



EIS Box™

Instrument Operator's Manual



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If You Have Problems

Please visit our service and support page at www.gamry.com/service-support/. This page contains information on installation, software updates, and training. It also contains links to the latest available documentation. If you are unable to locate the information you need from our website, you can contact us via email using the link provided on our website. Alternatively, you can contact us one of the following ways:

Internet	www.gamry.com/service-support/
Telephone	(215) 682-9330 9:00 AM–5:00 PM, US Eastern Standard Time (877) 367-4267, Toll Free US and Canada Only

Please have your instrument model and serial numbers available, as well as any applicable software and firmware revisions.

If you have problems in installation or use of a system containing an EIS Box, please try to call from a phone next to your computer, where you can type and read the screen while talking to us.

We will be happy to provide a reasonable level of free support for registered users of the EIS Box instrument. Reasonable support includes telephone assistance covering the normal installation, use, and simple customization of a computerized system containing an EIS Box instrument connected to a Windows®-compatible computer.

A service contract that extends both the hardware warranty and software update period is available at an additional charge. Software updates **do not** include software enhancements offered to our customers at additional cost.

Enhancements to the EIS Box instrument and Gamry's standard applications software that require significant engineering time on our part can be performed on a contract basis. Contact us with your requirements.

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Gamry Instruments, Inc. cannot guarantee that the EIS Box instrument will work with all computer systems, operating systems, and third-party software applications, hardware, or software.

The information in this manual has been carefully checked and is believed to be accurate as of the time of release. However, Gamry Instruments, Inc. assumes no responsibility for errors that might appear.

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Chapter 1: Safety Considerations

Your EIS Box instrument has been supplied in a safe condition. This chapter of the EIS Box Instrument Operator's Manual contains information and warnings that you must follow to ensure continued safe operation of the EIS Box.

Inspection

When you receive your EIS Box instrument, inspect it for evidence of shipping damage. If you observe any damage, please notify Gamry Instruments Inc. and the shipping carrier immediately. Save the shipping container for possible inspection by the carrier.



Warning: An EIS Box damaged in shipment can be a safety hazard. Do not operate damaged apparatus until a qualified service technician has verified its safety. Tag a damaged EIS Box to indicate that it could be a safety hazard.

Product Safety

The EIS Box has been designed, tested, and certified to meet the requirements of EN 61010, *Safety requirements for electrical equipment for measurement, control, and laboratory use*. As defined in this standard, it is a Category II apparatus, with any "hazardous live voltages" protected by "reinforced insulation".

Most of the EIS Box circuitry operates at voltages low enough to be considered safe. The EIS Box contains a limited amount of internal circuitry that is at "hazardous live" voltage as defined in EN 61010 (the standard mentioned above). "Reinforced insulation" (again defined in EN 61010) is used to reduce the risk of electrical shock caused by this hazardous live voltage.

The majority of the EIS Box's circuitry does not contain voltages higher than 15 V DC. Generally input and output voltages in the EIS Box are limited to ± 9 V. This voltage level is considered safe.



The EIS Box's power input is rated for operation from 100 to 240 V AC, 47 to 63 Hz. It should therefore be useful throughout the world.

The EIS Box is normally provided with an AC line cord suitable for your location. This AC line cord connects the AC mains to the chassis of the instrument. You must always use a line cord with a CEE 22 Standard V female connector on the instrument end of the cable. If your EIS Box has been provided without an AC line cord, or a cord that is not compatible with your local AC mains socket, obtain a line cord certified for use in your country. Contact your local Gamry Representative or email to techsupport@gamry.com if you are uncertain what AC line cord to use.

Grounding in the EIS Box

Protective Ground and System Ground Binding Posts

The **Protective Ground** binding post is a convenient access point to the protective (earth) ground in the EIS Box. It is connected to the third wire in the AC power cord and to the EIS Box's metal chassis.

This binding post can be connected to an additional earth ground to form a redundant protective ground.

Most electrochemical cells are isolated from earth ground, so isolation of the EIS Box from earth is not required. In these cases, connection of the EIS Box chassis to **System Ground** may lower the noise seen in an electrochemical test.

The **System Ground** is the common voltage reference point for the EIS Box's circuitry. It floats with respect to the **Protective Ground**.



Sources of earth ground include

- Most metal water pipes,
- The chassis of **most** electronic apparatus (which are generally earth-grounded), and
- The protective ground terminal of an AC mains power plug.

We recommend that you discuss grounding with an electrical or electronics professional prior to making this earth-ground connection.



Warning: Do not negate the protection of the EIS Box's earth ground by any means. Do not use the EIS Box with a two-wire extension cord, with an adapter that does not provide for protective grounding, or with an electrical outlet that is not properly wired with a protective earth ground. If the protective ground is not properly connected, it creates a safety hazard, which could result in personal injury or death.



Warning: Never connect the **Protective Ground** and **System Ground** if the electrochemical system you are testing is earth-grounded. Two earth-ground connections in a high-energy electrochemical system can create hazardous conditions.

The **System Ground** binding post is not intended for any use other than connecting the EIS Box to an earth ground to improve shielding against noise. Connecting this binding post to a hazardous voltage can create a significant safety hazard.



Warning: Do not connect the **Protective Ground** binding post to any voltage other than earth ground. An improper connection can create a safety hazard, which could result in personal injury or death.

The EIS Box contains surge suppressors that limit the voltage difference between the EIS Box's chassis ground and earth ground to about 28 V. These surge suppressors are not part of the safety mechanisms in the EIS Box. Instead they are present to limit the possibility of improper instrument operation or instrument damage due to electrostatic discharge (static electricity) and other surge events such as lightning.



Caution: The surge suppressors can be irreparably damaged by non-transient voltages that exceed their threshold voltage of ± 28 V. In the worst case this can cause catastrophic failure of the system. Do not connect an EIS Box to a cell in a battery or fuel cell stack when the cell voltage is more than 25 V from earth ground.

Temperature and Ventilation

Your EIS Box instrument was designed for indoor use at ambient temperatures between 0°C and 45°C.

The EIS Box uses forced-air cooling to keep the EIS Box components within their operating temperature range. Most of the air needed to cool the EIS Box enters the chassis through holes in its bottom plate.

The fan within the EIS Box has two operating speeds with different audible noise levels. The EIS Box normally operates with the slower, quieter fan setting. The fan switches to a higher speed when the EIS Box's internal heat sink gets hotter than 50°C.

The cooling air exits through the back of the instrument.



Caution: Do not block the airflow into or out of the EIS Box chassis. The circuitry is thermally protected so over-temperature will cause the instrument to enter a shut-down state. If shut-down occurs during data-acquisition, experimental data could be lost. Running the EIS Box without adequate cooling could also shorten the time to failure of some of the circuitry.

Be careful when operating the EIS Box in an enclosed space (such as an enclosed relay rack or NEMA enclosure). The temperature within the enclosure must not exceed 45°C. You may need to provide ventilation holes or even forced air-cooling for the enclosed space if excessive temperature rise occurs.

Defects and Abnormal Stresses

Treat your EIS Box as potentially hazardous if any of the following is true of the unit:

- It shows visible damage,
- It does not operate properly,
- It has been stored for a long period of time under unfavorable conditions,
- It has been dropped or subjected to severe transport stress,
- It has been subjected to environmental stress (corrosive atmosphere, fire, etc.).

Do not use your EIS Box or any other apparatus if you think it could be hazardous. Have it checked by qualified service personnel.

Environmental Limits

Note that there are environmental limit conditions on the storage, shipping and operation of this equipment. The EIS Box has **not** been designed for outdoor use.

Storage	Ambient temperature	–40°C to 75°C
	Relative humidity	Maximum 90% non-condensing
Shipping	Same as storage plus	
	Acceleration	Maximum 30 G
Operation	Ambient temperature	0°C to 45°C
	Relative humidity	Maximum 90% non-condensing



Warning: The EIS Box is not designed for operation in conditions where liquid water may enter the chassis, or water vapor may condense within the chassis. Operation of an EIS Box that has water within the chassis can create a safety hazard, which could result in personal injury or death.

Cleaning

Clean the external chassis only when necessary.

Disconnect the EIS Box from all power sources prior to cleaning.

Use a cloth **lightly** dampened with either clean water or water containing a mild detergent, to clean the outside of the EIS Box enclosure. Alternatively, you may use isopropyl alcohol. Do not use a wet rag or allow fluid to enter the EIS Box enclosure. Do not immerse the EIS Box in any type of cleaning fluid (including water). Do not use any abrasive cleaners.

Service

Except for switching between Ethernet and USB communications, your EIS Box instrument has no user-serviceable parts inside. Refer all service to a qualified service technician.



Warning: Never operate the EIS Box with any cover or panel on the chassis open. Dangerous voltages may be present at several points within the EIS Box chassis, including PC board traces. Always remove the power connection before opening the EIS Box case.

RF Warning

The EIS Box has been tested for both radiated and conducted RF interference and for immunity to RF fields, and has been found to be in compliance with FCC Part 18 and EU Council Directive 2014/30/EU, the EMC Directive EN 61326:2013—*Electrical equipment for measurement, control, and laboratory use—EMC Requirements*. Testing was performed in accordance with the Basic Immunity Requirements contained in Table 1 and the Emission Requirements contained in Section 7.

However, your EIS Box instrument still does generate some radio-frequency energy. The radiated levels are low enough that the EIS Box should not create an interference problem in most industrial laboratory environments.

Your EIS Box instrument may also respond to environmental radio-frequency energy. We recommend you avoid using mobile phones and other radio-frequency equipment in the same room as an EIS Box. The EIS Box circuitry has been tested for operation in high-intensity RF fields and has demonstrated little response to those fields. However, there is no guarantee that the electrochemical cell and its connections will not respond to RF fields. This response most often appears as DC shifts in a cell's response caused by rectification of the RF signal.

A Faraday cage surrounding your cell may be used to minimize the effect of environmental RF fields. If your cell is isolated from earth ground, Gamry recommends connecting the **System Ground** to a Faraday cage.

Electrical Transient Sensitivity

Your EIS Box instrument was designed to offer reasonable immunity from electrical transients, including transients on the incoming AC mains supply and electrostatic discharge. It has been tested for compliance with EN 61326-1:2013—*Electrical equipment for measurement, control, and laboratory use—EMC Requirements* describing acceptable limits for electrical transient susceptibility in laboratory test equipment. It should continue to operate when subject to the standard ESD and power-line events defined in EN 61326-1:2013.

In severe cases involving transients beyond the limits tested in EN 61326-1:2013, the EIS Box could still malfunction as a result of electrical transients. If you are having problems in this regard, the following steps may help:

If the problem is static electricity (sparks are apparent when you touch the EIS Box or its cables):

- Try placing your EIS Box on a static-control work surface. Static-control work surfaces are now generally available from computer-supply houses and electronics-tool suppliers. An antistatic floor mat may also help, particularly if a carpet is involved in generating the static electricity.
- Air-ionizers or even simple air-humidifiers can reduce the voltage available in static discharges.

If the problem is AC power-line transients (often from large electrical motors near the EIS Box):

- Try plugging your EIS Box into a different AC power branch circuit.
- Plug your EIS Box into a power-line surge-suppressor. Inexpensive surge-suppressors are now generally available because of their use with computer equipment.

Contact Gamry Instruments, Inc. if these measures do not solve the problem.

CE Compliance

The European Community has instituted standards limiting radio-frequency interference emitted by electronic devices, setting limits for susceptibility of apparatus to RF energy and transient events, and mandating safety requirements. Gamry Instruments, Inc. has designed and tested the EIS Box to comply with these standards.

The relevant CE regulations include EN 61010-1:2010 and EN 61326-1:2013.

RoHS Compliance

The EIS Box is built using lead-free components and lead-free solder. It complies with the European RoHS initiative.

Safety Considerations

Chapter 2: Introduction

About this Manual

This manual covers the installation, safety, and use of the Gamry Instruments EIS Box instrument with Revision 7 (and later revisions) of the Gamry Framework software. It is equally useful when setting up a newly-purchased instrument or modifying the setup of an older instrument for use with new software. Technical material such as specifications and connector pin-outs is in the Appendices.

This manual discusses software installation and software operation in some detail. The installation is written assuming installation using Revision 7 of Gamry's Framework software. Installation is also described in Gamry Instruments's Quick-Start Installation Guide.

Software support for the EIS Box is described in the Gamry Help system.

All Gamry Instruments applications running under the Gamry Framework control the EIS Box via a PSTAT object. See the Framework's Help for information concerning PSTAT objects and their functions.

About the EIS Box

The EIS Box (pronounced "ice box") is a value-oriented, research-grade electrochemical instrument packaged in a small case. It is designed to for battery-testing via electrochemical impedance spectroscopy up to eight cells.

The EIS Box excels at electrochemical impedance testing of small- to medium-sized single-cell energy-storage and power-conversion devices. Such devices include batteries, electrical double-layer capacitors, fuel cells, and photovoltaic cells. The EIS Box can apply and measure currents from 5 A to $\sim 0.05 \mu\text{A}$.

Features of the EIS Box include:

- Six-decade current auto-ranging for large and small batteries,
- Electrical isolation from earth ground, and
- Both analog and digital filtering.

A sine-wave generator on the EIS Box allows the instrument to make *accurate* impedance measurements at frequencies up to 100 kHz. EIS performance is good for low-impedance systems (such as low-ESR electrical double-layer capacitors).

A unique DSP (Digital Signal Processing) data-acquisition mode allows the EIS Box to reject noise, from the instrument itself, from the electrochemical cell, and from the lab environment. In many cases where other instruments require a cell in a Faraday shield to make quiet measurements, the EIS Box can be used with the cell exposed on a bench top.

The EIS Box, like all of our instruments, requires a computer for its use. The EIS Box connects to this computer through an Ethernet or USB connection (see photograph below of rear panel).



The EIS Box was developed to increase the throughput of your impedance testing program. Under the control of an external computer, the EIS Box connects one cell at a time, which makes an electrochemical measurement on that cell.

The EIS Box has been integrated into all Gamry Instruments' electrochemical impedance spectroscopy applications that run under the Gamry Framework. It allows many of the EIS measurement applications to increase their throughput by testing multiple cells in a single test run.

The Gamry Instruments Electrochemical Toolkit allows you to control the EIS Box using a library of software routines. You can find examples of such routines after you install the Electrochemical Toolkit software.

Software and Applications

The EIS Box supports Gamry Instruments' electrochemical impedance spectroscopy software under the Framework system.

Typical applications for the EIS Box include:

- Research in electrochemical storage and conversion, and
- Battery and electrochemical capacitor evaluation.

Notational Conventions

In order to make this manual more readable we have adopted some notational conventions. These are used throughout this manual and all other Gamry Instruments manuals:

- Numbered lists. A numbered list is reserved for step-by-step procedures, with the steps always performed sequentially.
- Bulleted list. The items in a bulleted list, such as this one, are grouped together because they represent similar items. The order of items in the list is not critical.
- File names and folders. References to computer files and Windows® folders are shown in Courier font, for example: `C:\MYGAMRYDATA\CV.DTA` and `GAMRY.INI`.

Chapter 3: General Operation

The EIS Box was developed to increase the throughput of your electrochemical impedance testing program. It allows one instrument to drive up to eight electrochemical cells. Under the control of an external computer, the EIS Box connects one cell at a time to the instrument, which makes an electrochemical measurement on that cell.

The EIS Box was specially designed for the needs of electrochemists. Extra features such as sense line and shield-switching—designed specifically for electrochemists—from other general-purpose switching devices.

The EIS Box is integrated into all Gamry Instruments' electrochemical impedance spectroscopy applications that run under the Gamry Instruments Framework software. It allows many of the applications to increase their throughput by testing multiple cells in a single test run.

This chapter of the EIS Box Operator's Manual provides an overview of the operation of the EIS Box. It discusses the following topics:

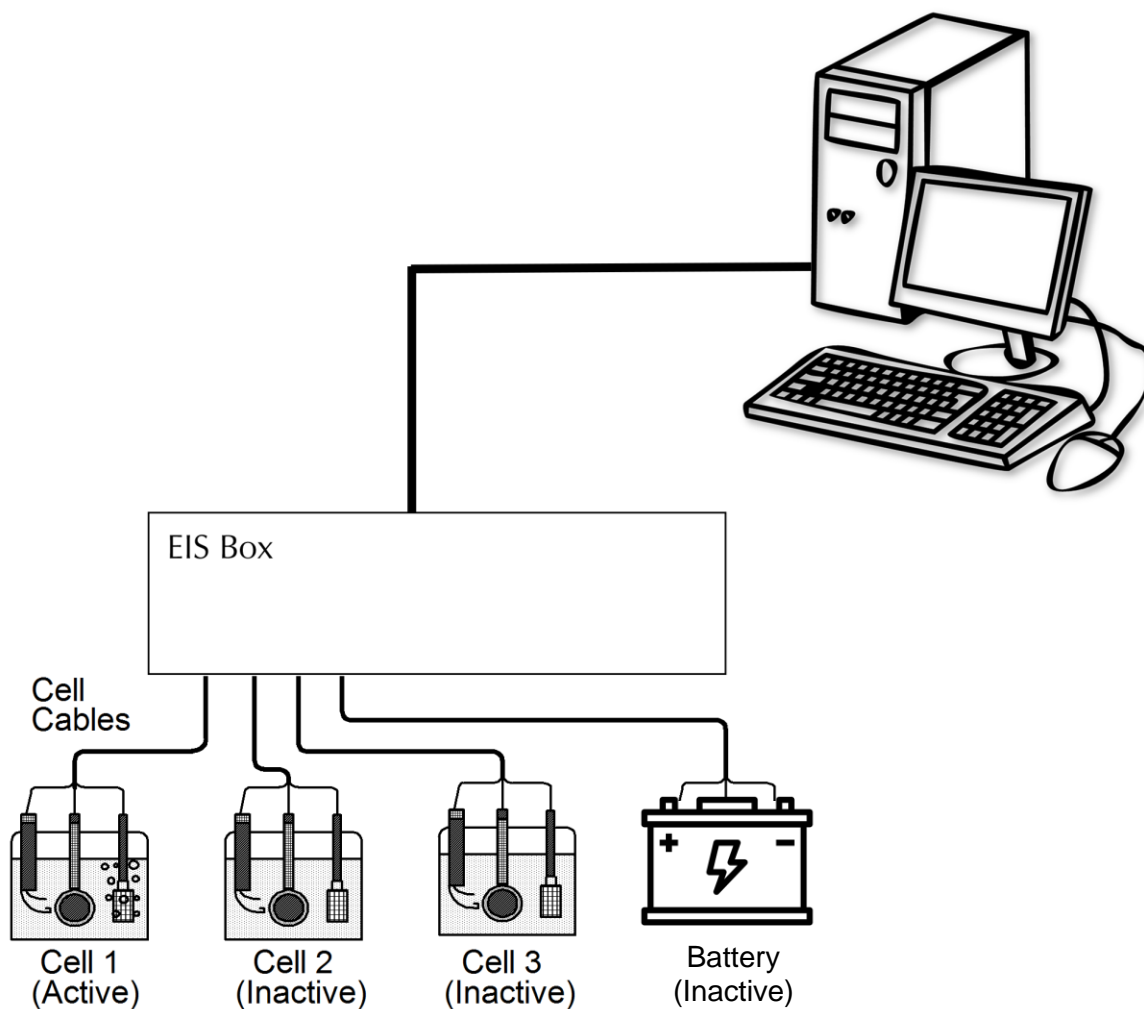
- Operation overview
- Switching and inactive cell control
- Communications overview

The material in this chapter is only an overview. If you are using your EIS Box with Gamry Instruments software this overview should give you sufficient understanding to make intelligent use of your EIS Box.

Operation Overview

Figure 3-1 shows a “typical” electrochemical test system built around an EIS Box instrument. Only four cells are shown in this figure, although up to eight cells can be connected.

Figure 3-1
A Typical Electrochemical Test System Using the EIS Box



The **system computer** is a critical component of the system. It controls the EIS Box by sending it simple commands through an ethernet or USB connection.

The most important function of these commands is to select which cell is **active** (connected to the EIS Box). You can think of an EIS Box as a complex switch with driving electronics. One of the eight cell cables on the EIS Box is switched so that it connects to the instrument's cell cable. All of the wires (including sense leads and shields) in the cell cable are switched.



Switching from channel to channel involves electromechanical relays. You will hear a click each time relays activate during the switching process.

The **system computer** also controls the **instrument**. When a cell is connected to the **instrument** cell leads, the computer causes a test to be run on that cell. The test can be as simple as a single current or potential measurement or as complex as a cyclic scan. The computer software and **instrument** are responsible for taking the measurement and storing it.

The EIS Box **instrument** in Figure 3-1 is shown as a “black box”. The relays in the EIS Box can carry currents up to 5 A.

In a typical EIS Box experiment, the **system computer** cycles through the cells. Each cell is connected in turn to the **instrument** and used to collect a measurement. Usually the computer delays at the end of each cycle through the cells so that the measurements on each cell are separated by a fixed time period.

Keyword Definitions

Active Cell

The active cell is the cell (if any) currently connected to the system potentiostat. Any electrochemical measurements are made on the active cell.

Cell

The term cell is used to describe either an electrochemical cell or the switches needed to connect an electrochemical cell to the instrument.

Channel

An EIS Box contains eight channels. A channel includes cell-switching relays. The term cell is used when only the cell-switching portion of a channel is being discussed.

Inactive Cell

The term inactive cell is any cell not currently connected to the instrument.

Instrument

This is the instrument responsible for making electrochemical measurements on the cells used in the experiment. The instrument is typically an EIS Box.

System Computer

The computer responsible for coordinating operation of an EIS Box-based electrochemical test system, not to be confused with the very simple micro-controller buried within the EIS Box.

Switching and Inactive Cell Control

In the Operation Overview, we said you can think of the EIS Box as a complex switch with controller. Each of the eight EIS Box channels is made up of an independent set of switches and control circuits. All the switches are under control of the system computer. The system computer must insure that only one cell at a time is connected to the instrument, therefore a main switch controls which cell is active.

Communications Overview

The system computer communicates with the EIS Box via an ethernet connection or a USB cable.

Chapter 4: Installation

This chapter of the Gamry Instruments Inc. EIS Box Operator's Manual covers normal installation of the EIS Box. We assume the EIS Box is installed as part of a Gamry Instruments' Framework-based electrochemical measurement system containing a Microsoft Windows®-compatible computer.

Figure 4-1
Front View of the EIS Box



Initial Visual Inspection

After you remove your EIS Box from its shipping carton, check it for any signs of shipping damage. If you observe any damage, please notify Gamry Instruments, Inc. and the shipping carrier immediately. Save the shipping container for possible inspection by the carrier.



Warning: The “reinforced insulation” that keeps the operator from accessing the “hazardous live” voltages in the EIS Box can be rendered ineffective if the EIS Box is damaged in shipment. Do not operate damaged apparatus until a qualified service technician has verified its safety. Tag a damaged EIS Box to indicate that it could be a safety hazard.

If the EIS Box is taken from a cold location (for example outdoors in winter conditions) to a warm, humid location, water vapor may condense on the cold surfaces inside the EIS Box, possibly creating a hazardous condition. Before connecting power to a “cold” EIS Box, allow at least one hour for the EIS Box to warm at room temperature.

Physical Location

Normally users place their EIS Box on a flat workbench surface. Keep easy access to the rear of the instrument because some cable connections are made from the rear. The EIS Box is generally operated in a “flat” position (see Figure 4-1). Operation in other orientations is possible as long as you insure that air movement through the chassis is not restricted.



Caution: Do not block the airflow into or out of the EIS Box chassis. The EIS Box will enter a power-down state if it becomes overheated. If this occurs during data-acquisition, you may lose experimental data.

If you place your EIS Box within an enclosed space, make sure that the internal temperature within that space does not exceed 45°C, the maximum ambient temperature for the EIS Box. Be particularly careful if a computer or other heat-dissipating equipment is mounted in the same enclosure as the EIS Box.

The EIS Box is not designed for outdoor use.

Computer Requirements

Before you connect an EIS Box to a computer, you must make sure that your computer meets these requirements:

- A computer based on one of the x86 or x64 families of Intel microprocessors, or a 100%-compatible processor from another vendor,
- Microsoft® Windows 7 or higher is required. Both 32-bit and 64-bit versions of these operating systems are supported. See the Gamry website “www.gamry.com” if you have a newer edition of Windows®.
- An ethernet port or a USB port.

Quick-Start Guide for System Installation

Your shipment should have included a document entitled **Quick-Start Installation Guide**. It contains the latest instructions for installing Gamry Instruments’ hardware and software onto a computer system. If this document is missing, you can find it on www.gamry.com. The Quick-start Guide found at www.gamry.com contains the latest information concerning system installation, so the information provided below is always subject to change.

Software Installation

The EIS Box is compatible with the Windows® Plug & Play configuration system. Like most Plug & Play hardware, it is best if you install the software for the EIS Box **before** you install the instrument hardware.

Gamry Instruments’ software can be installed from a physical medium such as a DVD or a pre-programmed software flash drive, or it can be installed via an Internet download. The most up-to-date download can be found on www.gamry.com.

If you install from a physical medium, Gamry Software Setup program will normally start automatically when you place the Gamry Instruments’ installation medium into your computer.

An Internet download of Gamry Instruments’ software will download a self-extracting .EXE file. Running this file will extract the software and begin the same installation process as you get with a physical medium.

If you have inserted the Gamry DVD or flash drive into your computer and the Gamry Setup program does not start automatically:

- 1) Navigate to the root folder of the device containing the Gamry Software (DVD or Flash Drive) or to a Windows® folder containing the Gamry Software.
- 2) Run the program called `AUTORUN.EXE` found in this folder.

If you do not know how to navigate to the Gamry Installation device, consult your local computer expert or network administrator, or email techsupport@gamry.com.

AUTORUN.EXE runs a set-up program. In most cases, you can choose the default choices or the most obvious choices on all screens shown during the set-up process.

Reboot Your Computer after Software Installation

Reboot your computer when the Gamry Setup program is done. The Setup program normally offers you the opportunity to do so. Following Setup, you may not be able to use your EIS Box until the drivers are loaded.



Device driver installation may not occur until a while after the Windows Desktop appears. On a slow computer, or a busy computer with lots of active applications, the delay before driver installation can be a minute or more.

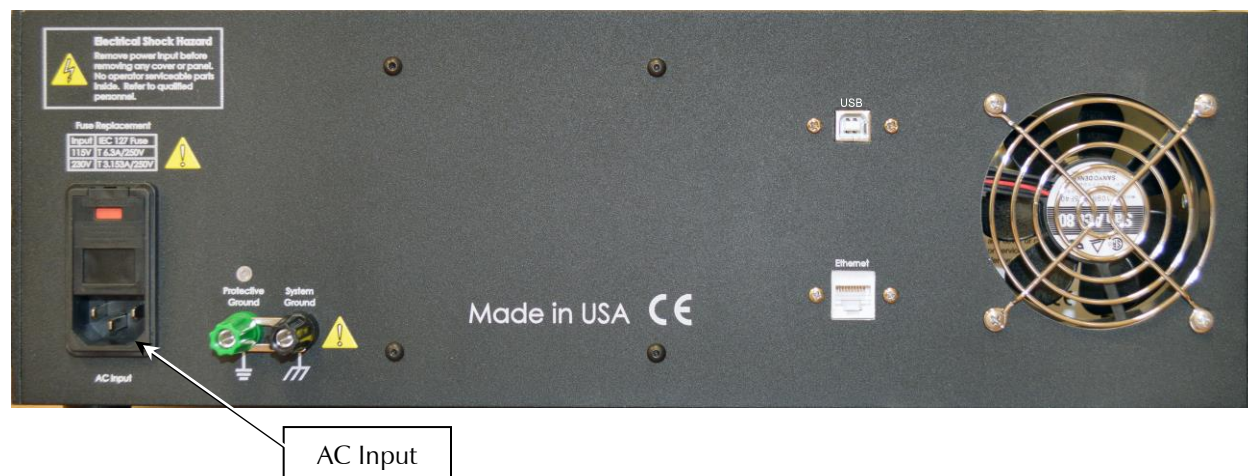
Power Cord and Power Connection

The mains are connected to the AC Input jack on the rear of the EIS Box (Fig. 4-2).

The power supply provided inside the EIS Box is rated for operation from 100 to 240 V AC, at frequencies from 47 to 63 Hz. It should therefore be useable worldwide.

The EIS Box is normally supplied with a line cord suitable for use in the United States. In other countries, you may have to replace the line cord with one suitable for your type of mains (electrical outlet). You must always use a line cord with a CEE 22 Standard V (IEC 320 C13) female connector on the end of the cable leading to the unit. This is the same connector used on the US standard line cord supplied with your EIS Box.

Figure 4-2
Rear Panel of the EIS Box



Power-up Test

Before you make any other connections to your EIS Box, check that the EIS Box is at least nominally functional.



After connecting AC power to the EIS Box, toggle the **Power** switch on the front panel of the EIS Box.

Watch the **Power** LED as the EIS Box powers up. It glows a steady blue. If you do not see a continuous blue color, contact technical support.

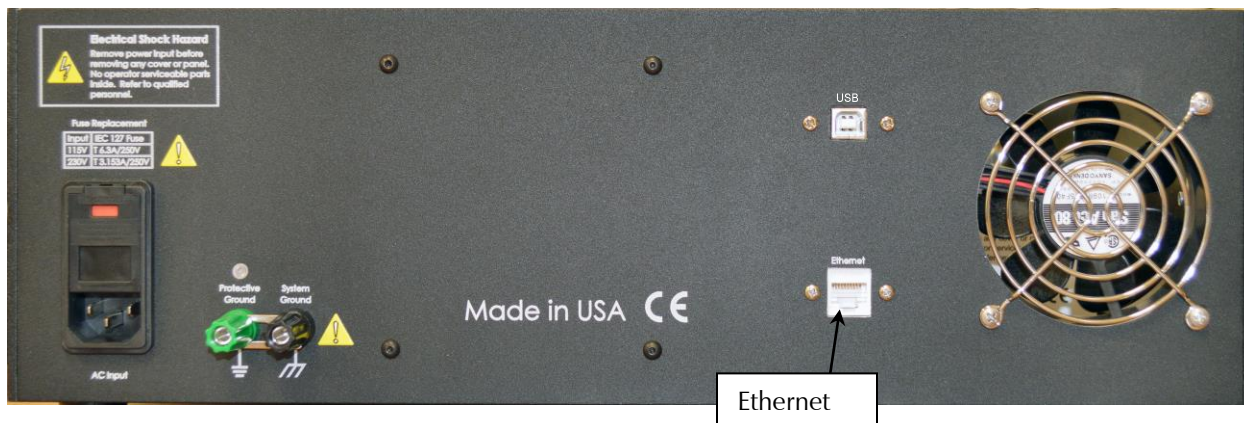
The status of the other LED indicators is not important at this time.



Caution: If the **Power** LED goes on, then turns off and stays off, the EIS Box is not working properly! If this power-up test fails, contact Gamry Instruments or your local Gamry Instruments representative as soon as possible.

Ethernet Cables

The EIS Box connects to the computer using a shielded CAT5E Ethernet cable (see figure below).



The **Ethernet** connection should not be “hot-plugged”. This means both the computer and the EIS Box must be powered OFF before the ethernet cable is plugged in.

Operation via USB



The EIS Box can be run via USB. To connect the EIS Box to a USB port on a computer:

1. Be sure that the EIS Box is powered off and unplugged from the AC source (mains).
2. Unscrew the screws holding the top panel onto the chassis. Remove the top panel of the EIS Box chassis.



Warning: Never remove the top panel of the EIS Box while the instrument is powered on. The electrical currents inside the EIS Box can cause severe injury.

3. Unplug the USB connection cable from the **USB** Type B (approximately square) port on the aluminum assembly inside the EIS Box.
4. Uncoil the USB cable affixed to the inside of the rear panel, and connect it to the now-free **USB** Type B port on the aluminum assembly.
5. Reattach the top panel on top of the EIS Box chassis.
6. Connect your computer to the external USB Type B port on the rear panel of the EIS Box (see image above), using a USB cable.

Cell Cable Installation

The Cell Cables connect pairwise to two 15-pin D-type connectors located on the front of the EIS Box (see Figure 4-1) for each channel. There are two cables per channel: one that carries the cell current, called the Current Carrying Cable which mates with the **Current Connector**, and one that senses the cell voltage, called the Sense Cable, which mates with the **Sense Connector**.

The standard Cell Cable is 3 m long. The D-connector ends of the cables are connected to the appropriate ports on the front of the EIS Box. Always use the knurled screws on this cable to hold the cables in place.



The current-carrying cable contains fuses that protect the instrument against excessive cell current. See Chapter 6 for more information concerning these fuses.

Running the Framework

Many newer electrochemical applications do not run as an application within Gamry Instruments' Framework software. This is true of all applications that use Gamry's Toolkit for instrument control. Gamry's Framework software is the main application software for performing routine analysis associated for electrochemical measurements. There are other software programs such as Resonator that are stand-alone programs. Programs that you develop using our toolkits will fall into the stand-alone software category.

The Framework Instrument Manager is useful in organizing the instruments in the system. The Framework also has a Calibration program that is used to calibrate instruments connected to the system.

Framework Device Status Bar

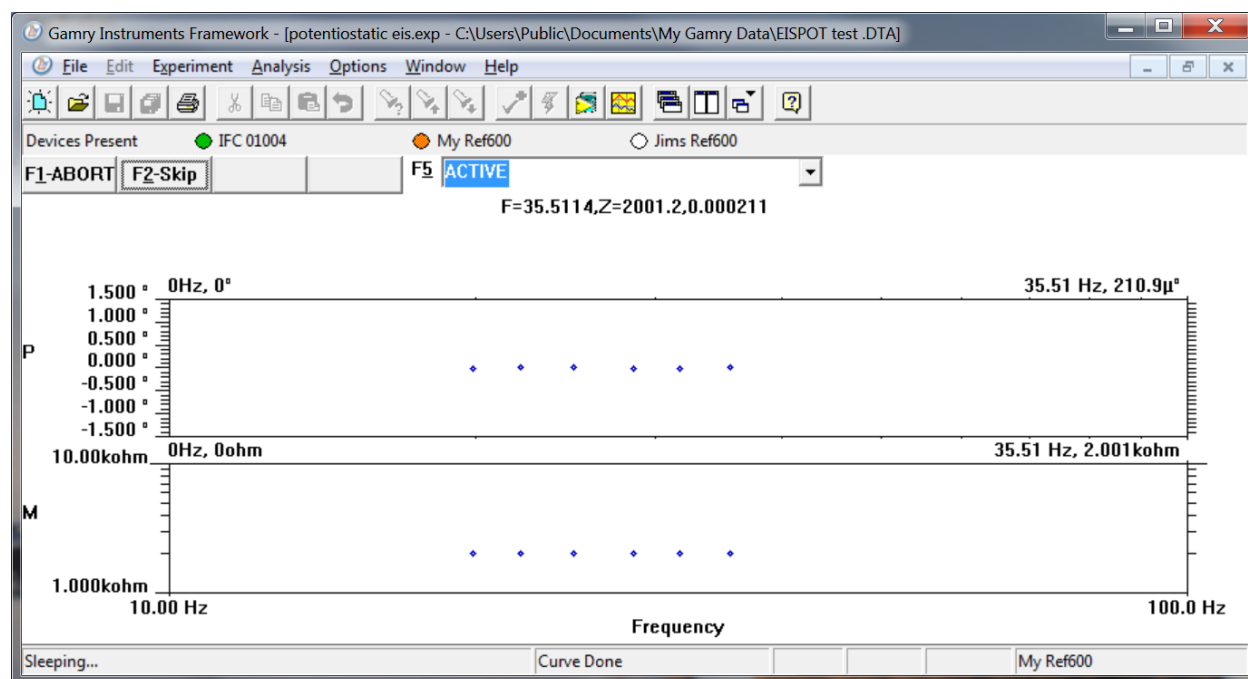
By default, the Gamry Framework shows a Device Status Bar under its main menu (see Figure 4-3). If you do not see the Device Status Bar when you run the Gamry Framework, it has been disabled in the Framework **Options** menu.

Instruments that are connected to the computer appear on this bar. The round indicator associated with each device shows its status:

Green	The device is available to run experiments
Orange	The device is currently running an experiment
White	The device is connected to the system, but is not usable. This is generally the result of a mismatch between the Framework software and the device's firmware. You can use the Gamry Instrument Manager to fix the mismatch.

The screen capture below shows a Framework screen with three USB instruments connected.

Figure 4-3
Framework with Three Potentiostats and One Running Test



The Interface 1000 (IFC 01004) in this system is shown with a green indicator because it is installed and ready to run. The Reference 600 labeled My Ref600 has an orange indicator because it is recording the EIS spectrum shown on the screen. The Reference 600 labeled Jims Ref600 has a white indicator, showing it is plugged in but cannot be used. This is an indication of a version mismatch between Gamry Instruments Framework software and the instrument's firmware.

Firmware Update

Your EIS Box was shipped with the latest version of all its firmware. From time to time, Gamry Instruments makes changes to the instrument's firmware code and a firmware update is required to make use of the new or improved code.

There are three separate firmware images that can be updated in the field on your EIS Box. The first is the Instrument Firmware. This is the program that handles most of the functions of the EIS Box. The second is the Communications Firmware. This program handles the communications between your EIS Box and the host computer. The third is the PLD firmware, which you should only change if a Gamry Instruments representative instructs you to.

Initiate the Firmware Update process using the Framework **Options, Instrument Manager...** command.

Appropriate update files can be obtained from the Gamry Instruments website at www.gamry.com. If you encounter a problem updating the firmware in your EIS Box, please contact Gamry Instruments for assistance.



Caution: Interrupting a firmware update can cause a catastrophic failure of your system. **Do not turn off the EIS Box, do not unplug the communications cable, and do not stop the operation of the host computer when the USB LED is a continuous red color.**

Do not interrupt a firmware update that is in progress. An incomplete update can render an EIS Box inoperable until it is returned to Gamry for reprogramming.

Should the firmware update be interrupted, contact Gamry before starting the return process.

Chapter 5: Calibration

Introduction

DC calibration for the EIS Box instrument is sometimes necessary.

Run calibration through the Framework™ software, or directly through Gamry Instrument Manager (GIM). Gamry recommends calibrating the instrument at least once per year, or when the quality of your data is in question. To initiate calibration, take the following steps:

Click the **Calibrate in Framework** button, located in the Calibration area of GIM. This launches the appropriate calibration routine for the instrument selected in GIM. Follow the instructions given in Framework. See the relevant Calibration Quick Start Guide for additional details.

If there are any failures during calibration, click the **Email Results to Gamry Support** button in GIM. One of our support engineers will review the results and provide appropriate advice.

You run the Instrument Manager by selecting **Options/Instrument Manager...** on the Framework Menu.

Calibrate each potentiostat installed in your system. A calibration utility is provided with the Gamry Framework.

The calibration for the EIS Box is divided into two sections: Instrument DC Calibration and cable calibration. Gain access to these calibration procedures via the **Utility** selection on the Framework's **Experiment** drop-down menu.

Calibrate each potentiostat installed in your system. A calibration utility is provided with the Gamry Framework. Get access to the calibration procedure via the **Utility** selection on the Framework's **Experiment** drop-down menu.

DC Calibration

This procedure uses an external resistive dummy cell called the 200 Ω Calibration Cell.



Caution: The standard EIS Box calibration calls for an external resistive dummy cell. Your EIS Box was shipped with a 200 Ω Calibration Cell, which includes a 200 Ω , 0.05% accurate resistor. After calibration, please place this dummy cell in a safe place where you can find it if your unit requires recalibration.

If you do need to recalibrate and you cannot find your calibration cell, you can perform DC Calibration using a different 200 Ω resistor. Its power-rating is unimportant. Some performance checks in the calibration process may fail if the resistor's inaccuracy exceeds 0.2% (4 Ω).

Calibration

Potentiostat calibration is only required infrequently. Recalibrate your EIS Box under the following circumstances:

- It is at least one year since your last calibration.
- Your instrument has been serviced.
- You notice breaks or discontinuities in the data curves recorded with your system.
- The system is being run in an environment that is very different from the previous operating environment. For example, if the EIS Box was calibrated at 15°C and you are now operating it at 30°C, you should recalibrate.

Connect the Calibration Cell to the appropriately colored banana plugs on the Cell Cable.

Chapter 6: Cell Connections

Cell Cable Overview

The EIS Box has eight channels. Each channel has two Cell Connectors on the front of the EIS Box. The Current Connections are female 15-pin D-connectors, and the Sense Connections are male 15-pin D-connectors.

Figure 6-1
Front Panel of the EIS Box



The upper (female) connectors are labeled **Current Connector**. They carry the cell current between the Counter electrode wires and the Working electrode wires.

The lower (male) connectors are labeled **Sense Connector**. They contain only high-impedance inputs used to sense potentials in the cells.

Gamry's EIS Box standard cell cables always come in pairs. Each cable has a D-connector on one end, and a number of leads to connect to electrodes in an electrochemical cell. The D-connector end of the cable is connected to the appropriate D-Connector on the front of the EIS Box. The male and female cables cannot be interchanged.

Every EIS Box is shipped with eight pairs of standard shielded cell cables. The Gamry part number for the Current Cable is 985-00183, and the Sense Cable is 985-00184. They are both 3 m complex cables, with D-connectors on one end, and color-coded banana plugs on the other end.

Always screw both cell cables into place because cables can fall off the unit if not properly attached. This can be disastrous if detachment occurs during an experiment.

Ancillary Apparatus

Do not use the EIS Box with ancillary apparatus connected directly to any of the cell leads. Examples of ancillary apparatus include DVMs, oscilloscopes, chart-recorders, and data-loggers. Ammeters and voltmeters, regardless of their specifications, almost always create problems when connected to the EIS Box cell leads.

Normal Cell Connections

This section assumes that you are using standard, shielded cell cables. This information does not depend on the length of such cables.

The cell end of the standard cell cables terminates in a number of banana plugs and pin jacks. Each termination comes with a removable alligator clip. Table 6-1 identifies the terminals of the cables.

Table 6-1
Cell Cable Terminations

Color	Type	Name	Normal Connection
Blue	Banana Plug	Working Sense	Connect to working electrode
Green	Banana Plug	Working Electrode	Connect to working electrode
White	Banana Plug	Reference	Connect to counter electrode
Red	Banana Plug	Counter Electrode	Connect to counter electrode

Connect both the blue and green cell leads to the positive terminal (usually). The working electrode is the electrode being tested. The blue plug connection senses the voltage of the working electrode. The green working electrode connection carries the cell current. The working electrode may be as much as 520 mV above the circuitry ground (floating ground).

Connect the white plug to the negative terminal (usually). The measured cell potential is the potential difference between the blue and white cell connectors.

Connect the red banana plug to the negative terminal also. The counter-electrode terminal is the output of the EIS Box's power amplifier.

If your cell is a typical glass laboratory cell, all of the electrodes are isolated from earth ground. In this case, you may be able to reduce noise in your data by connecting the EIS Box's Floating Ground to an earth ground.



Warning: Make sure that your earth-ground connection is made to a legitimate source of earth ground. Consult a qualified electrician if you are uncertain how to obtain an earth ground. Connecting the EIS Box to an incorrect and unsafe voltage can create a safety hazard (see Chapter 1 for details).



Caution: If any electrode in your cell is at earth ground, **never** connect the EIS Box Protective Ground to System (floating) Ground. Autoclaves, stress apparatus, and field measurements may involve earth-grounded electrodes. water pipe can be a suitable earth ground.

Membrane Cell Connections

The EIS Box can be used with membrane cells. In this type of cell, a membrane separates two electrolyte solutions. Two reference electrodes are used: one in each electrolyte. Each electrolyte also contains a counter electrode. The EIS Box controls the potential across the membrane. Table 6-2 shows the cell connections used with a membrane type cell.

Table 6-2
Cell Cable Connections for a Membrane Cell

Color	Type	Name	Normal Connection
Blue	Banana Plug	Working Sense	Connect to reference electrode #1
Green	Banana Plug	Working Electrode	Connect to counter electrode #1
White	Banana Plug	Reference	Connect to reference electrode #2
Red	Banana Plug	Counter Electrode	Connect to counter electrode #2



Reference electrode #1 and counter electrode #1 must be on one side of the membrane, and reference electrode #2 and counter electrode #2 must be on the other side.

Fuses in the Cell Cable

The EIS Box can be damaged if currents much larger than 6 A flow into or out of the Counter electrode or Working electrode leads. Improper connection to a battery, fuel cell, or supercapacitor can cause this type of damaging current to flow.

All standard EIS Box Counter/Working cell cables include fuses in the current-carrying leads. These fuses protect the instrument from the extremely large currents that can flow through an improperly connected electrochemical-energy generation or storage device (including batteries, fuel cells, and capacitors). For convenience, the term “battery” is used here to refer to all single-cell or stacked electrochemical devices that can distribute energy.

Grounding errors on a battery can be particularly dangerous, for they can result in the battery being shorted through the instrument.



Warning: The fuses in the EIS Box Counter/Working cell cable do not protect against a safety hazard. They are needed to prevent damage to the instrument if it is improperly connected.

Both the counter electrode lead and the working electrode lead have fuses, rated to carry 6.3 A.



Always turn off the EIS Box and disconnect both ends of the Counter/Working cable before checking or replacing the fuses in the cable.

Access to the fuses requires removal of two screws on opposite sides of the hood covering the D-connector end of the Counter/Working cable. A drawing of the D-connector end of a cable with the hood opened is given in Figure 6-3. The small rectangular fuses snap into fuse-holders labeled **Work** and **Cntr**. To remove the fuse,

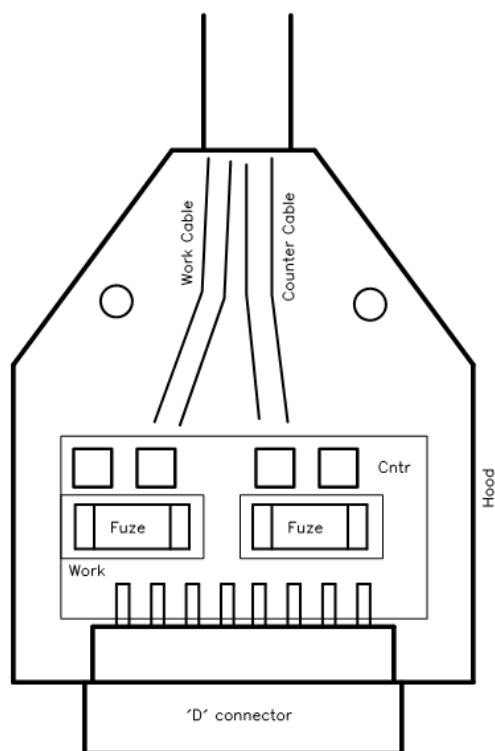
either grip it with small pliers and gently lift the fuse out of the fuse-holder, or pry the fuse out of the fuse-holder using a small screwdriver or knife blade.

After a fuse has been removed, check it using an ohmmeter, such as that found on modern digital voltmeters. Do not trust a visual inspection of the fuse. A blown (open) fuse always should have a resistance of greater than 100 Ω . The resistance of a good fuse is very small.



Don't forget the jackscrews when you reassemble the hood.

Figure 6-3
Drawing of Fuse-holder in the D-Connector Hood



Four replacement fuses should accompany every Counter/Working cell cable shipped by Gamry Instruments. The Gamry Part Number for the small rectangular fuses is 630-00030. If you need to find replacement fuses locally, we currently only recommend Very Fast Acting, 6.3 A, Nano Fuses from the Littelfuse corporation (Littelfuse part number 045106.3MRL). Fuses with similar ratings from other manufacturers have not been tested, so we cannot recommend their use.



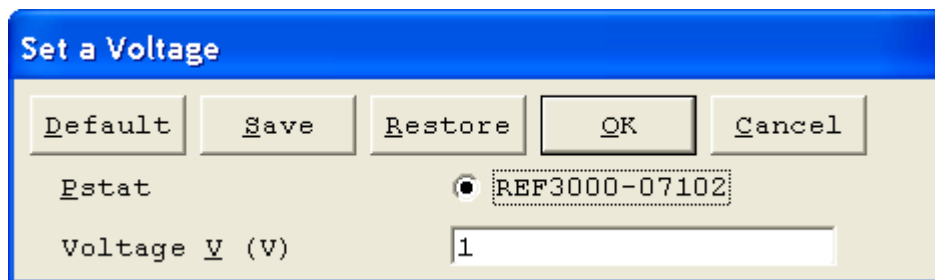
Caution: Always replace the fuses in an EIS Box cable with the recommended fuse. Use of an improper fuse, especially a fuse with a higher current rating, can cause instrument failure if a battery cell is improperly connected. Use of a non-approved fuse voids Gamry Instruments' factory warranty.

Testing for Open Fuses

A Gamry Instruments Framework test checks for blown fuses without having you remove the fuses. A simple Potentiostatic test is run on the Calibration Cell. Run the test using the `SET A VOLTAGE.EXP` script in the Framework's **Utilities** package.

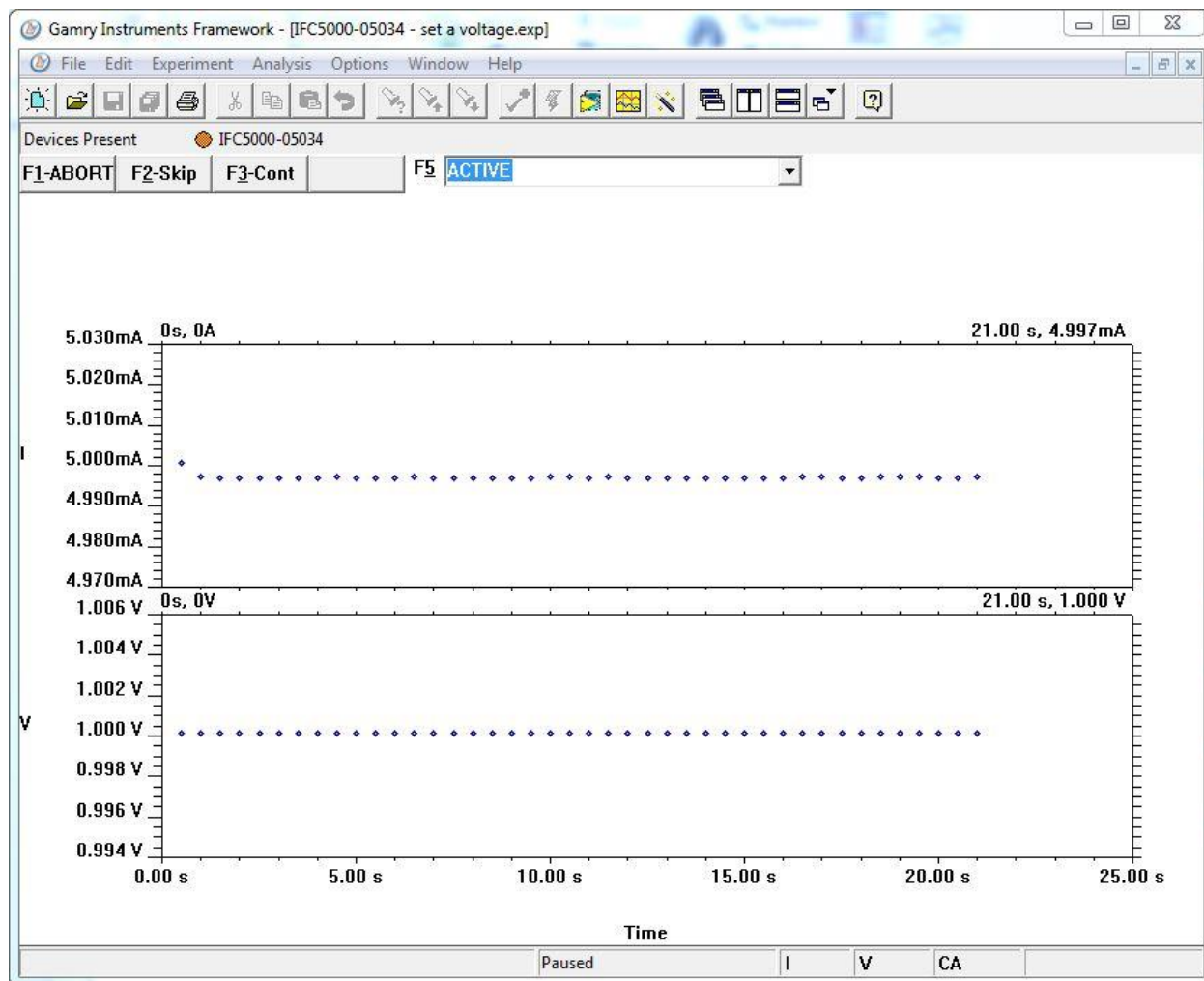
Connect the cell leads to the Calibration Cell. You do not need to place the Calibration Cell within a Faraday cage. Select the command **Experiment > Utilities > Set a Voltage** on the Framework software's menu bar. You see a **Set a Voltage** dialog box similar to this:

Figure 6-4
Setup Dialog Box for the Set a Voltage Script



In the **Voltage** field, enter a **Voltage** of 1 V as shown above, then click the **OK** button. The Framework opens a runner window, and a graph of current versus time should appear:

Figure 6-5
Typical Runner Window with Good Fuses



We expect you to see one of two very different results:

- If the instrument is working properly and the fuses in the cable are good, the measured current is ~ 5 mA as seen above. No overloads are seen.
- If the one or both fuses are open, all the current readings are near zero, and a red CA Overload indication may be seen at the bottom of the runner window.

If this test indicates an open fuse, use the procedures described above to check **both** fuses. This test cannot tell which fuse is blown. Both fuses can blow simultaneously.

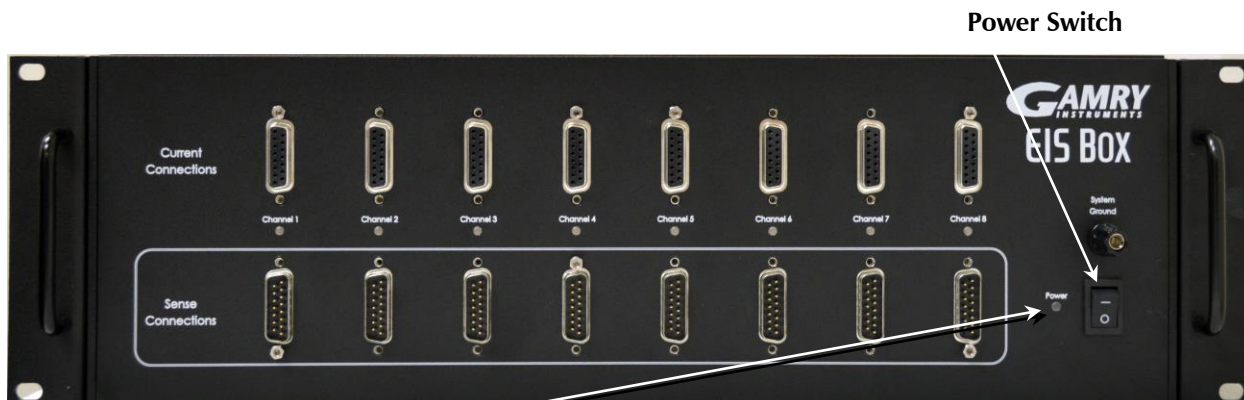
If the fuse test indicates an open fuse, and the fuses both check out a good with an ohmmeter, some other problem has occurred in the cables or the instrument. Contact Technical Support at Gamry Instruments as soon as possible.

Chapter 7: Panel Indicators and Connectors

Front Panel

Power Switch

The **Power** switch is on the far right side of the EIS Box Front Panel. Normally the blue **Power** LED illuminates when the EIS Box is powered on; see the **Power** LED description below.



The Power LED

The **Power** LED is on the lower right of the EIS Box front panel. It normally glows a continuous blue when the EIS Box is turned on and has passed some simple power-on tests.

When the **Power** LED is off, these are possible causes:

- The **Power** switch is off.
- There is no AC (mains) supply connected to the rear panel **Power In** connector.
- One of the internal DC power supplies has failed.

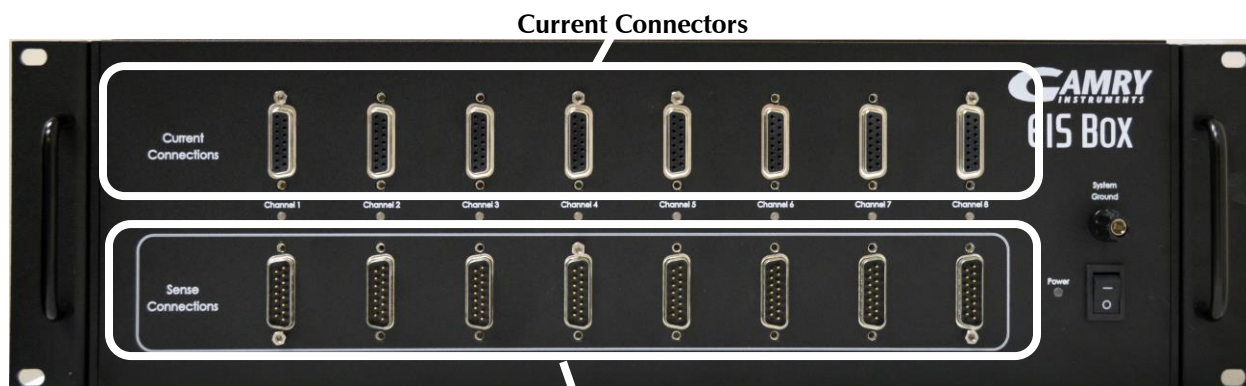


Caution: The **Power** LED indicates power status, and that power-up tests have passed. Never rely on the **Power** LED as a true power-status indicator. Always unplug the **Power In** connection if you suspect your EIS Box is malfunctioning.

Cell Connectors

The EIS Box has two sets of eight cell cable connectors, for a total of 16 connectors on the front panel. Each connector is a 15-pin D-type connector. Each pair of D-type connectors is a channel, for connection to a cell or battery.

The upper (female) connectors are labeled **Current Connector**. They carry the cell current between the Counter electrode wire and the Working electrode wires.

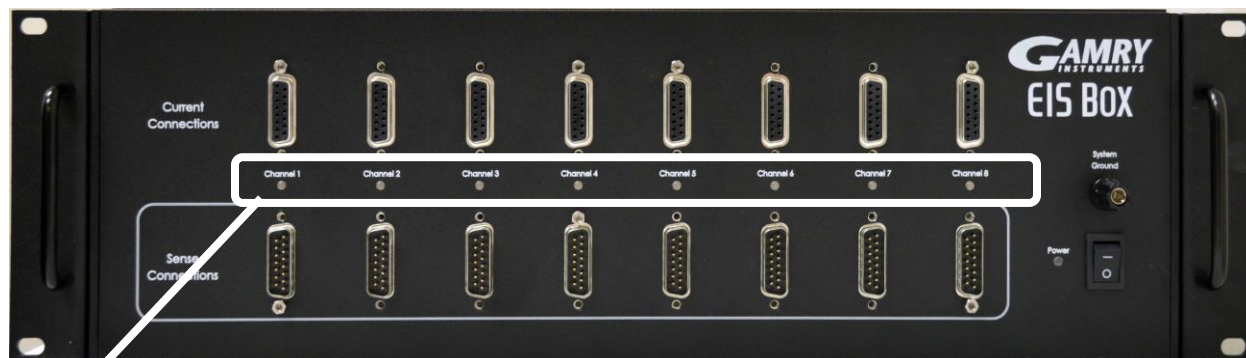


Sense Connectors

The lower (male) connectors are labeled **Sense Connector**. They contain only high-impedance inputs used to sense potentials in the cell.

In addition to the pins used for cell connections, each EIS Box Cell Connector also uses four pins to read a cell cable ID. Gamry software can compensate for the cell-cable characteristics to attain optimal system performance in EIS (Electrochemical Impedance Spectroscopy).

The cell connections are discussed in Chapter 3. A pin-out description of the cell cable connector is found in Appendix B.



Channel LED

A **Channel LED** is between each pair of Cell connectors.

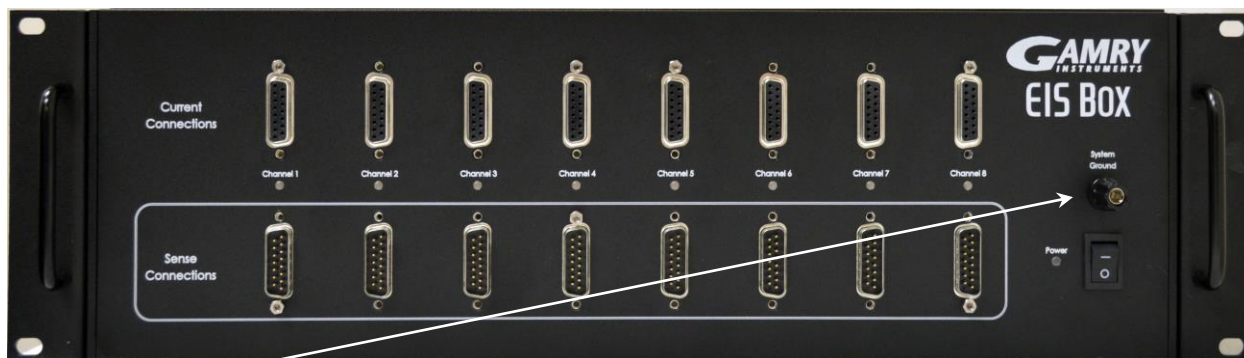
The **Channel** LEDs glow amber whenever the EIS Box is actively applying voltage or current to the electrochemical cell attached to that channel. Avoid touching the cell cable leads whenever the **Channel** LED is lit, because the quality of the data being collected in your experiment may be compromised.



The **Channel** LED does not indicate a dangerous condition when it is lighted. The voltages generated by the EIS Box are generally considered safe. Still, avoid touching the cell leads when the cell is on.

If you need to make changes to your cell leads, do so after powering down the EIS Box.

In a typical experimental sequence, the **Channel** LED is off between experiments and during any open-circuit potential measurements. It glows amber whenever that channel's cell is polarized.



System Ground binding post

The front-panel System Ground black banana jack is intended for one use only. When the EIS Box is used with cells isolated from earth ground, connecting the System Ground to earth ground may lower the noise measured in the system. Note that the chassis of the EIS Box is isolated from the **System** (floating) **Ground**. Safety information concerning this is in Chapter 1.

A banana plug is the only way you can connect to the Chassis Ground jack. Use a wire to connect the banana plug to earth ground.

A black banana-plug-to-banana-plug lead is provided with your EIS Box. You may find it useful when making this earth-ground connection.

Rear Panel



AC Input

The **AC Input** receptacle accepts a three-terminal AC line cord. You must always use a line cord with a CEE 22 Standard V female connector on the instrument end of the cable. The EIS Box derives all its power from your local AC (mains). The input current is less than 2.1 A.

The **AC Input** jack is rated for operation from 100 to 240 V AC, at frequencies from 47 to 63 Hz. It should therefore be useable worldwide.



System Ground

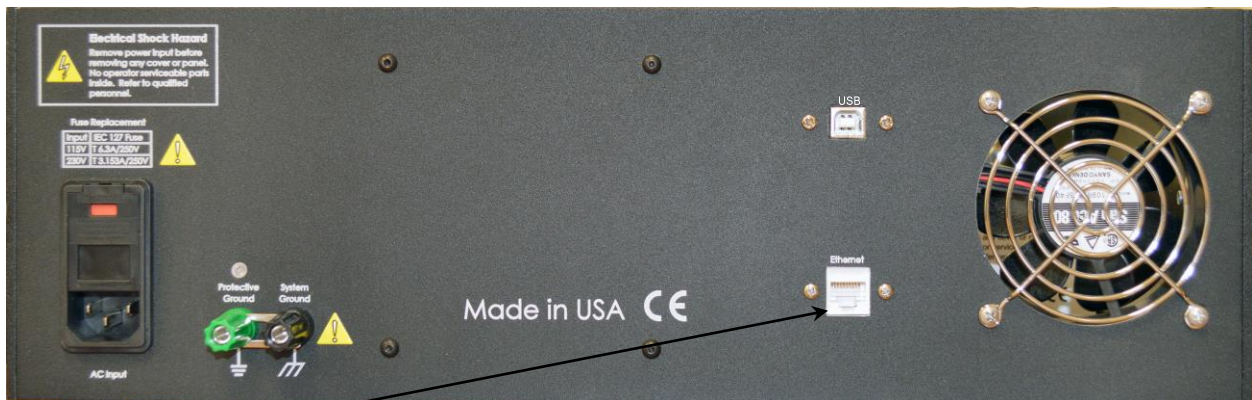
The rear-panel **System Ground** black banana jack is intended for one use only. When the EIS Box is used with cells isolated from earth ground, connecting the **System Ground** to earth ground may lower the noise measured in the system. Note that the chassis of the EIS Box is connected to the **Protective** (earth) **Ground**. Safety information concerning this is in Chapter 1.

Use a metal link to connect the **Protective Ground** to the **System Ground** as shown above.

Protective Ground

The green **Protective Ground** binding post is a convenient access point to the protective (earth) ground in the EIS Box. It is connected to the third wire in the AC power cord and to the EIS Box's metal chassis. This binding post can be connected to an additional earth ground to form a redundant protective ground.

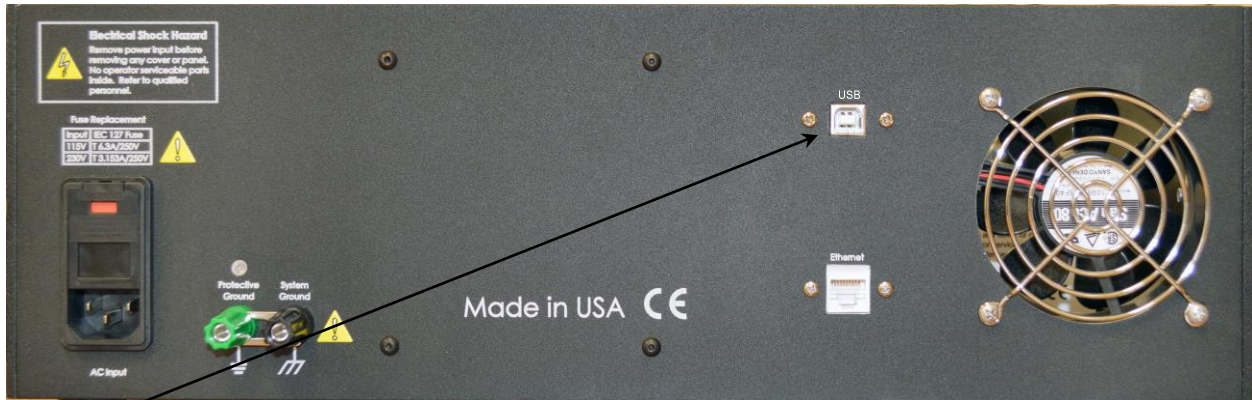
A black banana-plug-to-banana-plug lead is provided with your EIS Box. You may find it useful when making the earth-ground connection (if a redundant protective ground is required).



Ethernet

The Ethernet port on the rear panel of the EIS Box is a receptacle for an RJ-45 ethernet cable. Use a standard ethernet cable with RJ-45 connector to connect this port to a computer's ethernet.

A suitable ethernet cable was included with your EIS Box. If this cable is lost, you can replace it with a cable from your local computer retailer.



USB

The USB port on the rear panel of the EIS Box is a Type B receptacle for a USB cable. Use a standard USB cable with a Type B USB (nearly square) connector to connect this port to a computer's USB port.

AC Power-line Fuses

This section gives step-by-step instructions for changing the AC power-line fuses in your EIS Box. Please follow these instructions carefully. You need a small flat-blade screwdriver to perform this procedure.



1. Unplug the AC power line cord from the back of the EIS Box. The fuses cannot be changed with the AC line cord plugged into the EIS Box.
2. Find the AC input module on the left side of the EIS Box's rear panel. It can be identified by the line-cord connector built into it.
3. Find the small slot on the right side of the AC input module near the line-voltage setting window. Place the blade of a small screwdriver in this slot and pry open the AC input module.
4. The fuses are contained inside two fuse holders. The tops of the fuse holders are black plastic with a white arrow on them.

Use the screwdriver to gently pry up the plastic portion of the fuse holders. After the fuse holders are up about 1 cm you should be able to grab them with your fingers and pull them completely out of the AC input module.

5. Remove the old fuses by prying them out of the fuse holders. Replace them with the correct fuses, which simply pop into the fuse holders. The fuse orientation in the fuse holder is unimportant.

Replace the fuse(s) **only** with the correct value and type of fuse. See Table 1-3 and the text preceding it for fuse values and type descriptions.

6. Replace the fuse holders (with the correct fuses) in the AC input module. The arrows on the fuse holders must point towards the bottom of the EIS Box.
7. Close the cover of the AC input module. It should snap into place.
8. Make sure you have not inadvertently changed the AC line-voltage setting, which is displayed in a small window on the AC input module. If the voltage shown is not the appropriate setting for the line voltage in your area, change it before powering up your EIS Box.



Caution: The AC line fuses are important components for safe operation of the EIS Box. Do not replace the fuses with incorrect values or types, or in any way circumvent the fuse action. If your EIS Box routinely blows the AC line fuses it indicates a serious problem with the EIS Box. Contact Gamry Instruments, Inc. for repair information.

Appendix A: EIS Box Specifications

All specifications are at an ambient temperature of 22°C, with the EIS Box powered using the external power supply shipped with the unit, a standard shielded 3 m cell cables, and the cell enclosed in a Faraday shield. All specifications obtain after software calibration.

A numbered note qualifies many of the specifications. Many of these notes describe the method used to measure a specification. The notes are found at the end of this appendix.

All specifications are subject to change without notice.

Control Amplifier

Compliance Voltage	Min	±6.5	V	Note 1
Output Current	Min	±5	A	Note 2
Unity Gain Bandwidth	Typ	1050, 250, 43, 4.4, 0.5	kHz	Note 3
Slew Rate	Typ	10, 4.4, 0.7, 0.07, 0.007	V/ μ s	Note 4

Differential Electrometer

Max Input Voltage	Max	±6.0	V	Note 4
Input Current	Max	25	pA	Note 6
Input Resistance Differential (between inputs) Common Mode (input to ground)	Typ	10 1	T Ω	Note 7
Input Capacitance Differential (between inputs) Common Mode (input to ground)	Typ	8 12	pF	Note 7
Bandwidth (–3 dB)	Min	12	MHz	Note 8
CMRR DC to 10 kHz 10 kHz to 100 kHz	Min	98 88	dB	Note 9

Voltage Measurement

A/D Full Scale Ranges	Typ	±6.5536	V	Notes 5, 10
Resolution (before gains)	Typ	200	μ V/bit	
Zero Offset Error	Max	0.5	mV	Note 11
Gain Error	Max	0.2	%	Note 11
Offset Range	Typ	±6.5536	V	Note 12
Post-offset Gain	Typ	1 \times , 10 \times , 100 \times		

Current to Voltage Converter

Maximum Full-scale Range		± 5	A	Note 13
Minimum Full-scale Range		± 50 ± 500 (after $100\times$ gain)	μA nA	Note 13
Voltage across R_m	Typ	± 100	mV at full scale	Note 14
Output Voltage (at Monitor and ADC in)	Typ	± 3.0	V full scale	
Input Offset Current	Max	25	pA	Note 15
Range Zero Offset	Max	0.05	% of range	Note 15
Gain Tolerance, 5 A to 50 μA ranges	Max	0.2	% of reading	Note 15
Zero drift	Typ	0.02	% FS/ $^{\circ}\text{C}$	Note 16
Bandwidth (-3 dB)	Typ	5	MHz	Note 17

Current Measurement

Resolution	Typ	0.00333...	% FS/bit	
Offset Range	Typ	± 100	% of range	
Post-offset Gain	Typ	$1\times$, $10\times$, $100\times$		
Accuracy	Typ	Dominated by current-to-voltage error (see above)		

Environmental

Operating Temperature Range		0 to $+45$	$^{\circ}\text{C}$	
Relative Humidity	Max	90 (non-condensing)	%	
Storage and Shipping Temperature		-25 to $+75$	$^{\circ}\text{C}$	
Maximum Shipping Acceleration		30	g	

General

DC Power Input Voltage	Range	100–240	V	
Fuses		IEC 127 For 115 VAC, use 6.3 A 250 V For 230 VAC, use 3.153 A 250 V		
Power	Max	120	W	
Leakage Current (floating, earthed working electrode)	Typ	± 10	nA	Note 22
Dimensions		41.5 W \times 45.7 D \times 13.3 H	cm	
Mounting		Fits 19" (48.3 cm) standard rack mount 3 U height		
Weight	Max	10	kg	

Channel Characteristics

Mode	Active	
Channel switching time	<10 ms	
Cell current	5 A	Maximum carried
Counter electrode voltage	± 6.5 V maximum	Measured versus EIS Box chassis ground.

Channel Isolation

Current leakage	<2 nA maximum	To active channel pin from any source.
Impedance	>500 M Ω <20 pF	Equiv. impedance to EIS Box chassis ground.

NOTES:

1. Measured in galvanostatic mode with a high-power 2.4 Ω load resistor connected from the counter to the working electrode leads. The compliance voltage is measured using an external voltmeter across the 2.4 Ω load. Under these conditions, the output current is approximately 2.72 A.
2. Measured with a high-power 1 Ω load resistor connected between the counter and working electrode leads, in potentiostatic mode.
3. Unity gain bandwidth and slew rate are correlated. Each has five settings, with the highest slew rate occurring at the highest bandwidth, down to the lowest slew rate occurring at lowest bandwidth. Both are measured with 2 k Ω between counter and reference, and 20 Ω between the reference and the working and working sense leads.
4. Cell resistor 90 Ω connected between the counter and working electrode leads, in potentiostatic mode.
5. The A/D and signal-processing chain in the EIS Box allows measurement of voltage signals as large as ± 6.5536 V. The voltage on the Work Sense lead can be as high as ± 0.51 V when measuring 5A using a 60 cm cell cable. This implies a maximum voltage input on the differential electrometer of ± 6.04 V.
6. This specification is tested using a 2 G Ω resistor switched into the input and measuring the voltage difference with and without the input resistance.
7. The differential impedance is measured between the Reference and Work Sense inputs. This is the impedance you measure when you record the EIS spectrum of an infinite impedance (open lead) cell. There is also a common-mode resistance and capacitance associated with the differential electrometer inputs. These values tell you how much the electrometer response is modified by a resistance in series with the source.
8. The bandwidth is for a sine-wave source with a 50 Ω output impedance driving either input. The bandwidth is well in excess of this specification, which is limited by the measurement equipment used in routine testing of the EIS Box.
9. CMRR is common-mode rejection ratio. It specifies the ability of the differential electrometer to reject signals connected to both inputs. The CMRR is measured driving both inputs with a sine-wave source with a 50 Ω output impedance, and measuring the error as a function of frequency. Resistance in either input will cause a loss of CMRR.
10. Voltage measurement is performed with a nominal ± 6 V signal input to the ADC signal chain. The actual full scale is 6.5536 V.
11. The total error in a voltage measurement is:

$$\text{Error} = \text{Zero Offset Error} + \text{Gain Error} \times \text{Voltage}$$

For a 1 V signal the theoretical error can be as high as 2.5 mV. This error is typically less than 0.2 mV.

12. Offsets are summed into the signal. Offset inaccuracy is approximately $\pm 0.05\%$ of the setting plus ± 0.5 mV.
13. There are six hardware current ranges, separated in sensitivity by decades. The ranges are 50 μ A, 500 μ A, 5 mA, 50 mA, 500 mA and 5 A full scale. The $\times 10$ and $\times 100$ gains add two virtual ranges of 5 μ A and 500 nA full scale.

14. The voltage across the current measurement resistor, R_m , is as shown. On ranges below 5 mA, the working electrode voltage is similar to the voltage across R_m . At 5 A and 1 MHz, the working electrode voltage can be as high as 0.51 V, because the cable has both resistive and inductive impedance.
15. The total error in a current measurement is:

$$\text{Error} = \text{Input Current Offset} + \text{Range Zero Offset} \times \text{FS Current} + \text{Gain Tolerance} \times \text{Measured Current}$$

The first term can generally be ignored on the EIS Box. The units for the error are amperes.

16. Drift can be approximated by simple drift in the Range Zero Error. In reality all three terms in the equation above can have drift.
17. The Current to Voltage converter bandwidth is a function of the current range, the cell cable, and the IEstability setting. Longer cell cables add capacitance and slow the current measurement. The specified I/E Converter BW is measured at 5 mA I/E Range.
18. The total error in a voltage setting is:

$$\text{Error} = \text{DC Zero Offset} + \text{Gain} \times \text{Voltage Setting}$$

For a 1 V signal the theoretical error can be as high as 2.5 mV. In practice the error is generally less than 1 mV.

19. This specification is guaranteed by design. It is not tested.
20. This specification is measured by applying zero voltage across a 1 Ω resistor and measuring current noise on the 500 μA scale. 1 μV of voltage noise creates a current of 1 μA . The filters in the ADC Chain for the I Signal are used to limit the bandwidths as shown in the specifications. Signal averaging via Gamry DSP mode further reduces the measured noise.
21. Excluding external power adapter and any cables supplied with unit.
22. Isolation quality has both DC and AC factors, predominantly at the power-supply frequency of 300 kHz. Only the DC leakage current is shown here. Measured under the following conditions: cell is a 10 k Ω resistor, PSTAT mode, CA speed is normal, I/E stability is slow, I/E range is 50 μA , I-channel filter is 5 Hz, and I-channel gain is 100.

Appendix B: EIS Box Cell Connectors

Chapter 4 describes the connections between a cell cable and an electrochemical cell. This appendix describes the other end of the cell cable.

Multiple pins assigned to the same signal are connected together on the EIS Box's Potentiostat board. If you must connect this using a special cell cable, you need a wire connected to **any one** of the D-connector pins.

Table B-1
Current Connector

Pin(s)	Signal Name	Use
1,9	Working	Connected to the working electrode (see Chapter 4).
2, 10	Working Shield	The shield for the working electrode. Connected to Floating Ground on D-end of the cable. Left open at the cell end of the cell cable.
3	Ground	
4, 11	Ground	The potentiostat's floating ground. Can be used to shield the cell if very low currents need to be measured. Also used as a shield for the counter electrode cable.
5,12	Counter	Connected to the counter electrode
6	No connection	
7	CBL_ID1	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
8	CBL_ID2	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
13	Counter shield	
14	CBL_ID0	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
15	CBL_ID3	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.

Table B-2
Sense Connector

Pin(s)	Signal Name	Use
1	CBL_ID2	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
2	CBL_ID1	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
3	Ground	The potentiostat's floating ground. Can be used to shield the cell if very low currents need to be measured. Also used as a shield for the counter electrode cable.
4	No connection	
5,6,12,14	Reference Shield	The shield for the reference electrode input. Driven to the same potential as Pin 13. Left open at the cell end of the cell cable.
7,15	Work Sense Shield	The shield for the work sense electrode input. Driven to the same potential as Pin 8. Left open at the end of the cell cable.
8	Work Sense	Connected to the working electrode in most cases (see Chapter 5). This lead has a 261 Ω resistor in the cell end of the cable. Custom cell cables are likely to require a similar resistor.
9	CBL_ID3	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
10	CBL_ID0	One of four cable ID bits. Used to identify the type of cell cable attached to the unit. Pull to a logic High through a resistor. Ground to set the bit low.
11	No connection	
13	Reference Electrode	Connected to the reference electrode in most cases (see Chapter 4). This lead has a 261 Ω resistor in the cell end of the cable. Custom cell cables are likely to require a similar resistor.

Appendix C: CE Certificate

Certificate of Conformance

**CERTIFICATE OF CONFORMANCE
EUROPEAN COMMUNITY
COUNCIL DIRECTIVE 2014/30/EU**

Date of Issue: October, 2018

Issued By: Retlif Testing Laboratories
3131 Detwiler Road
Harleysville, PA 19438

Issued To: Gamry Instruments
734 Louis Drive
Warminster, PA 18974

Reference: Retlif Report Number R-2944P-1

Retlif Testing Laboratories hereby acknowledges that compliance testing in accordance with the below listed standards was performed on a representative sample of the equipment listed below. Retlif Testing Laboratories further acknowledges that the test sample listed below was found to be in compliance with these standards.
This certificate is hereby issued to the above named grantee and is valid only for the equipment identified below.

Manufacturer: Gamry Instruments
734 Louis Drive
Warminster, PA 18974

Equipment Tested: EIS Box

Model Number: EIS Box 5000

Serial Number: 04501

Product Type: Measurement, Control Equipment and Laboratory Use

Note(s):

- 1) See attached report R-2944P-1 for details and/or conditions pertaining to this certificate.
- 2) Conforms to the emissions requirements of EN 61326-1:2013; Clause 7.2:
CISPR 11 Edition 5.0: 2009, A1: 2010 Conducted Emissions, Group 1, Class B
CISPR 11 Edition 5.0: 2009, A1: 2010 Radiated Emissions, Group 1, Class B
IEC 61000-3-2: 2005, A1: 2008, A2: 2009 Harmonics
IEC 61000-3-3: 2008 Flicker
- 3) Conforms to the immunity requirements of EN 61326-1:2013; Table 1:
IEC 61000-4-2: 2008 Electrostatic Discharge
IEC 61000-4-3: 2006, A1: 2007, A2: 2010 Radiated Immunity
IEC 61000-4-4: 2004, A1: 2010 EFT/Burst, Power Ports and I/O Ports
IEC 61000-4-5: 2005 Surge Immunity, Power Ports
IEC 61000-4-6: 2008 Conducted Immunity, Power Ports and I/O Ports
IEC 61000-4-8: 2009 Power Frequency Magnetic Fields
IEC 61000-4-11: 2004 Voltage Dips and Interrupts

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