during the experiment. The experiment starts at the Initial Potential, sweeps to Vertex #1, to Vertex #2, and then to the Final Potential. Click on the **Used** boxes to turn on and off the Vertex #1 and Vertex #2 setpoints. If a Vertex's **Used** box is not checked, that segment of the sweep will be skipped. For example, if only Vertex #1 is checked the sweep Initial --> Vertex #1 --> Final is performed. If neither Vertex is checked, Initial --> Final is performed.

A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the open circuit potential of the cell. For example 0.1 V vs Open Circuit would apply a potential 0.1 Volts above the measured open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list (or the previous setpoint in the Potentiodynamic experiment). For example, if the **Vertex Potential #1** is set to 0.45 V vs. Reference, and **Vertex Potential #2** as 0.1 V vs. Previous, the experiment will sweep from 0.45 V to 0.55 V.

The **Scan Rate** selects how fast the potential is scanned between one potential and another.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method calculates the acquisition rate based on the **Scan Rate** and the specified **mV/Point** value (Points/Sec = (mV/Sec)/(mV/Point)).

Sweep Termination/Reversal:

If the **Term.** box is checked, the sweep will be ended if certain potential and current conditions are met. If the **Rev.** is checked, when certain potential and current conditions are met, the experiment will immediately start sweeping toward the **Final Potential.**

The Termination or Reversal will occur when the current is above the **Current>** or the current is below **Current<** and the potential is above the **Potential >** and the potential is below Potential **<**. Three of these conditions must be met to trigger the Termination or Reversal, one current condition and both of the voltage conditions. Be aware that the Termination/Reversal conditions in the Potentiodynamic experiment are quite different than those in the other types of experiments.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

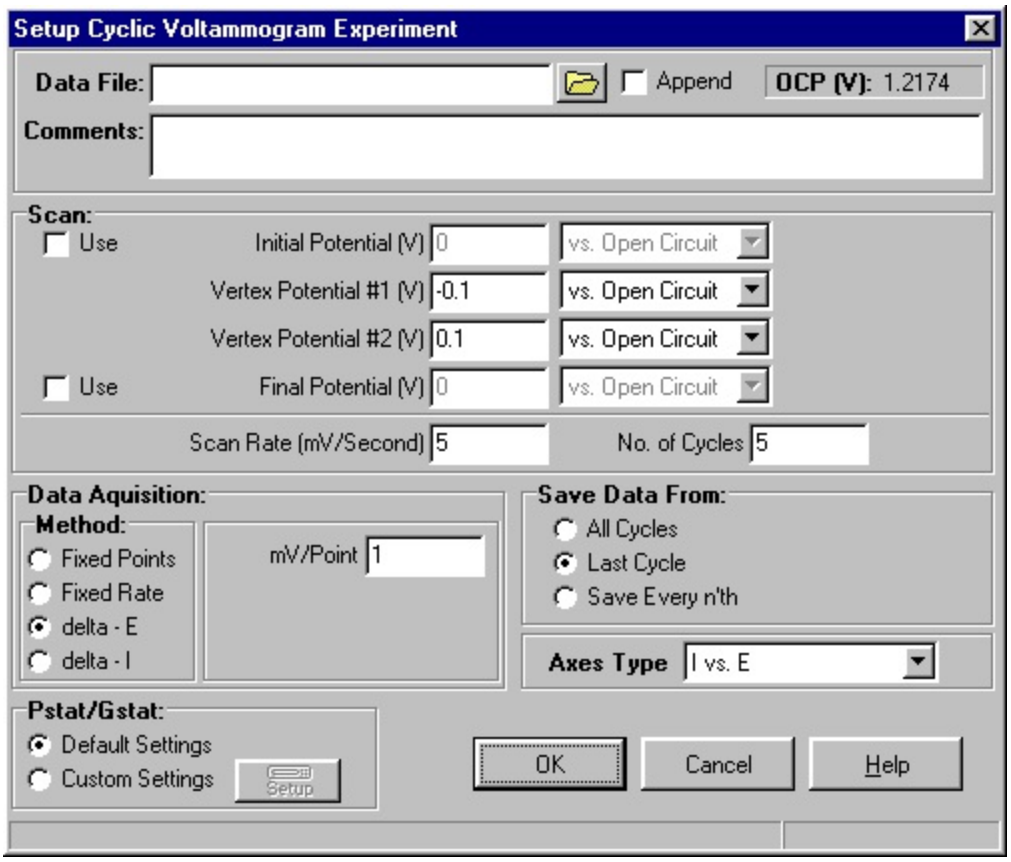
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Cyclic Voltammogram

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment applies a potential sweep between up to 4 separate potential setpoints. If only 2 setpoints are used, multiple cycles may be performed.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement

parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

The potential may be swept between up to 4 separate set points in this experiment. The experiment starts at the Initial Potential, sweeps to Vertex #1, to Vertex #2, and then to the Final Potential. Click on the **Used** boxes to turn on and off the Initial and Final setpoints. If the Initial of Final setpoint is unchecked, this segment of the sweep is skipped. For example, if only Initial is checked, the sweep Initial --> Vertex #1 --> Vertex #2 is performed. If both Initial and Final are unchecked, Vertex #1 --> Vertex #2 is performed.

A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the measured open circuit potential of the cell. For example 0.1 V vs Open Circuit would apply a potential 0.1 Volts above the open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list (or the previous setpoint in the Cyclic Voltammogram). For example, if the **Vertex Potential #1** is set to 0.45 V vs. Reference, and **Vertex Potential #2** uses 0.1 V vs. Previous, the experiment will sweep from 0.45 V to 0.55 V.

The **Scan Rate** selects how fast the potential is scanned between one potential and another.

No. of Cycles specifies how many times the potential is cycled between Vertex #1 and Vertex #2. The Initial and Final Potentials can only be used if the Number of Cycles is set to '1'. To perform multiple cycles, the Initial and Final Potentials must be disabled. Potentiostatic experiments can be used before and after a Cyclic Voltammogram to apply an independent potential before and/or after the experiment.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method calculates the acquisition rate based on the **Scan Rate** and the specified **mV/Point** value (Points/Sec = (mV/Sec)/(mV/Point)).

Save Data From:

When applying multiple Cycles, it may be useful to save data only from particular cycles. **All Cycles** saves the data from all cycles in a single data file. **Last Cycle Only** saves the data after each cycle, replacing the data from the previous cycle. **Save Every n'th** saves the data from periodic cycles, incrementing the filename extension for each saved cycle.

For example, if 20 cycles are performed, **All Cycles** would save all 20 cycles in a single file. If **Last Cycle Only** is selected, only the 20th cycle would be saved. Using **Save Every n'th** with a period of 5 and a file name of *test.cor* would save cycles 1, 5, 10, 15 and 20 in files *test_Cy01.cor*, *test_Cy05.cor*, *test_Cy10.cor*, *test_Cy15.cor* and *test_Cy20.cor* respectively.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

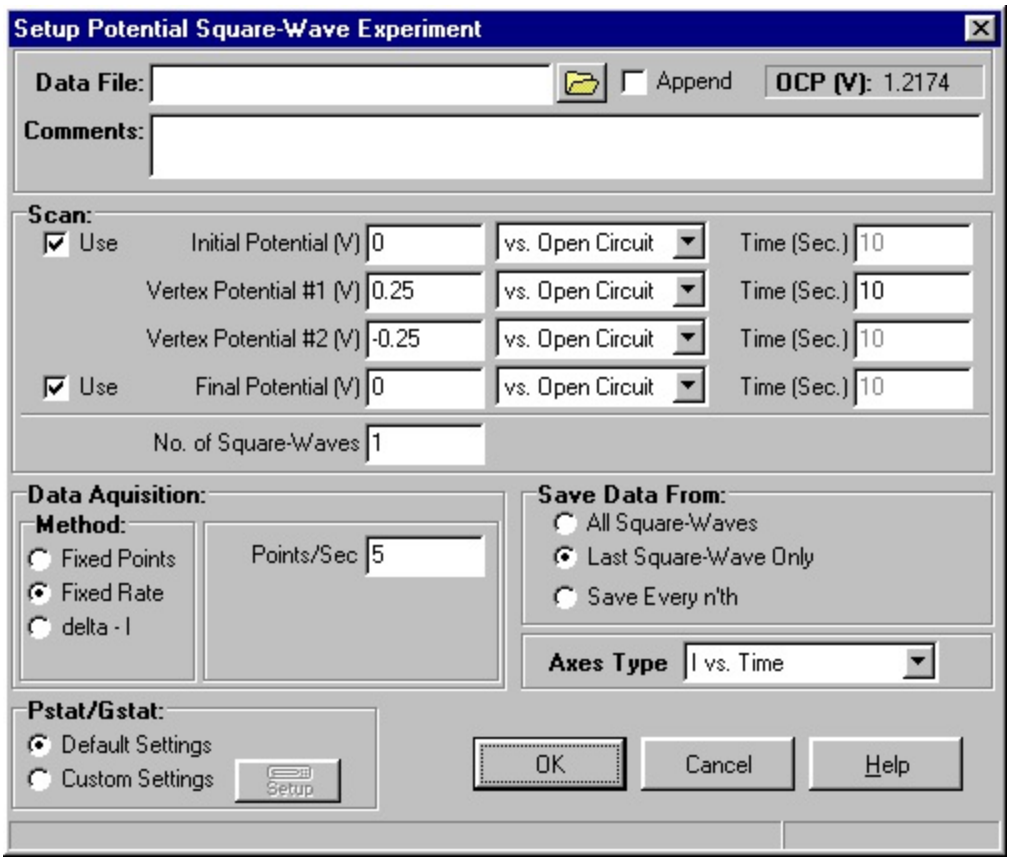
Setup Experiment

Setup Experiment - Potential Square-Wave

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment applies a potential step for a specified time between up to 4 separate potential setpoints. If only 2 setpoints are used, multiple cycles may be performed, producing a potential 'Square Wave'.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate potentials can be applied during the experiment. Click on the **Used** boxes to turn on and off the Initial and Final setpoints.

A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the open circuit potential of the cell. For example 0.1 V vs Open Circuit would apply a potential 0.1 Volts above the open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list (or the previous setpoint in the square wave). For example, if the **Vertex Potential #1** is set to 0.45 V vs. Reference, and **Vertex Potential #2** uses 0.1 V vs. Previous, 0.55 Volts is used for this vertex.

Each segment of the Square Wave has a separate time value specifying the length of time which that particular potential is applied.

No. of Square-Waves specifies how many times the potential is cycled between Vertex #1 and Vertex #2. The Initial and Final Potentials can only be used if the Number of Square-Waves is set to '1'. To perform multiple cycles, the Initial and Final Potentials must be disabled. Potentiostatic experiments can be used before and after a Square-Wave to apply an independent potentials before and after the experiment.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-I** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell current changes (compared to the last point saved) by more than the **mA/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at the rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points

when the signal is stable. Before using **delta-I**, you may wish to use a **Fixed Rate** experiment to get a feel for the amount of current and the noise level of the cell. This will help in selecting an appropriate value for **mA/Point**.

Save Data From:

When applying multiple Square-Waves, it may be useful to save data only from particular waveforms. **All Square-Waves** saves the data from all waveforms in a single data file. **Last Square-Wave Only** saves the data after each Square-Wave, replacing the data from the previous Square-Wave. **Save Every n'th** saves the data from periodic waveforms, incrementing the filename extension for each saved Square-Wave.

For example, if 20 Square-Waves are performed, **All Square-Waves** would save all 20 waveforms in a single file. If **Last Square-Waves Only** is selected, only the 20th waveform would be saved. Using **Save Every n'th** with a period of 5 and a file name of *test.cor* would save Square-Waves 1, 5, 10, 15 and 20 in files *test_Cy01.cor*, *test_Cy05.cor*, *test_Cy10.cor*, *test_Cy15.cor* and *test_Cy20.cor* respectively.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

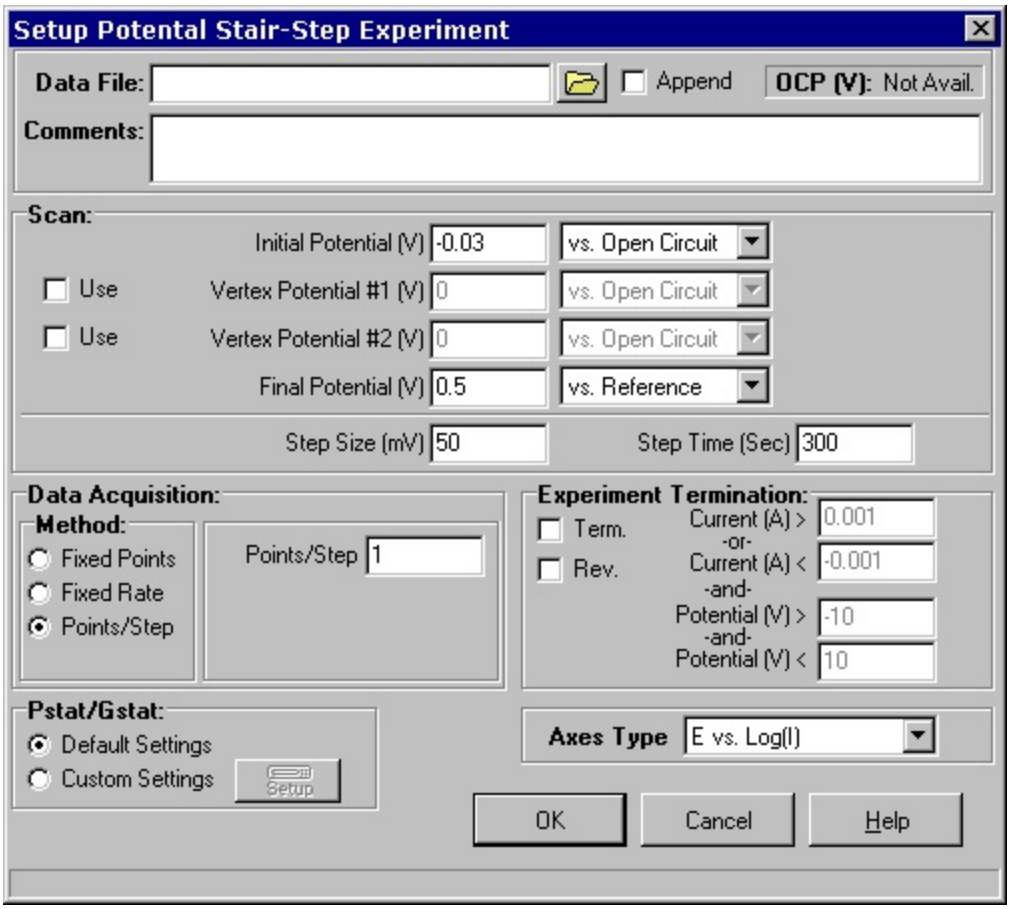
Setup Experiment - Potential Stair-Step

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

A potential sweep between up to 4 separate potential setpoints is applied and the current response is measured. Unlike the Potentiodynamic experiment, the potential in changed in discrete steps rather than a smooth sweep. The sweep can be terminated or the sweep direction reversed if a particular current is reached.

Note: This experiment is not available with the AMEL 5000 potentiostat.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate potentials can be applied during the experiment. The experiment starts at the Initial Potential, sweeps to Vertex #1, to Vertex #2, and then to the Final Potential. Click on the **Used** boxes to turn on and off the Vertex #1 and Vertex #2 setpoints. If a Vertex's **Used** box is not checked, that segment of the sweep will be skipped. For example, if only Vertex #1 is checked the sweep Initial --> Vertex #1 --> Final is performed. If neither Vertex is checked, Initial --> Final is performed.

A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the open circuit potential of the cell. For example 0.1 V vs Open Circuit would apply a potential 0.1 Volts above the measured open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list (or the previous setpoint in the Potential Stair-Step experiment). For example, if the **Vertex Potential #1** is set to 0.45 V vs. Reference, and **Vertex Potential #2** as 0.1 V vs. Previous, the experiment will sweep from 0.45 V to 0.55 V.

The **Step Size** selects the size of the potential steps. The **Step Duration** determines how long the potential will be held at each step.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time** of the experiment.

If **Points/Step** is chosen, an exact number of data points for each potential step may be chosen. If the number of **Points/Step** is 1 (one), a data point will measured at the very end of each step, just before the potential is stepped to a new value.

Sweep Termination/Reversal:

If the **Term.** box is checked, the sweep will be ended if certain potential and current conditions are met. If the **Rev.** is checked, when certain potential and current conditions are met, the experiment will immediately start sweeping toward the **Final Potential.**

The Termination or Reversal will occur when the current is above the **Current>** or the current is below **Current<** and the potential is above the **Potential >** and the potential is below Potential **<**. Three of these conditions must be met to trigger the Termination or Reversal, one current condition and both of the voltage conditions. Be aware that the Termination/Reversal conditions in the Potentiodynamic experiment are quite different than those in the other types of experiments.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information

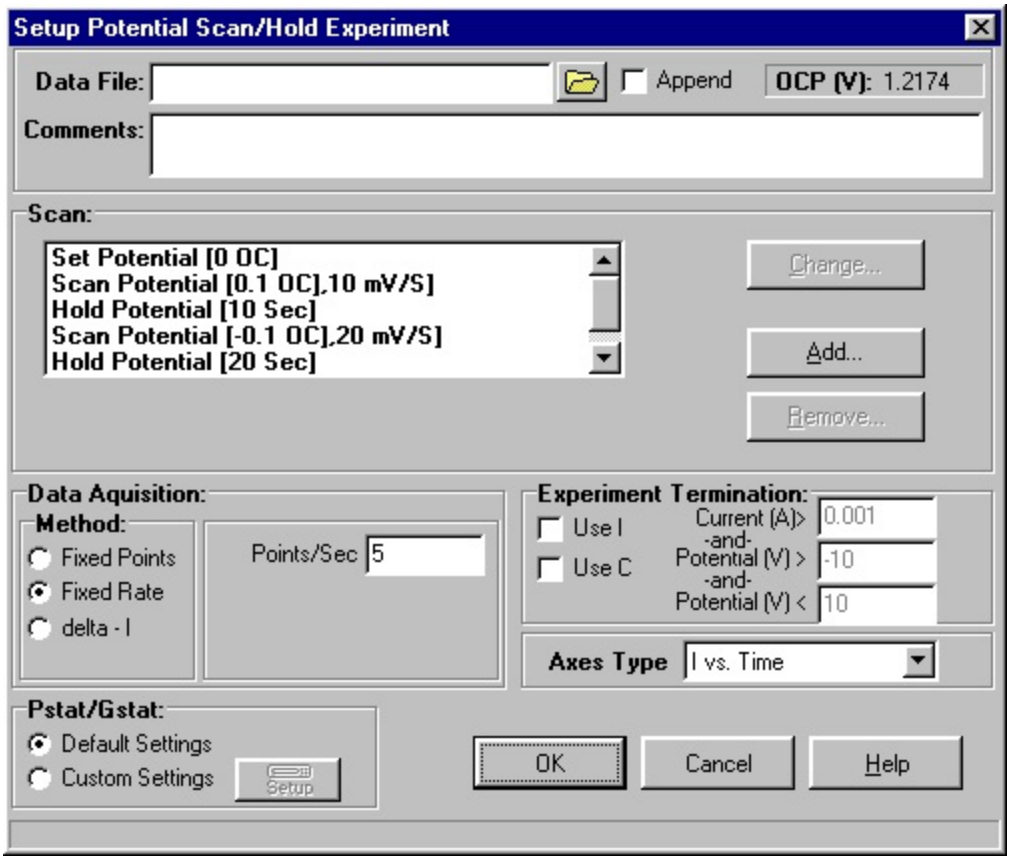
Load/Save Setup

Setup Experiment - Potential Scan/Hold

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

A list of segments is used to create a complex applied potential sequence. This experiment can be used to create specialized waveforms containing combinations of potential sweeps and potential holds. It can also be used to create scans in which the scan rate changes during the experiment.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

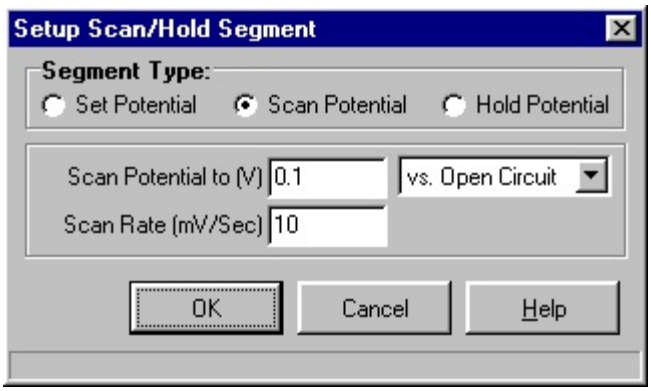
Scan:

The **Scan List** contains the potential sequence to be applied. The list must contain at least 2 lines and the first line must be a **Set Potential**. Up to 100 segments may be added to the list. Because of the limits of the instruments, a sequence this long may not be measurable. A warning will be displayed if the sequence is longer than the instrument can handle. If the experiment is performed, some segments at the end of the list may not be used. The instrument limits are:

Solartron Limits: 4 segments. A 5th segment may be used if the potential at the end of the 5th segment EXACTLY matches the first **Set Potential**.
PAR Limits: 50 segments.
AMEL Limits: 9 segments.

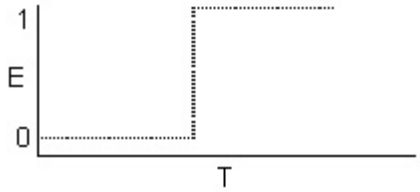
The **Change...** button is used to modify a segment. The **Add...** and **Remove** buttons are used to insert and delete lines from the list.

When **Change...** or **Add...** is used, the following options are displayed:

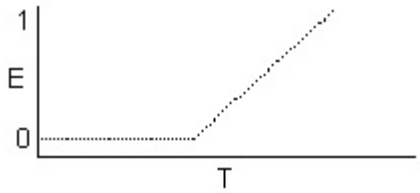


Set Potential is used to step to specified potential. **Scan Potential** performs a potential sweep from the potential at the end of the previous segment to the specified potential. **Hold Potential** is used to apply a constant potential for a specified time.

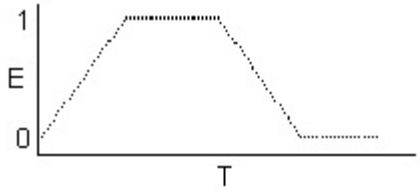
The following examples show waveforms and their corresponding segments as entered into the scan list.



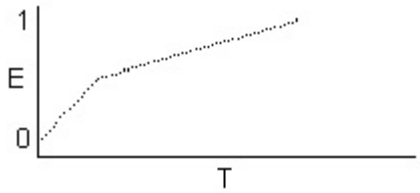
1. Set Potential to 0 V
2. Hold for 50 seconds
3. Set Potential to 1 V
4. Hold for 50 seconds



1. Set Potential to 0 V
2. Hold for 50 seconds
3. Scan to 1 V, 20 mV/Sec



1. Set Potential to 0 V
2. Scan to 1 V, 20 mV/Sec
3. Hold for 50 seconds
4. Scan to 0 V, 20 mV/Sec
5. Hold for 50 seconds



1. Set Potential to 0 V
2. Scan to 0.5 V, 50 mV/Sec
3. Scan to 1 V, 20 mV/Sec

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-I** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell current changes (compared to the last point saved) by more than the **mA/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at a rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-I**, you may wish to use a **Fixed Rate** experiment to get a feel for the amount of current and the noise level of the cell. This will help in selecting an appropriate value for **mA/Point**.

Sweep Termination:

If the **Use** box is checked, the sweep will be ended if certain potential and current conditions are met.

The Termination will occur when the current is above the **Current>** and the potential is above the **Potential >** and the potential is below **Potential <**. All three of these conditions must be met to trigger the Termination. Be aware that the Termination, conditions in the Scan/Hold experiment are quite different than those in the other types of experiments.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

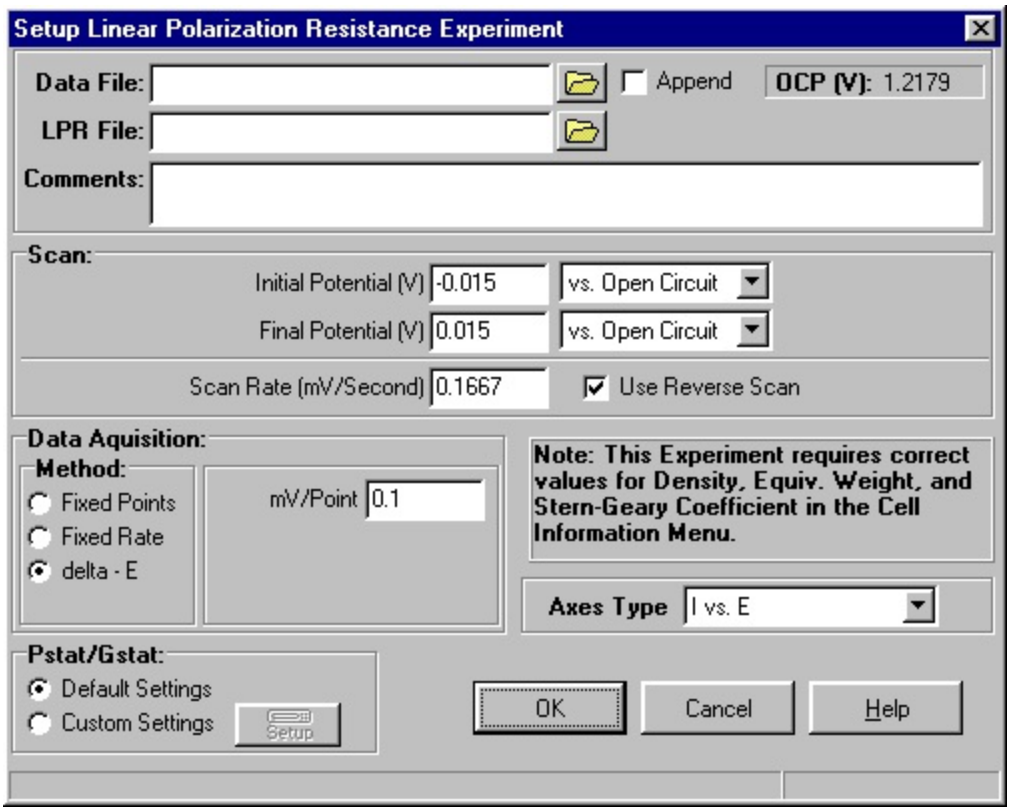
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Polarization Resistance

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

A slow sweep of the potential above and below the open circuit potential is used to calculate the Polarization Resistance and corrosion rates.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

An additional file to hold calculated Linear Polarization Resistance values is created using the file specified by **LPR File**. The **Dir** button can be used to display a list of all directories

and files. This is particularly useful if you forget the file names you have already used.

CorrWare automatically appends the suffix '.txt' to LPR file if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.txt* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used. Since they use different extensions, the same base file name may be used for both the **Data File** and **LPR File**.

The **LPR File** contains one line per experiment. Rp (Polarization Resistance), Ecorr, Icorr, and Corrosion Rate are saved. This file is not accessible by the **CorrView** analysis program. Instead, it is saved as a tab delimited text file which can be read by word processors or spreadsheet programs such as Excel or 1-2-3.

When using a Polarization Resistance experiment inside a scanner loop, unlike the data file, the LPR file name extension is not incremented. Instead, each time through the loop adds an extra line to the LPR file.

The Polarization Resistance calculations are described in Tutor #2 - Polarization Resistance Calculations.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

The experiment starts at the **Initial Potential** and sweeps to **Final Potential** at the specified **Sweep Rate**. If **Use Reverse Scan** is checked, the potential sweeps from the Initial Potential to the Final Potential and then sweeps back to the Initial Potential. The Polarization Resistance for both the forward and reverse sweeps are saved in the LPR File.

A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the open circuit potential of the cell. For example 0.03 V vs Open Circuit would apply a potential 0.03 Volts above the measured open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list (for the Final Potential, the Previous potential would be the Initial Potential). For example, if the **Initial Potential** is set to -0.03 V vs. OC, and **Final Potential** as 0.06 V vs. Previous, the experiment will sweep from 30 mV below Open Circuit to 30 mV above Open Circuit.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method calculates the acquisition rate based on the **Scan Rate** and the specified **mV/Point** value (Points/Sec = (mV/Sec)/(mV/Point)).

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information

Load/Save Setup

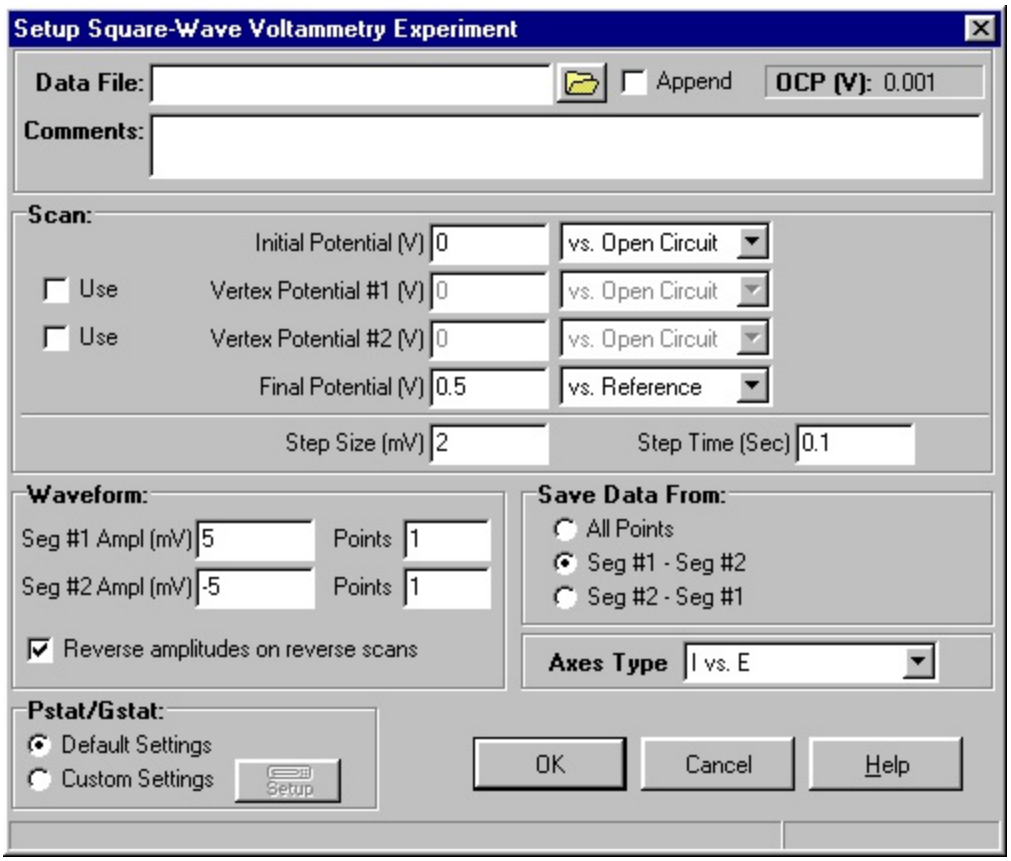
Setup Experiment - Square-Wave Voltammetry

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

A square wave or other waveform is superimposed on a potential scan. This method can be used to perform square-wave voltammetry as well as differential pulse experiments.

Note: Because of the electrical design of the Solartron and AMEL instruments, they are unable to perform this experiment.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one.

Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate potentials can be applied during the experiment. The experiment starts at the Initial Potential, sweeps to Vertex #1, to Vertex #2, and then to the Final Potential. Click on the **Used** boxes to turn on and off the Vertex #1 and Vertex #2 setpoints. If a Vertex's **Used** box is not checked, that segment of the sweep will be skipped. For example, if only Vertex #1 is checked the sweep Initial --> Vertex #1 --> Final is performed. If neither Vertex is checked, Initial --> Final is performed.

A potential can be specified several ways. If 'vs. Open Circuit' is chosen, the specified potential is added to the open circuit potential of the cell. For example 0.1 V vs Open Circuit would apply a potential 0.1 Volts above the measured open circuit potential. 'vs. Reference' is used to select an exact potential to be applied. Use 'vs. Previous' to change the potential relative to the potential in the cell at the end of the previous experiment in the experiment list (or the previous setpoint in the Potential Stair-Step experiment). For example, if the **Vertex Potential #1** is set to 0.45 V vs. Reference, and **Vertex Potential #2** as 0.1 V vs. Previous, the experiment will sweep from 0.45 V to 0.55 V.

The **Step Size** selects the size of the potential steps. The **Step Time** determines how long the potential will be held at each step.

Waveform:

During each potential step, a waveform is added to the potential applied by the scan. **Segment #1 Amplitude** and **Segment #2 Amplitude** determine the size of the waveform during the first and second section of the waveform. **Segment #1 Points** and **Segment #2 Points** determine the number of points measured during each waveform segment. The points are always equally spaced over the **Step Time**, thus using different point values will produce a non-symmetric waveform.

When a scan is performed in the negative direction (from a more positive to a more negative potential), the signs of the amplitudes can be reversed by selecting **Reverse Amplitudes on Reverse Scans**. For example, for a scan from 0 to -1 volts using a step

size of 5 mV and amplitudes of 10 and -20 mV, if **Reverse Amplitudes** is not selected, the applied potentials would be +10,-20; +5,-25; 0,-30; ... If **Reverse Amplitudes** is used the applied potentials would be-10,+20; -15,+15; -20,+10;... This function is primarily used when the **Vertex Potentials** are used, producing a scan which reverses directions during the scan.

Save Data From:

In most measurements, the desired data is the difference between the current in segment 1 and segment 2. **Seg #1 - Seg #2** and **Seg #2 - Seg #1** both calculate the difference between the currents at the end of each of the segments. They differ only in the sign of the resulting difference. **All Points** saves the actual currents from segment 1 and 2. It is most often used as a diagnostic tool because it displays the actual waveform. It can be used to make sure the waveform has be correctly defined and help select appropriate current ranges.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Tips and Techniques:

The following pages show examples of how the compete waveform is generated.

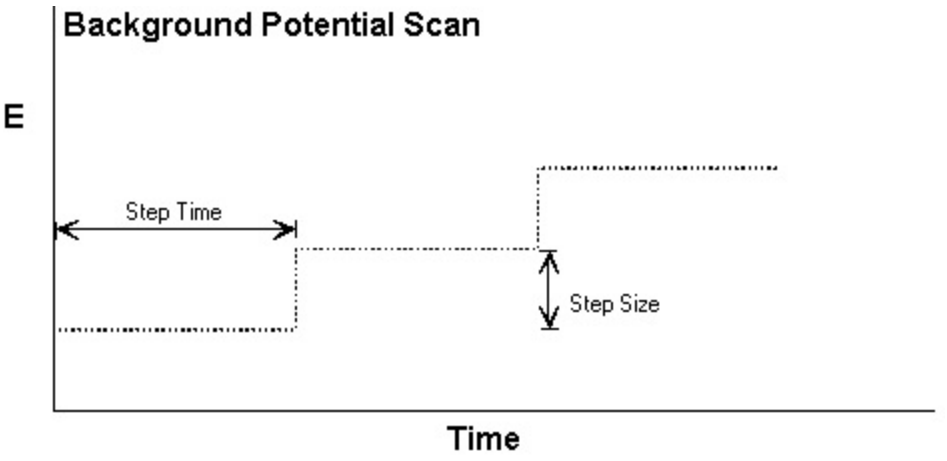
Before using this experiment, draw a diagram of the desired waveform and label each point with the desired potential and time.

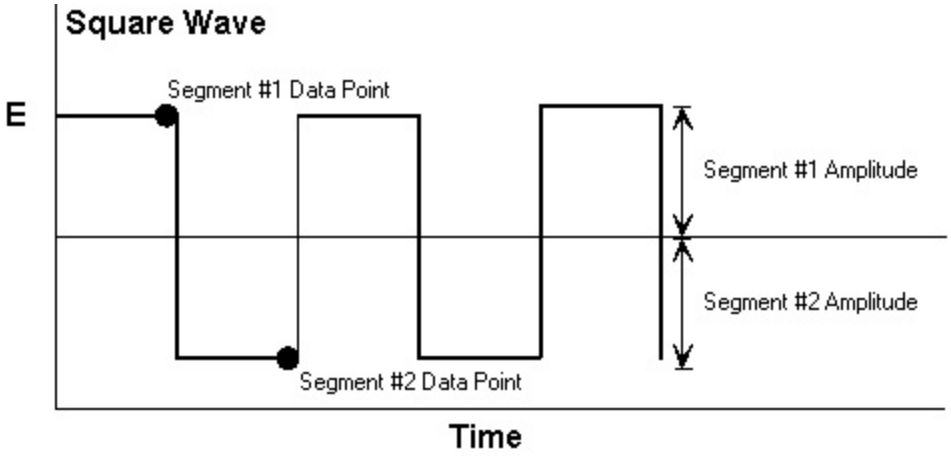
The minimum time per point is 1 mS. The is calculated as: step time / (Seg #1 points + Seg #2 points). For fast waveforms (step time<100 mS) a fixed current range will generally work best because the instrument may not have enough time to automatically change current ranges.

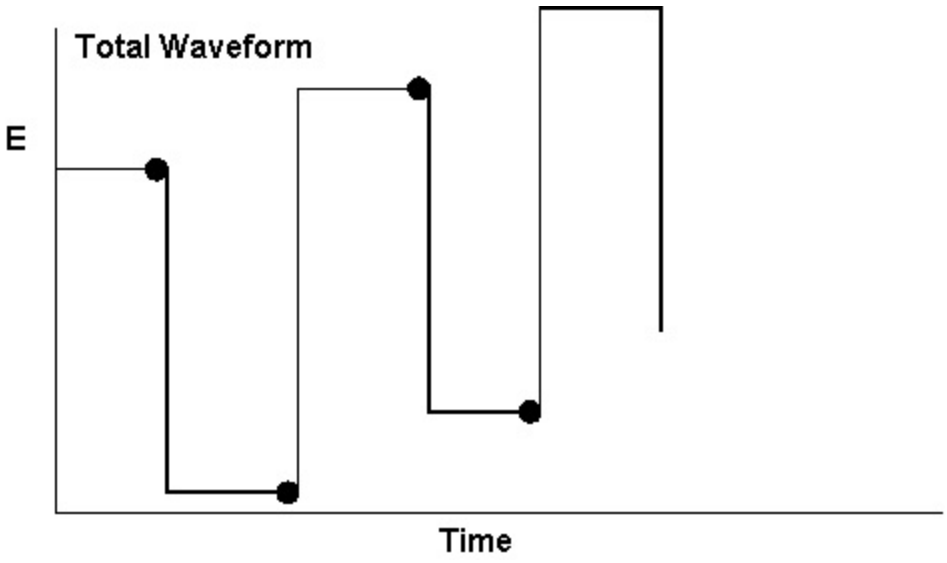
The total number of points in this experiment is limited to 3072 points. The number of points in a scan can calculated as: (total scan length in volts / step size in volts) * (Seg #1 points + Seg #2 points). If an experiment is defined which would used more than 3072 points, the end of the experiment will be truncated.

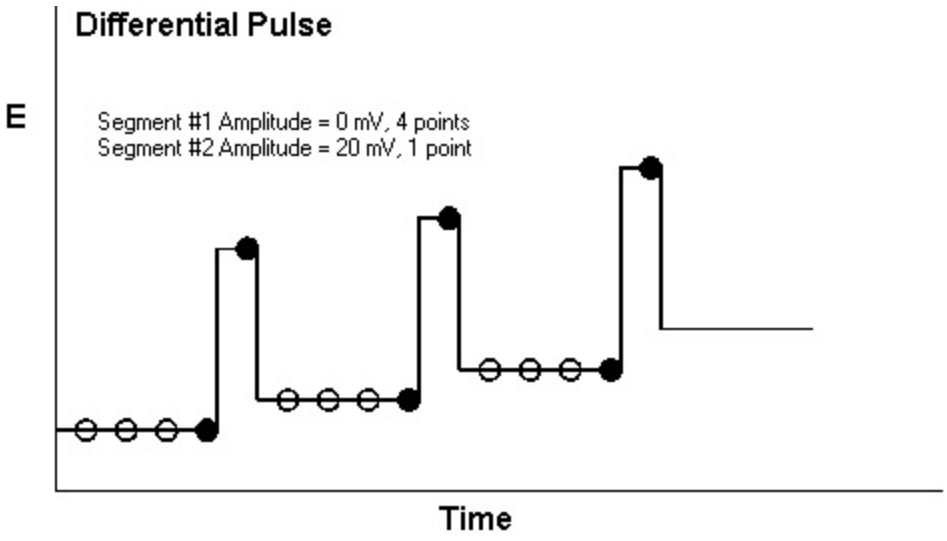
If only one data point is used per waveform segment and **All Points** is used, the data will appear as a triangle. A square wave is actually applied to the cell, but cannot be graphed using a single point. To help check a waveform shape, set the number of points in segment #1 and segment #2 to 5 (keep in mind the limit on total points and minimum time per point described above).

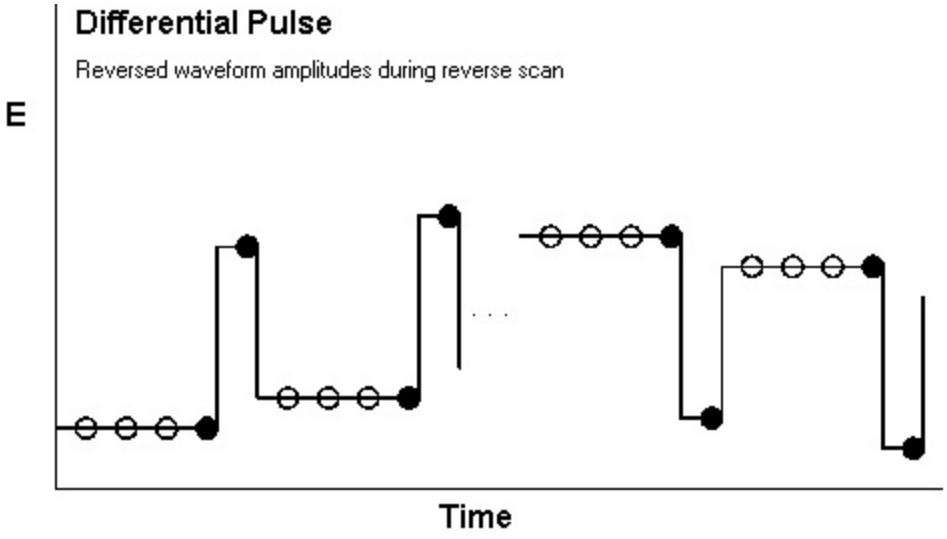
Because of the time required to transmit the waveform from the computer to the instrument, there will be a delay of 1-10 seconds before the start of the experiment.




Square Wave
E
Segment #1 Data Point
Segment #1 Amplitude
Segment #2 Amplitude
Segment #2 Data Point
Time


Total Waveform
E
Time


Differential Pulse
E
Segment #1 Amplitude = 0 mV, 4 points
Segment #2 Amplitude = 20 mV, 1 point
Time



Related Topics

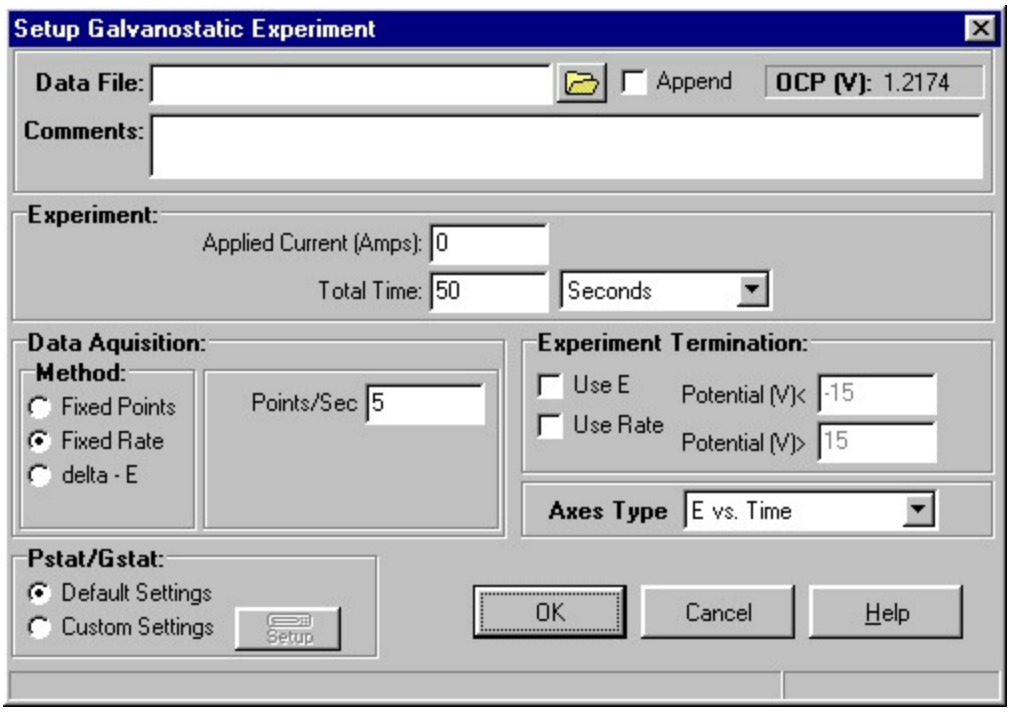
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Galvanostatic

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

A constant current is applied and the potential is monitored as a function of time. The experiment can be performed for a fixed duration or until a particular potential is reached.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Applied Current specifies the amount of current applied during the experiment. This is the total current applied, not the current density.

The **Total Time** determines the total length of the experiment.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell potential changes (compared to the last point saved) by more than the **mV/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at the rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-E**, you may wish to use a **Fixed Rate** experiment to get a feel for the noise level of the cell. This will help in selecting an appropriate value for **mV/Point**.

Experiment Termination:

If the **Use I** box is checked, the experiment is automatically terminated if the potential goes below the **Potential (V) <** value or above the **Potential (V) >** value.

If the **Use delta-E** box is checked, the experiment is automatically terminated when the cell potential changes by less than **delta-E** (mV) over the specified delta-T (seconds).

The Termination methods are further described in Tutor #2 -Termination and Reversal.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

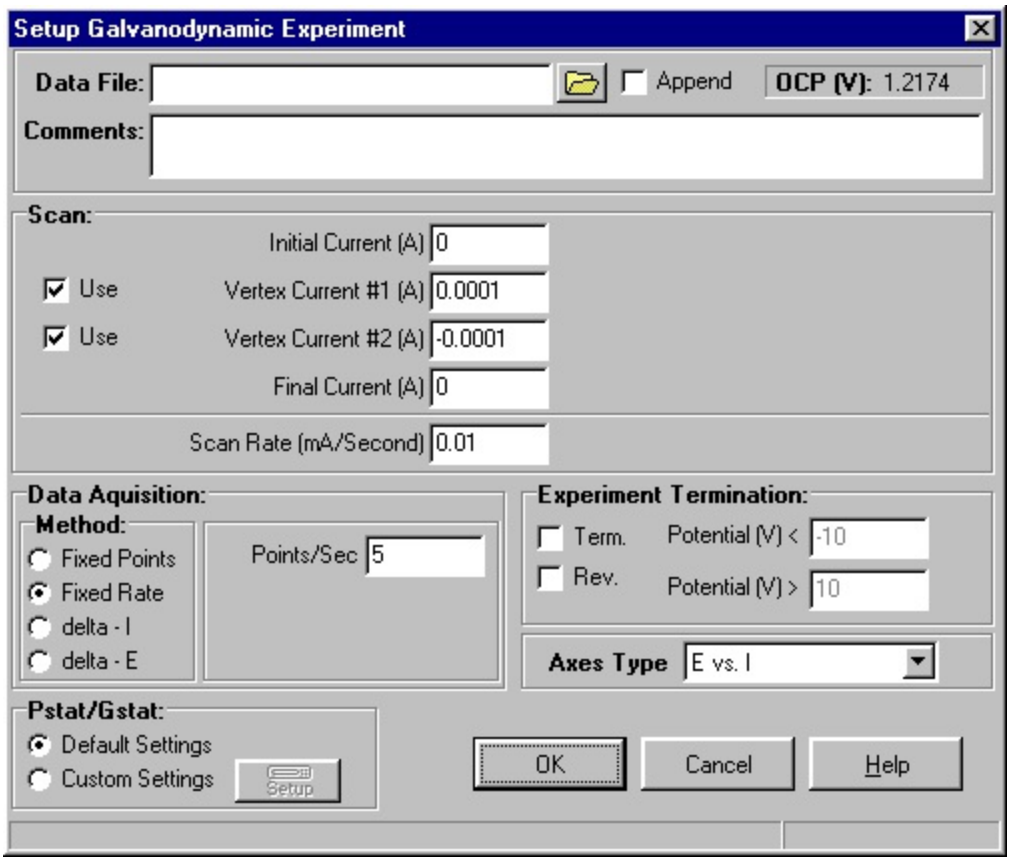
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Galvanodynamic

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment applies a current sweep between up to 4 separate setpoints. The sweep can be terminated if a particular potential is reached.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement

parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate currents can be applied during the experiment. The experiment starts at the Initial Current, sweeps to Vertex #1, to Vertex #2, and then to the Final Current. Click on the **Used** boxes to turn on and off the Vertex #1 and Vertex #2 setpoints. If a Vertex's **Used** box is not checked, that segment of the sweep will be skipped. For example, if only Vertex #1 is checked the sweep Initial --> Vertex #1 --> Final is performed. If neither Vertex is checked, Initial --> Final is performed.

Note: The Current values specify the total current applied, not the current density.

The **Scan Rate** selects how fast the current is scanned between one current and another.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-I** method calculates the acquisition rate based on the **Scan Rate** and the specified **mA/Point** value (Points/Sec = (mA/Sec)/(mA/Point)).

Sweep Termination/Reversal:

If the **Term.** box is checked, the sweep will be ended if certain potential conditions occur. If the **Rev.** is checked, when certain potential conditions are met, the experiment will immediately start sweeping toward the **Final Current**.

The Termination or Reversal will occur if the potential goes below the **Potential (V) <** value or above the **Potential (V) >** value. This termination method is turned on by checking the **Used** box.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

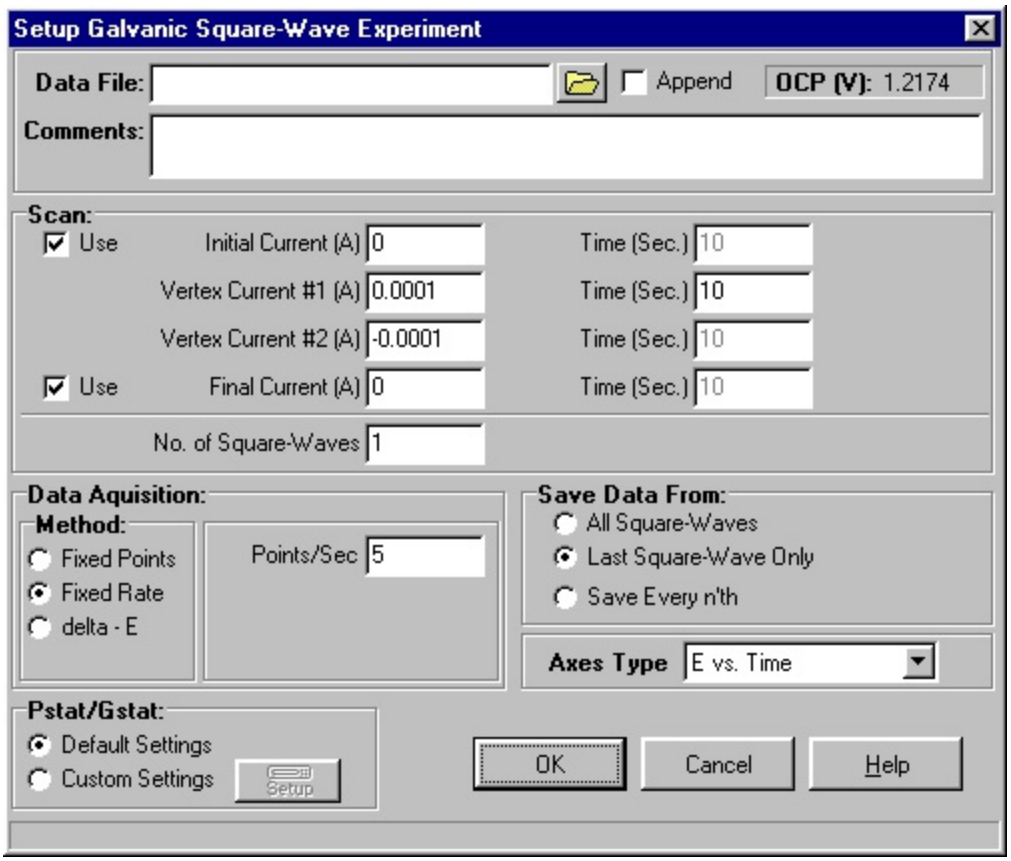
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Galvanic Square-Wave

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment applies a current step for a specified time between up to 4 separate setpoints. If only 2 setpoints are used, multiple cycles may be performed, producing a current 'Square Wave'.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate currents can be applied during the experiment. Click on the **Used** boxes to turn on and off the Initial and Final setpoints.

Note: The Current values specify the total current applied, not the current density.

Each segment has a separate time value specifying the length of time which that particular current will be applied.

No. of Square-Waves specifies how many times the current is cycled between Vertex #1 and Vertex #2. The Initial and Final Currents can only be used if the number of Square-Waves is set to '1'. To perform multiple cycles, the Initial and Final Currents must be disabled. Galvanostatic experiments can be used before and after a Square-Wave to apply an independent currents before and/or after the experiment.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell potential changes (compared to the last point saved) by more than the **mV/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at the rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-E**, you may wish to use a **Fixed Rate** experiment to get a feel for the noise level of the cell. This will help in selecting an appropriate value for **mV/Point**.

Save Data From:

When applying multiple Square-Waves, it may be useful to save data only from particular waveforms. **All Square-Waves** saves the data from all waveforms in a single data file. **Last Square-Wave Only** saves the data after each Square-Wave, replacing the data from the previous Square-Wave. **Save Every n'th** saves the data from periodic waveforms, incrementing the filename extension for each saved Square-Wave.

For example, if 20 Square-Waves are performed, **All Square-Waves** would save all 20 waveforms in a single file. If **Last Square-Waves Only** is selected, only the 20th waveform would be saved. Using **Save Every n'th** with a period of 5 and a file name of *test.cor* would save Square-Waves 1, 5, 10, 15 and 20 in files *test_Cy01.cor*, *test_Cy05.cor*, *test_Cy10.cor*, *test_Cy15.cor* and *test_Cy20.cor* respectively.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information

Load/Save Setup

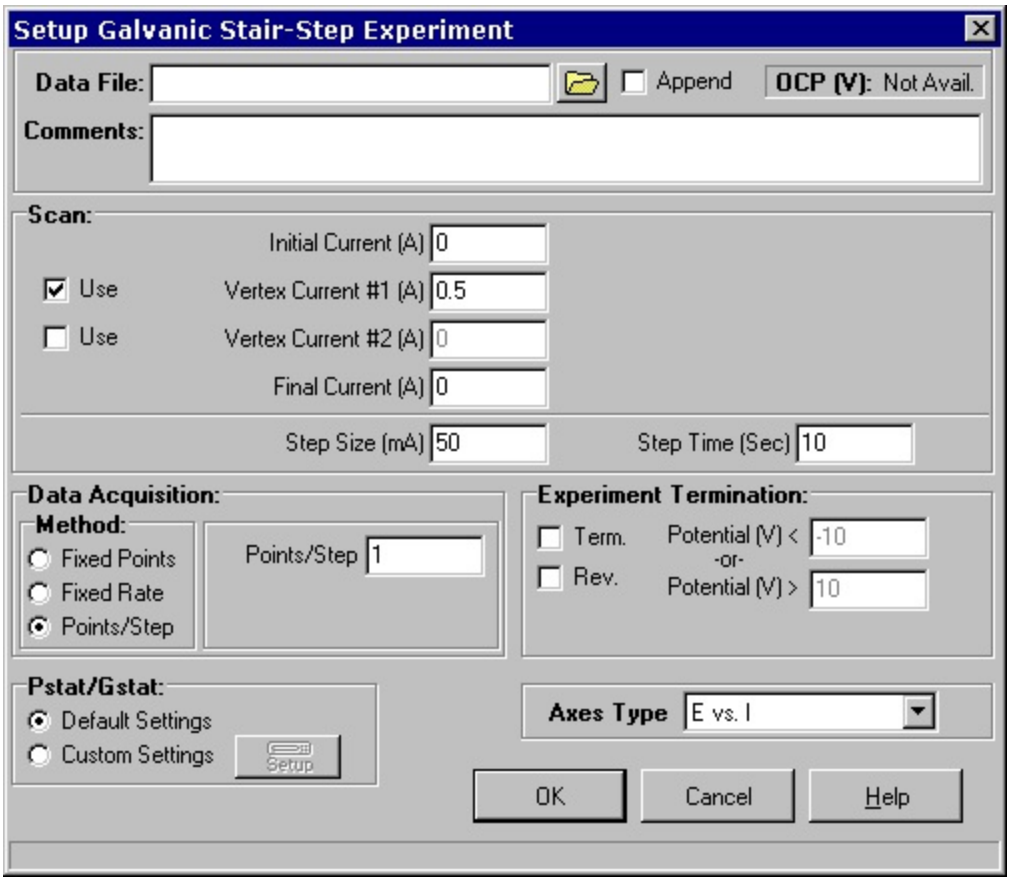
Setup Experiment - Galvanic Stair-Step

Accessed by: **Experiments | Setup Experiment...** 

or: press <Enter> key

A galvanic sweep between up to 4 separate current setpoints is applied and the potential response is measured. Unlike the Galvanodynamic experiment, the current is changed in discrete steps rather than a smooth sweep. The sweep can be terminated or the sweep direction reversed if a particular potential is reached.

Note: This experiment is not available with the PAR or AMEL 5000 potentiostat.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one.

Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Scan:

Up to 4 separate currents can be applied during the experiment. The experiment starts at the Initial Current, sweeps to Vertex #1, to Vertex #2, and then to the Final Current. Click on the **Used** boxes to turn on and off the Vertex #1 and Vertex #2 setpoints. If a Vertex's **Used** box is not checked, that segment of the sweep will be skipped. For example, if only Vertex #1 is checked the sweep Initial --> Vertex #1 --> Final is performed. If neither Vertex is checked, Initial --> Final is performed.

The **Step Size** selects the size of the current steps. The **Step Duration** determines how long the current will be held at each step.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time** of the experiment.

If **Points/Step** is chosen, an exact number of data points for each current step may be chosen. If the number of **Points/Step** is 1 (one), a data point will measured at the very end of each step, just before the potential is stepped to a new value.

Sweep Termination/Reversal:

If the **Term.** box is checked, the sweep will be ended if certain current conditions are met. If the **Rev.** is checked, when certain potential and current conditions are met, the experiment will immediately start sweeping toward the **Final Current.**

The Termination or Reversal will occur when the potential is above the **Potential>** or the potential is below **Potential<.**

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

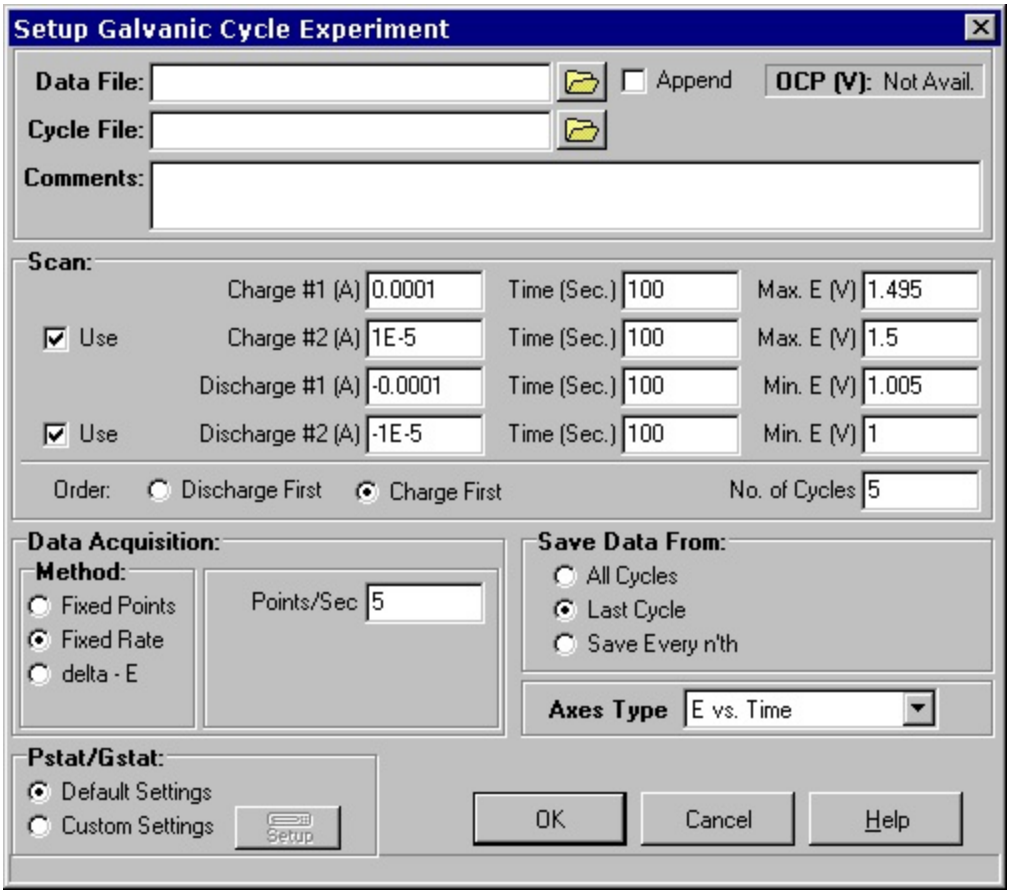
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Galvanic Cycle

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment performs a 2 to 4 step charge and discharge cycle.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

An additional file to hold calculated Cycle values for the charge and discharge segments is

created using the file specified by **Cycle File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used.

CorrWare automatically appends the suffix '.txt' to Cycle file if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.txt* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used. Since they use different extensions, the same base file name may be used for both the **Data File** and **Cycle File**.

The **Cycle File** contains one line per experiment. The total Charge and Discharge capacity as well as the Discharge/Charge ratio is saved. In addition, the capacity for both of the charge and discharge segments is saved as well as the potential at the end of each of the segments. This file is not accessible by the **CorrView** analysis program. Instead, it is saved as a comma delimited text file which can be read by word processors or spreadsheet programs such as Excel or 1-2-3.

When using a Galvanic Cycle experiment inside a scanner loop, unlike the data file, the Cycle file name extension is not incremented. Instead, each time through the loop adds an extra line to the Cycle file.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

Cycle:

Up to 4 separate currents can be applied during the experiment. Click on the **Used** boxes to turn on and off the Charge #2 and Discharge #2 setpoints.

Note: The Current values specify the total current applied, not the current density.

Each segment has a separate time value specifying the length of time which that particular current will be applied. Each current also has a **Max. E** or **Min. E** value. The segment will end when either the specified time is used or the maximum or minimum potential is exceeded. This can be used to produce a dual step charge or discharge. For example, a battery can be charged at a fast rate until a specific potential is reached and then charged at a slower rate until another potential is reached. To charge for a specified time (independent of the potential) set the Max. E value to a higher potential than expected.

Order:

Use the Order selections to determine if a Charge or Discharge is performed first.

No. of Cycles

Specifies how many times the charge/discharge cycle is repeated.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second** but not all of this data is saved. If the cell potential changes (compared to the last point saved) by more than the **mV/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at the rate specified by the **Minimum Points/Second**. Using this method allows CorrWare to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-E**, you may wish to use a **Fixed Rate** experiment to get a feel for the noise level of the cell. This will help in selecting an appropriate value for **mV/Point**.

Save Data From:

When applying multiple cycles, it may be useful to save data only from particular cycles. **All Cycles** saves the data from all cycles in a single data file. **Last Cycle** saves the data after each cycle, replacing the data from the previous cycle. **Save Every n'th** saves the data from periodic cycles, incrementing the filename for each saved Cycle.

For example, if 20 Cycles are performed, **All Cycles** would save all 20 cycles in a single file. If **Last Cycle** is selected, only the 20th cycle would be saved. Using **Save Every n'th** with a period of 5 and a file name of *test.cor* would save Cycles 1, 5, 10, 15 and 20 in files *test_Cy01.cor*, *test_Cy05.cor*, *test_Cy10.cor*, *test_Cy15.cor* and *test_Cy20.cor* respectively.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

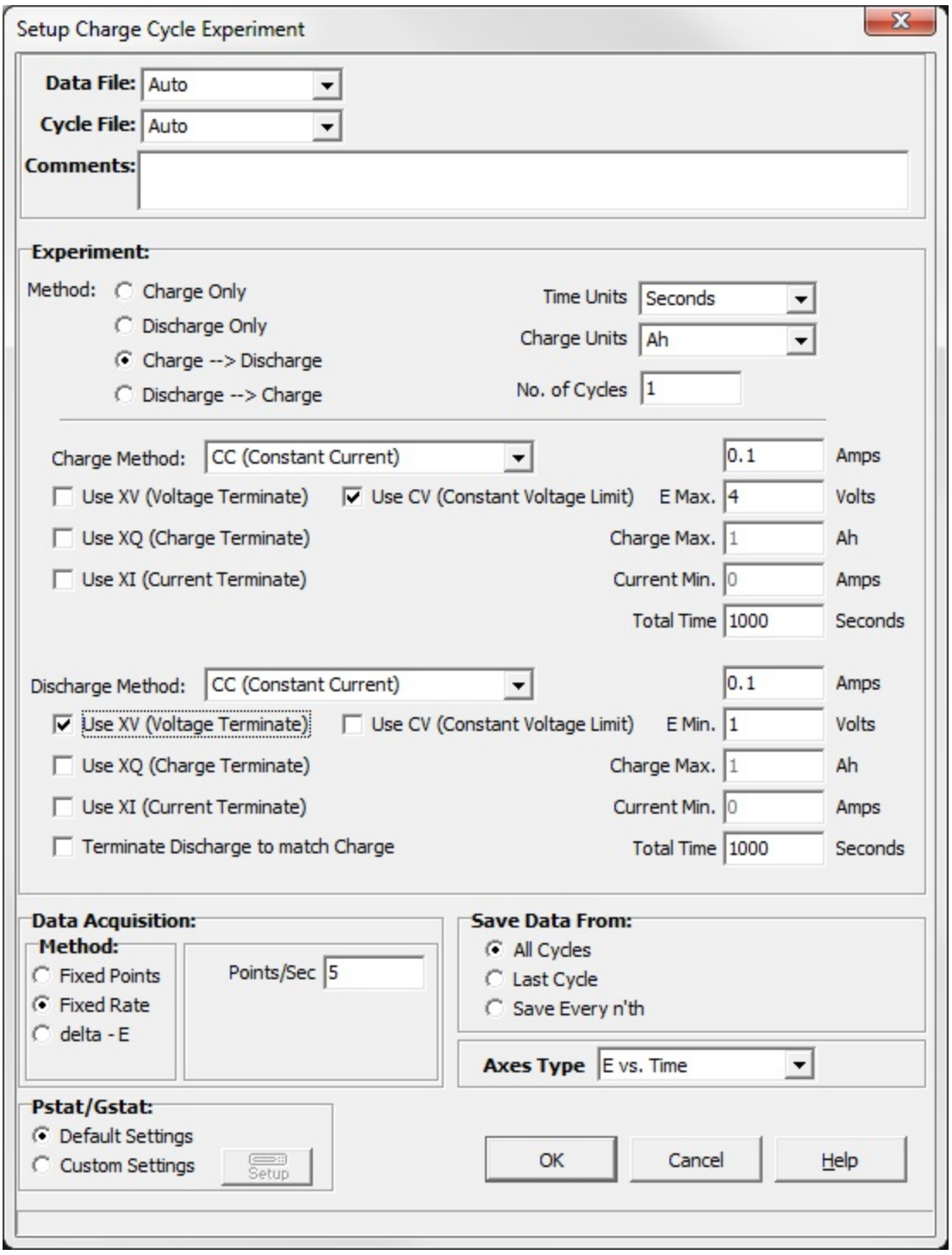
Setup Experiment - Charge Cycle

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment performs a multistep charge and discharge cycle.

Note that this experiment requires that the instrument is operating in its default polarity convention. For the Solartron 1470, the Positive (+) terminal connected to the Red+Blue cables, and the Red+Blue cable type selected in File | New Instrument, so that CorrWare displays a positive voltage value. For the Solartron 1287, connect the Positive (+) terminal to the WE+RE2 cables so that CorrWare displays a positive voltage value.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display Not Available.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the experiment list, you will be warned, if the file already exists.

CorrWare automatically appends the suffix .COR to data files, if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc*, the file *tutor1.abc* will be used.

An additional file to hold calculated cycle values for the charge and discharge segments is created using the file specified by **Cycle File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful, if you forget the file names you have already used.

CorrWare automatically appends the suffix .txt to cycle file, if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.txt* will be used. If however, you specify *tutor1.abc*, the file *tutor1.abc* will be used. Since they use different extensions, the same base file name may be used for both the **Data File** and **Cycle File**.

The **Cycle File** contains one line per experiment. The total Charge and Discharge capacity as well as the Discharge/Charge ratio is saved. In addition, the capacity for both of the charge and discharge segments is saved as well as the potential at the end of each of the segments. This file is not accessible by the **CorrView** analysis program. Instead, it is saved as a comma delimited text file which can be read by word processors or spreadsheet programs such as Excel or 1-2-3.

When using a Charge Cycle experiment inside a scanner loop, unlike the data file, the cycle file name extension is not incremented. Instead, each time through the loop adds an extra line to the cycle file.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file, so you do not need to write these into the comment lines.

Experiment:

The **Charge Only** and **Discharge Only** methods will perform only half of a cycle. **Charge à Discharge** performs a charge followed by discharge. **Discharge à Charge** will perform

a discharge followed by charge.

Time Units selects the units for the Total Time (Seconds, Minutes, Hours).

Charge Units selects the units for the Charge Max. value (As [Coulombs], Ah)

No. of Cycles specifies how many times the charge/discharge cycle is repeated. This value must be 1 if the **Charge Only** or **Discharge Only** methods are used.

The CC (Constant Current) **Charge Method** selects the current used to charge a cell.

If **Use CV (Constant Voltage Limit)** is checked, the **E. Max.** voltage limit can be specified. When charging, if the voltage reaches the E Max. value, the charging method changes to Constant Voltage at the E Max. value for the remainder of the Total Time.

If **Use XV (Voltage Terminate)** is checked, the **E. Max.** voltage limit can be specified. When charging, if the voltage reaches the E Max. value, the experiment proceeds to the next step.

If **Use XQ (Charge Terminate)** is checked, the **Charge Max.** charge termination limit can be specified. When charging, if the charge reaches the Charge Max. value, the experiment proceeds to the next step.

If **Use XI (Current Terminate)** is checked, the **Current Min.** current termination limit can be specified. When charging, if the current falls below the Current Min. value, the experiment proceeds to the next step.

If the Charging process is not terminated by the CQ or CI values, the Charge proceeds for the full **Total Time**.

If Discharge à Charge is used, the **Limit Charge to match Discharge** option will stop the charge (proceeding to the next step) if the total charge (Ah or Coulombs) matches the total previous discharge.

The CC (Constant Current) **Discharge Method** selects the current used to discharge the cell.

If **Use CV (Constant Voltage Limit)** is checked, the **E. Min.** voltage limit can be specified. When discharging, if the voltage reaches the E Min. value, the discharging method changes to Constant Voltage at the E Min. value for the remainder of the Total Time.

If **Use XV (Voltage Terminate)** is checked, the **E. Min.** voltage limit can be specified. When discharging, if the voltage reaches the E Min. value, the experiment proceeds to the next step.

If **Use XQ (Charge Terminate)** is checked, the **Charge Max.** charge termination limit can be specified. When discharging, if the charge reaches the Charge Max. value, the experiment proceeds to the next step.

If **Use XI (Current Terminate)** is checked, the **Current Min.** current termination limit can be specified. When discharging, if the current falls below the Current Min. value, the

experiment proceeds to the next step.

If the Discharge process is not terminated by the CQ or CI values, the Charge proceeds for the full **Total Time**.

If Charge à Discharge is used, the **Limit Discharge to match Charge** option will stop the discharge (proceeding to the next step) if the total discharge (Ah or Coulombs) matches the total previous charge.

Data Acquisition:

If **Fixed Points** is selected, the specified **Number of Points** will be equally spaced over the **Total Time**.

If **Fixed Rate** is chosen, the acquisition rate in **Points/Second** is specified.

The **delta-E** method is specified by three parameters. Data is measured by the instrument at the rate specified by **Maximum Points/Second**, but not all of this data is saved. If the cell potential changes (compared to the last point saved) by more than the **mV/Point** setting, a new data point is saved. If the signal is not changing, the data is saved at the rate specified by the **Minimum Points/Second**. Using this method allows MultiStat to collect large numbers of data points when the signal is changing quickly, and relatively few points when the signal is stable. Before using **delta-E**, you may wish to use a **Fixed Rate** experiment to get a feel for the noise level of the cell. This will help in selecting an appropriate value for **mV/Point**.

Save Data From:

When applying multiple cycles, it may be useful to save data only from particular cycles. **All Cycles** saves the data from all cycles in a single data file. **Last Cycle** saves the data after each cycle, replacing the data from the previous cycle. **Save Every nth** saves the data from every nth cycle, automatically incrementing the filename for each saved cycle.

For example, if 20 cycles are performed, **All Cycles** would save all 20 cycles in a single file. If **Last Cycle** is selected, only the 20th cycle would be saved. Using **Save Every nth** with a period of 5 and a file name of *test.cor* would save cycles 1, 5, 10, 15 and 20 in files *test_Cy01.cor*, *test_Cy05.cor*, *test_Cy10.cor*, *test_Cy15.cor* and *test_Cy20.cor* respectively.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see *Chapter 6 - MultiStat Menus*) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes.

Cancel exits the setup window. Any changes made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Setup Experiment - E & I Noise

Accessed by: **Experiments | Setup Experiment...** 

or: press <Enter> key

This experiment measures the potential and current noise generated by a galvanic couple of two samples of the same material.

Very Important - Read This!

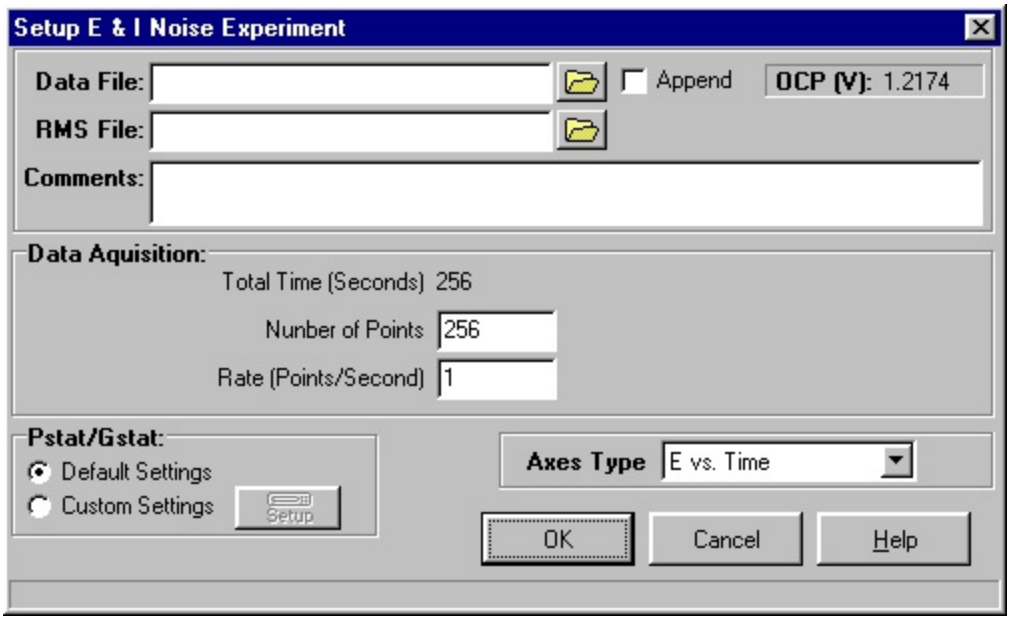
The E&I Noise experiment requires a different configuration of the cell cables from all other experiments. Using the E&I Noise configuration with other experiments could potentially damage the instrument or expose the user to a dangerous electrical shock!

Using the Normal cable configuration with an E & I Noise measurement will not cause damage but will result is incorrect and useless data. CorrWare will not allow E & I Noise and Normal experiments to be run from the same experiment list, but cannot warn of incorrect cables because it has no way to determine if the cell cables have been configured correctly.

It is up to the user to assure that the correct connections are made for a particular experiment.

We strongly suggest that you read Tutor #2 - Noise Measurement Techniques before attempting any Noise measurements. This section also contains a complete description of the proper cell connections.

Note: Because of the electrical design of the PAR 273/273A and AMEL 5000, these instruments are unable to perform this experiment properly.



OCP will display the actual open circuit potential of the cell (updated every 2 seconds). If the instrument is turned off, this value will display 'Not Available'.

When the experiment is performed, the data will be saved in the file specified by **Data File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used. However, before CorrWare begins performing the first experiment in the Experiment List, you will be warned if the file already exists.

CorrWare automatically appends the suffix '.COR' to data files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.cor* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used.

The **Comments** text is saved in the data file. The time, date, and all measurement parameters displayed in this window are automatically saved in the data file so you don't need to write these into the comment lines.

An additional file to hold calculated RMS values for the potential and current is created using the files specified by **RMS File**. The **Dir** button can be used to display a list of all directories and files. This is particularly useful if you forget the file names you have already used.

CorrWare automatically appends the suffix '.txt' to RMS files if you do not enter one. Thus if you specify *tutor1*, the file *tutor1.txt* will be used. If however, you specify *tutor1.abc* the file *tutor1.abc* will be used. Since they use different extensions, the same base file name may be used for both the **Data File** and **RMS File**.

The **RMS File** contains one line per experiment. The time of the experiment as well as the Root Mean Square (RMS) of the amplitude of the potential and current noise is saved. This file is not accessible by the **CorrView** analysis program. Instead, it is saved as a comma delimited text file which can be read by word processors or spreadsheet programs such as Excel or 1-2-3.

When using a Noise experiment inside a scanner loop, unlike the data file, the RMS file name extension is not incremented. Instead, each time through the loop adds an extra line to the RMS file.

Data Acquisition:

The **No. of Points** selects the number of data points to be measured by the experiment and the **Rate** sets the data acquisition rate. The Total Time of the experiment is calculated from the number of points and the acquisition rate.

Axes Type:

When the experiment is performed, the data will be displayed as specified by the **Axes Type**. CorrView can be later used to display the data in any of the other formats.

Pstat/Gstat:

The **Experiments | Setup Pstat/Gstat...** menu item (see CorrWare Menus) is usually used to configure the Pstat/Gstat for all experiments in the experiment list. These settings apply to all experiments where the **Default Settings** are selected. If you wish to use different Pstat/Gstat settings for a particular experiment, select **Custom Settings** and use the **Setup** button to configure the custom settings. The custom settings are used for this experiment only. All experiments before or after it will use either the default settings or their own custom settings.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

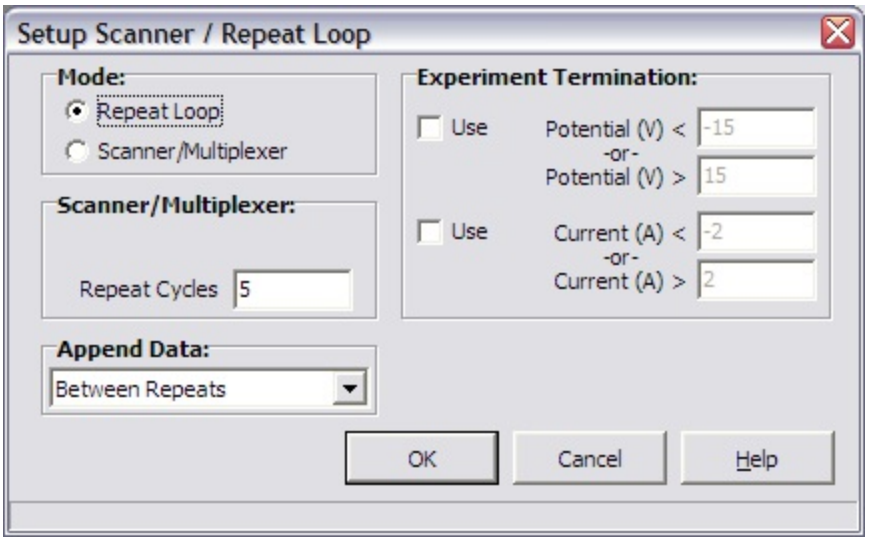
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Scanner

Accessed by: **Experiments | Setup Experiment...** 

or: press <Enter> key

This experiment does not perform measurements. It is used to repeat a series of experiments multiple times. If a multiplexer is available, the same experiments may be performed on multiple cells.



The **Repeat** mode is described in this manual. **Multiplexer** support is provided though the optional CorrWare Multiplexer Support package. Use of this menu for multiplexer support is described in the Multiplexer Support manual. If a Multiplexer is not installed, this option is not available.

When a Scanner experiment is created, it inserts two lines in the experiment list (Scanner-begin and Scanner-end). Any experiments between the Scanner-begin and Scanner-end experiments are repeated the number of times specified by **Repeat Cycles**.

If certain potential or current conditions occur, the Scanner experiment will stop repeating experiments earlier than specified by **Repeat Cycles**.

If the cell potential goes below the **Potential <** value or above the **Potential >** value, the experiment repetition will be ended. This termination method is activated by checking its **Used** box.

If the cell current goes below the **Current <** value or above the **Current >** value, the experiment repetition will be ended. This termination method is activated by checking its **Used** box.

When performing experiments between Scanner-begin and Scanner-end, the data files

names will be extended. For example, when setting up an experiment between Scanner-begin and Scanner-end, the file name *tutor1.cor* is specified. The first time through the repeat loop, the data will be saved in *tutor1_Rp01.cor*. The next time through the loop, it would use *tutor1_Rp02.cor*, etc.

The **Append Data** parameter will control how data is saved if the Append box is checked in a experiment step. If **Inside Loop** is selected, the _Rp0x extension is added to the data files as described above. If **Between Repeats** is selected, the _Rp01 extension is **not** added. The original data file is used, and data from multiple repeats are saved in a single file.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

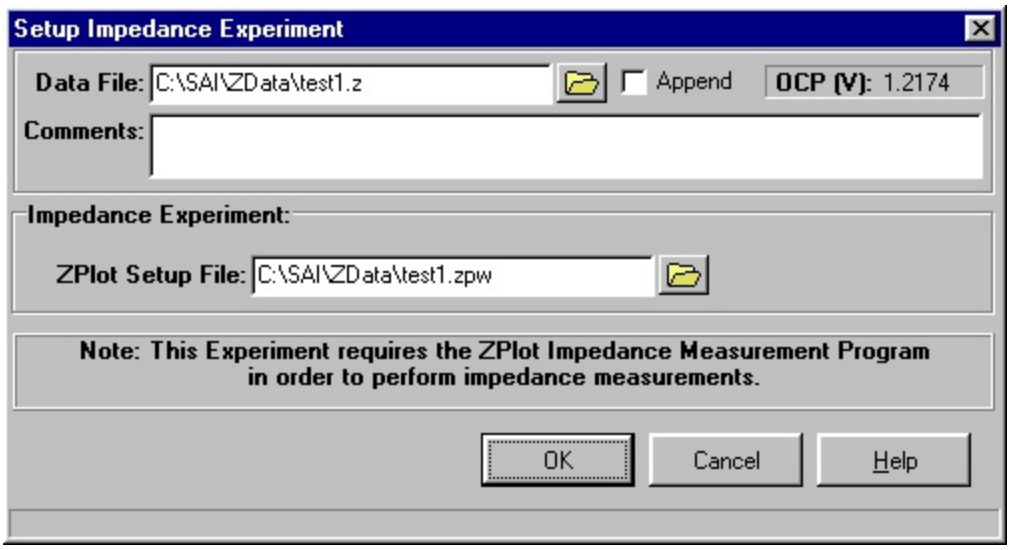
Setup Experiment
Setup Pstat/Gstat
Setup Cell Information
Load/Save Setup

Setup Experiment - Impedance

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment uses the ZPlot for Windows software package to perform impedance measurements. A ZPlot setup file must already have been created before using this experiment type. To use this experiment, you must have ZPlot Version 1.2 (or greater). The version can be checked by running ZPlot and choosing **Help | About**. If you have an earlier version of ZPlot, contact your Solartron Representative or Scribner Associates for an update.



Before performing impedance experiments from within CorrWare, you should first make sure that you know how to perform the impedance experiments using ZPlot by itself. From ZPlot use **File | Save Setup As...** to create a ZPlot Setup file with your preferred impedance measurement parameters.

This setup file should be entered as the **ZPlot Setup File**. The **Dir** button may be used to see your drives and directories, and will help locate the desired setup file.

After ZPlot performs the impedance measurements, it will save the data in the files specified by **ZPlot Data File**.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Impedance Queue

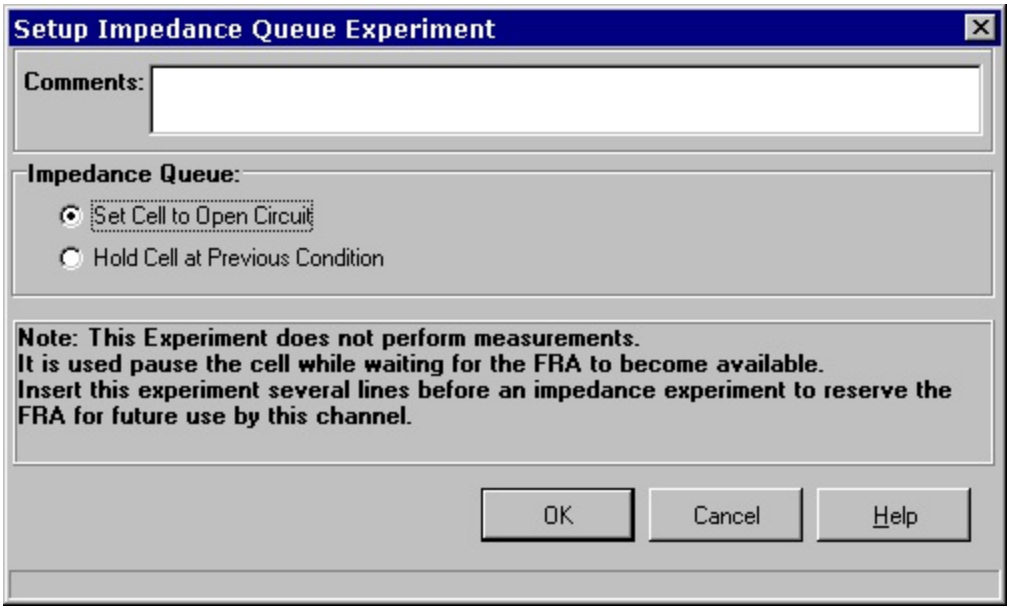
Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment does not perform any measurements. It is used when a single Frequency Analyzer (FRA) is used to measure multiple channels with the Solartron 1470/80 MultiStat.

The FRA can only measure one channel at a time. The Impedance Queue experiment is used to control the state of the channels that are waiting for the FRA to become available. Because each channel will wait a different amount of time to be measured by the FRA, the pretreatment before the impedance measurement is not consistent.

The Impedance Queue experiment is placed in the experiment list SEVERAL STEPS BEFORE the Impedance Experiment. After the FRA is available, the channel will perform the experiments BETWEEN the Impedance Queue and Impedance Experiment, thus each channel can apply specific pretreatments immediately before measuring impedance.



If **Set Cell to Open Circuit** is selected, the channels will pause at the Impedance Queue experiment and the channels be under Open Circuit conditions.

If **Hold Cell at Previous Condition** is selected, the channels will pause at the Impedance Queue experiment and the channels will continue to apply the previous cell condition.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

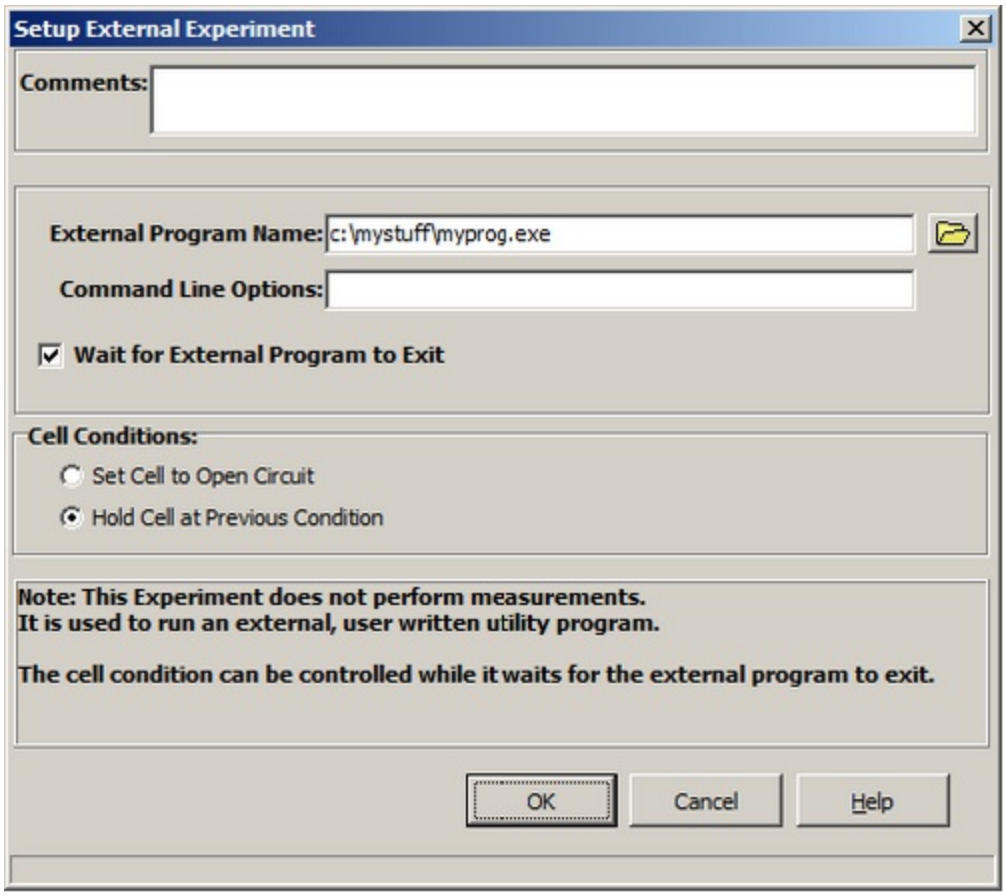
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Run External Utility

Accessed by: **Experiments | Setup Experiment...** 

or: press <Enter> key

This experiment does not perform any measurements. It is use to launch external utility programs written by the user. For example, if the user wrote a small program in Visual Basic to set the temperature on a temperature controller, this experiment could be used to run the program to change the cell temperature between experiments. CorrWare will resume performing experiments when the user written program exits. The cell will be held under the ending conditions of the previous experiment.



External Program Name should the name of the user written program to be run. The **Dir** button may be used to see your drives and directories, and will help locate the desired program file.

The **Command Line Options** is text that will be given to the utility program. CorrWare does not interpret the command line information in any way, but simply passes it on to the utility. The utility can be written to interpret the command line information. For example, a utility program to set the temperature on a temperature controller could interpret the command line: *50 10* to mean that it should set the temperature to 50 C and wait for 10 minutes before exiting (to let the temperature stabilize).

If **Wait for External Program to Exit** is checked, CorrWare will pause while the external program is active. When the external program closes, CorrWare will resume the experiment list.
If CorrWare is waiting for the external program to exit, the **Cell Conditions** can be selected. Selecting **Set Cell to Open Circuit** will turn off the potentiostat while the external program is active. If **Hold Cell at Previous Condition** is selected, the potentiostat will stay on and the cell will continue to be polarized during this period.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

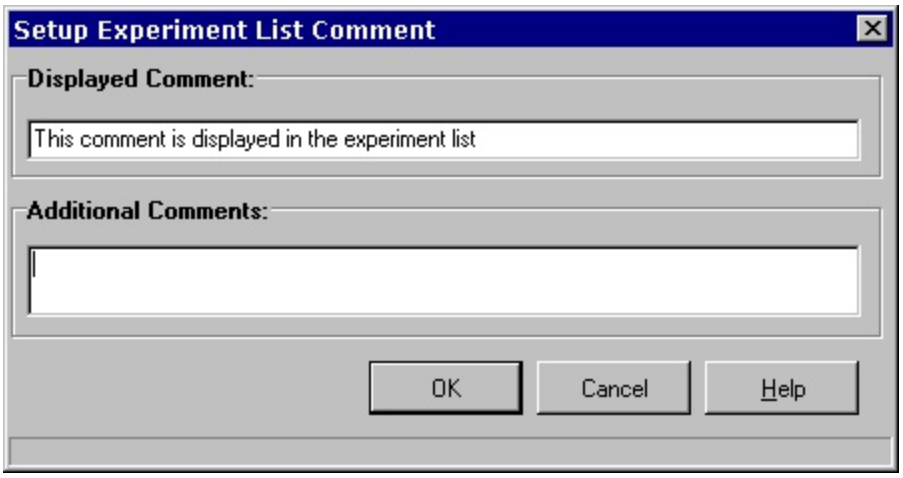
- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Setup Experiment - Comment

Accessed by: **Experiments | Setup Experiment...**

or: press <Enter> key

This experiment does not perform any measurements. It is use to add comments to the list of experiments for documentation purposes.



The **Displayed Comment** will be show in the experiment list.

The **Additional Comments** are not show in the experiment list, but will be saved in the experiment setup file.

The **OK** button exits the setup window and saves any changes you may have made.

Cancel exits the setup window. Any changes you may have made to the parameters are lost.

Help accesses the on-line help information on the setting up of this experiment.

Related Topics

- Setup Experiment
- Setup Pstat/Gstat
- Setup Cell Information
- Load/Save Setup

Starting Measurements

Measurements can be performed using some or all of the experiments in the experiment list.

Use: **Experiments | Measure Selected Lines** 
or: <Ctrl>+S
to measure all of the selected (highlighted) lines in the experiment list.

Use: **Experiments | Measure Selected ...to End** 
or: <Ctrl>+M
to measure all of the experiments between the selected (highlighted) lines and the end of the the experiment list.

These functions are used to initiate measurements of the experiments in the experiment list.

To measure all the experiments in the list, press <Home> to highlight the first line in the list, and use **Measure Selected ...to End**.

To measure from the middle of the list to the end of the list, highlight the experiment you wish to start with and use **Measure Selected ...to End**. This method is very useful if you aborted measurements in the middle of the list and you wish to restart them.

To measure a single experiment, highlight the desired experiment and use **Measure Selected Lines**.

To measure a subset of the experiment list, highlight a section of the experiment list and use **Measure Selected Lines**.

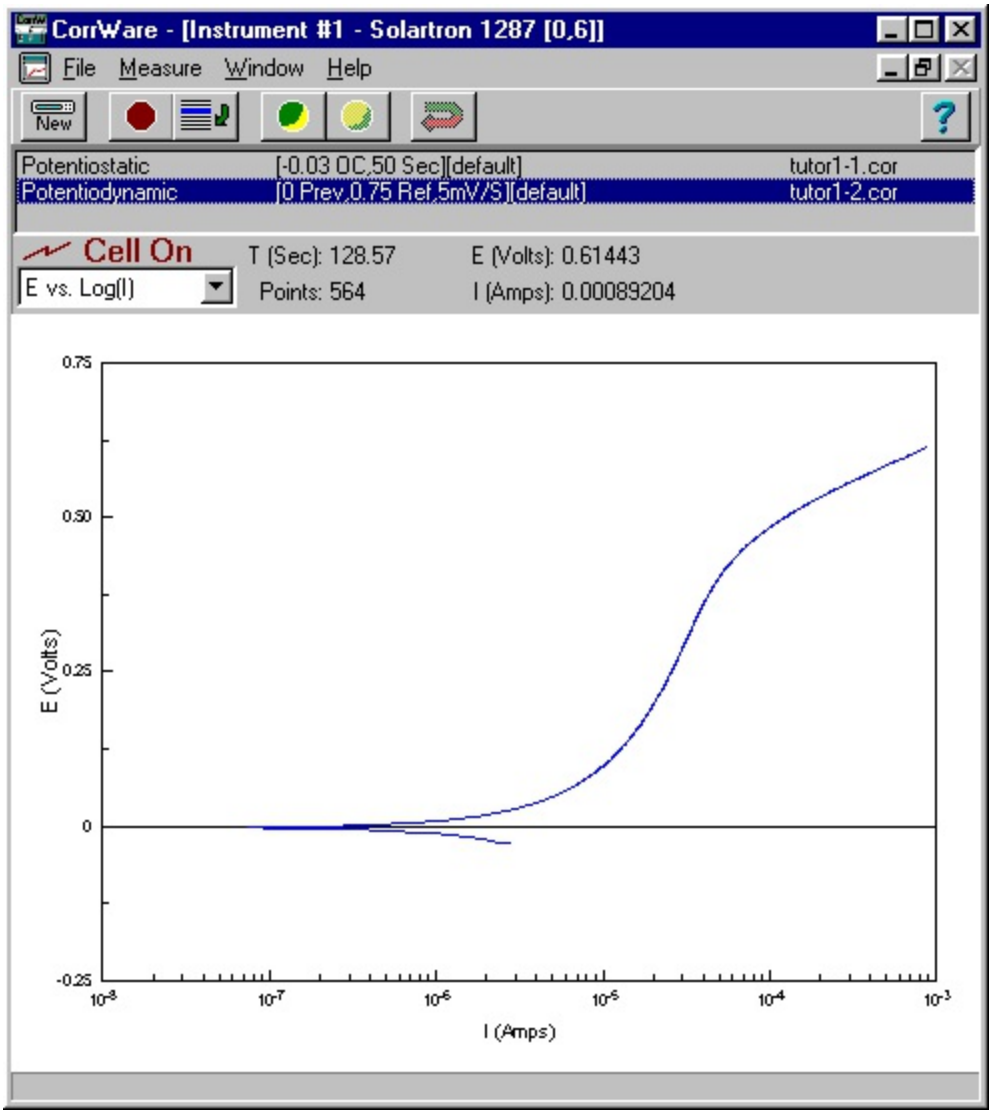
The functions available during measurements are described in CorrWare Measurements.

Related Topics

Measurements

Measurements

During measurements, CorrWare changes its menus to show the options which are available. The options under File, Window, and Help are the same as those available when setting up experiments and are described in CorrWare Menus.



The menu items under **Measure** are also available through the icon bar. Certain options may be 'grayed' if the function is unavailable. For example, when performing an Open Circuit experiment, a sweep reversal is meaningless and is thus unavailable.

Below the icons is a list of the experiments to be performed. Normally the previous, current, and next experiment are shown, but the scroll bar may be used to see the entire list. Just above the graph is a status area which shows the current condition of the cell.

Measure | Stop 

Stops the current experiment and returns to the experiment setup menu. The opportunity

will be given to save the measured data. To save the data, select a file name and choose OK. If you do not wish to save the data, select Cancel.

Measure | Skip 

Stops the current experiment, saves any data measured, and immediately starts the next experiment in the experiment list. If the last experiment in the experiment list is currently being performed, the measurements are stopped as described in **Measure | Stop** (see above).

Measure | Pause 

Temporarily pauses the experiment. The potentiostat remains on, and the experiment may be resumed using **Measure | Continue** described below.

Measure |Continue 

Resumes a measurement which has been paused using **Measure | Pause** described above.

Measure | Reverse 

This function is only available when performing potentiodynamic or galvanodynamic experiments with more than one segment. The experiment immediately starts sweeping from the current cell conditions toward the final potential or current. If the experiment is already on its last segment (it is already sweeping toward final), this function has no effect.

During a measurement, the displayed axes can be changed using the list box below the CELL ON indicator. The default axes for each experiment is defined in the experiment setup menu. When vs. Time' axes are displayed, the axis may be rescaled during the experiment. This may be helpful if a stray data point causes the axis to scaled so that the rest of the data is difficult to
see clearly. To rescale the axis, hold down the Ctrl key and drag the mouse over the graph to
indicate to desired scaling range. This method rescales only the vertical axis and not the horizontal (Time) axis. Return to the original autoscaling by reselecting the axes using the axes selection box below the CELL ON indicator.

Related Topics

- Starting Measurements