



**EIS Box™ 5000**

## **Operator's Manual**





## If You Have Problems

Please visit our service and support page at [www.gamry.com/service-support/](http://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	<a href="http://www.gamry.com/service-support/">www.gamry.com/service-support/</a>
Telephone	(215) 682-9330 9:00 AM–5:00 PM US Eastern Standard Time (877) 367-4267 Toll-free US & 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 5000, 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 5000 instrument. Reasonable support includes telephone assistance covering the normal installation, use, and simple customization of a computerized system containing an EIS Box 5000 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 5000 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. warrants to the original user of this product that it shall be free of defects resulting from faulty manufacture of the product or its components for a period of two years from the original shipment date of your purchase.

Gamry Instruments, Inc. makes no warranties regarding either the satisfactory performance of the EIS Box 5000 instrument including the software provided with this product or the fitness of the product for any particular purpose. The remedy for breach of this Limited Warranty shall be limited solely to repair or replacement, as determined by Gamry Instruments, Inc., and shall not include other damages.

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## **Disclaimers**

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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 5000 instrument has been supplied in a safe condition. This chapter of the EIS Box 5000 Instrument Operator's Manual contains information and warnings that you must follow to ensure continued safe operation of the EIS Box 5000.

### Inspection

When you receive your EIS Box 5000 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 5000 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 5000 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 5000 circuitry operates at voltages low enough to be considered safe. The EIS Box 5000 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 5000's circuitry does not contain voltages higher than 15 V DC. Generally, input and output voltages in the EIS Box 5000 are limited to  $\pm 9$  V. This voltage level is considered safe.



The EIS Box 5000'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 5000 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 5000 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](mailto:techsupport@gamry.com) if you are uncertain what AC line cord to use.

### Grounding in the EIS Box 5000

#### 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 5000. It is connected to the third wire in the AC power cord and to the EIS Box 5000's metal chassis.

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

## Safety Considerations

Most electrochemical cells are isolated from earth ground, so isolation of the EIS Box 5000 from earth is not required. In these cases, connection of the EIS Box 5000 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 5000'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 5000'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 5000 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 5000 contains surge suppressors that limit the voltage difference between the EIS Box 5000's chassis ground and earth ground to about 28 V. These surge suppressors are not part of the safety mechanisms in the EIS Box 5000. 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  $\pm 28$  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 5000 instrument was designed for indoor use at ambient temperatures between 0°C and 45°C.

The EIS Box 5000 uses forced-air cooling to keep the EIS Box 5000 components within their operating temperature range. Most of the air needed to cool the EIS Box 5000 enters the chassis through holes in its bottom plate.

The fan within the EIS Box 5000 has two operating speeds with different audible noise levels. The EIS Box 5000 normally operates with the slower, quieter fan setting. The fan switches to a higher speed when the EIS Box 5000'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 5000 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 5000 without adequate cooling could also shorten the time to failure of some of the circuitry.

Be careful when operating the EIS Box 5000 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 5000 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 5000 or any other apparatus if you think it could be hazardous. Have it checked by qualified service personnel.

## Environmental Limits

There are environmental-limit conditions on the storage, shipping, and operation of this equipment. The EIS Box 5000 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 5000 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 5000 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 5000 enclosure. Alternatively, you may use isopropyl alcohol. Do not use a wet rag or allow fluid to enter the EIS Box 5000 enclosure. Do not immerse the EIS Box 5000 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 5000 instrument has no user-serviceable parts inside. Refer all service to a qualified service technician.



**Warning:** Never operate the EIS Box 5000 with any cover or panel on the chassis open. Dangerous voltages may be present at several points within the EIS Box 5000 chassis, including PC board traces. Always remove the power connection before opening the EIS Box 5000 case.

## RF Warning

The EIS Box 5000 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 5000 instrument still does generate some radio-frequency energy. The radiated levels are low enough that the EIS Box 5000 should not create an interference problem in most industrial laboratory environments.

Your EIS Box 5000 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 5000. The EIS Box 5000 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 5000 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 5000 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 5000 or its cables):

- Try placing your EIS Box 5000 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 5000):

- Try plugging your EIS Box 5000 into a different AC power branch circuit.
- Plug your EIS Box 5000 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 5000 to comply with these standards.

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

## RoHS Compliance

The EIS Box 5000 is built using lead-free components and lead-free solder. It complies with the European RoHS initiative.



## Chapter 2: Introduction

### About this Manual

This manual covers the installation, safety, and use of the Gamry Instruments EIS Box 5000 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 information such as specifications and connector pin-outs are 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.

Software support for the EIS Box 5000 is described in the Gamry Help system.

All Gamry Instruments applications running under the Gamry Framework control the EIS Box 5000 via a PSTAT object. See the Framework's Help for information concerning PSTAT objects and their functions.

### About the EIS Box 5000

The EIS Box 5000 (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 5000 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 5000 can apply and measure currents from 5 A to  $\sim 0.05 \mu\text{A}$ .

Features of the EIS Box 5000 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 5000 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 5000 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 5000 can be used with the cell exposed on a bench top.

The EIS Box 5000, like all our instruments, requires a computer for its use. The EIS Box 5000 connects to this computer through an Ethernet or USB connection (see photograph below of rear panel).



The EIS Box 5000 was developed to increase the throughput of your impedance testing program. Under the control of an external computer, the EIS Box 5000 connects one cell at a time, which makes an electrochemical measurement on that cell.

The EIS Box 5000 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 5000 using a library of software routines. You can find examples of such routines after you install the Electrochemical Toolkit software.

The EIS Box 5000 is **not** supported by Gamry's Electrochemical Signal Analyzer (ESA410™) and Virtual Front Panel (VFP600™) software.

## Software and Applications

The EIS Box 5000 supports Gamry Instruments' electrochemical impedance spectroscopy software under the Framework system.

Typical applications for the EIS Box 5000 include:

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



**Caution:** Though the EIS Box 5000 was designed for single-cell measurements of individual cells, it can measure voltages within a stack of cells. Each EIS Box channel can measure a  $\pm 5$  V cell whose maximum voltage does not exceed 28 V versus ground.

Additionally, the EIS Box 5000 cannot measure more than 28 V total in a stack. For example, if you had eight or more 4.2 V cells in a stack, the EIS Box 5000 cannot measure more than the first six in that stack.

Exceeding the voltage limit can damage your EIS Box 5000 and render it inoperable. It also voids the Warranty.

Please contact us if you need further explanation for this special application.



The EIS Box 5000 has been developed to work with Gamry Instruments' Framework™ software and the Electrochemical Toolkit. It is **not** supported by Gamry's Electrochemical Signal Analyzer (ESA410™) and Virtual Front Panel (VFP600™) software.

## 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.
- Menu commands. Menu commands are shown in Boldface, with a greater-than sign separating menu levels: i.e., **Utilities > Instrument Manager** which is the Instrument manager found on the Gamry Framework Utilities Menu.
- File names and folders. Inside paragraphs, references to computer files and Windows® folders are capitalized and placed within quotes, for example: "C:\MYGAMRYDATA\CV.DTA" and "GAMRY.INI".



## **Chapter 3: General Operation**

The EIS Box 5000 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 5000 connects one cell at a time to the instrument, which makes an electrochemical measurement on that cell.

The EIS Box 5000 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 5000 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 5000 Operator's Manual provides an overview of the operation of the EIS Box 5000. It discusses the following topics:

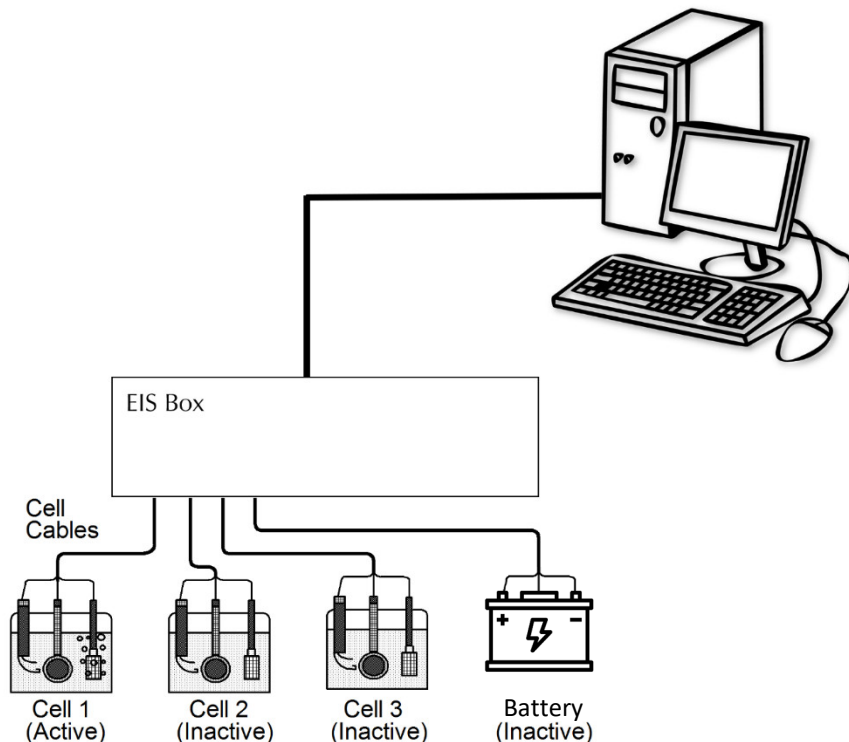
- Operation overview
- Switching and inactive cell control
- Communications overview

The material in this chapter is only an overview. If you are using your EIS Box 5000 with Gamry Instruments software this overview should give you sufficient understanding to make intelligent use of your EIS Box 5000.

## Operation Overview

Figure 3-1 shows a “typical” electrochemical test system built around an EIS Box 5000 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 5000**



The **system computer** is a critical component of the system. It controls the EIS Box 5000 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 5000). You can think of an EIS Box 5000 as a complex switch with driving electronics. One of the eight cell cables on the EIS Box 5000 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 5000 **instrument** in Figure 3-1 is shown as a “black box”. The relays in the EIS Box 5000 can carry currents up to 5 A.

In a typical EIS Box 5000 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 measured or controlled. 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 5000 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 measured or controlled.

### **Instrument**

This is the instrument responsible for making electrochemical measurements on the cells used in the experiment. The instrument is typically an EIS Box 5000.

### **System Computer**

The computer responsible for coordinating operation of an EIS Box 5000-based electrochemical test system, not to be confused with the very simple micro-controller buried within the EIS Box 5000.

## **Switching and Inactive Cell Control**

In the Operation Overview, we said you can think of the EIS Box 5000 as a complex switch with controller. Each of the eight EIS Box 5000 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**

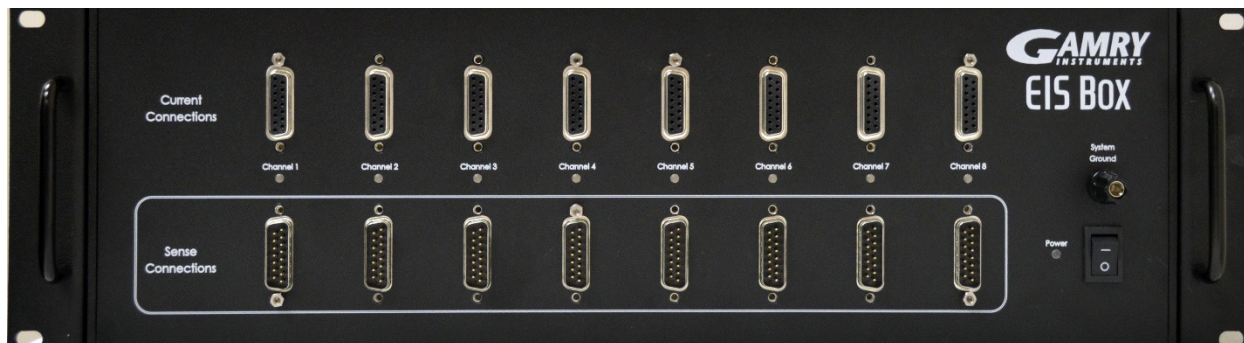
The system computer communicates with the EIS Box 5000 via an ethernet connection or a USB cable.



## Chapter 4: Installation

This chapter of the Gamry Instruments Inc. EIS Box 5000 Operator's Manual covers normal installation of the EIS Box 5000. We assume the EIS Box 5000 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 5000**



### Initial Visual Inspection


After you remove your EIS Box 5000 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 5000 can be rendered ineffective if the EIS Box 5000 is damaged in shipment. Do not operate damaged apparatus until a qualified service technician has verified its safety. Tag a damaged EIS Box 5000 to indicate that it could be a safety hazard.

If the EIS Box 5000 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 5000, possibly creating a hazardous condition. Before connecting power to a “cold” EIS Box 5000, allow at least one hour for the EIS Box 5000 to warm at room temperature.

Be sure you have the correct version of the EIS Box 5000. Compare the packing list with the chassis of the EIS Box 5000. Below are the variants:

Part #	Configuration	External appearance
992-00141	120 V with Ethernet	 (USB is capped)
992-00142	240 V with Ethernet	

Part #	Configuration	External appearance
992-00147	120 V with USB	 (Ethernet is capped)
992-00148	240 V with USB	

## Physical Location

Normally users place their EIS Box 5000 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 5000 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 5000. The EIS Box 5000 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 5000 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 5000. Be particularly careful if a computer or other heat-dissipating equipment is mounted in the same enclosure as the EIS Box 5000.

The EIS Box 5000 is not designed for outdoor use.

## Computer Requirements

Before you connect an EIS Box 5000 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 10 is required. Both 32-bit and 64-bit versions of these operating systems are supported.
- An ethernet port or a USB port. Please verify availability when ordering your system.

## Software Installation

The EIS Box 5000 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 5000 **before** you install the instrument hardware.

Gamry Instruments’ software can be installed via an Internet download. The most up-to-date download can be found on [www.gamry.com](http://www.gamry.com).

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 do not know how to navigate to the Gamry Installation device, consult your local computer expert or network administrator, or email [techsupport@gamry.com](mailto: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 5000 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 5000 (Figure 4-2).

The power supply provided inside the EIS Box 5000 is rated for operation from 100 to 240 V AC, at frequencies from 47 to 63 Hz. It should therefore be useable worldwide.

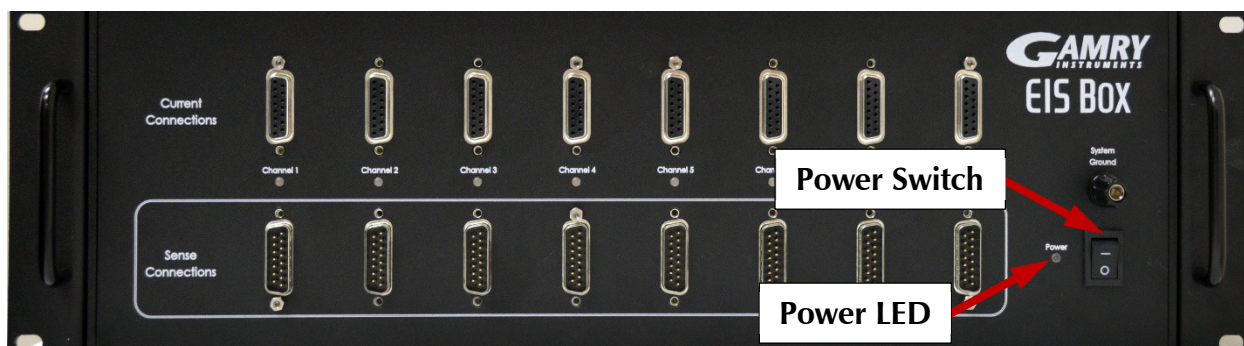
The EIS Box 5000 is normally supplied with a line cord suitable for use in the United States. In other countries, you may have to replace the line cord with one suitable for your type of mains (electrical outlet). You must always use a line cord with a CEE 22 Standard V (IEC 320 C13) female connector 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 5000.

**Figure 4-2**  
**Rear Panel of the EIS Box 5000**



## Power-up Test

Before you make any other connections to your EIS Box 5000, check that the EIS Box 5000 is at least nominally functional.



After connecting AC power to the EIS Box 5000, toggle the **Power** switch on the front panel of the EIS Box 5000.

Watch the **Power** LED as the EIS Box 5000 powers up. It glows a steady blue. If you do not see a continuous blue color, contact technical support.

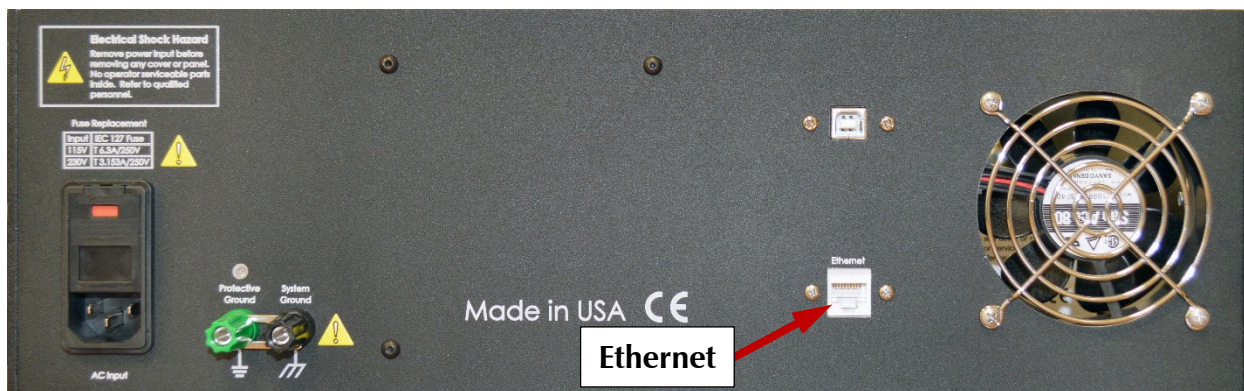
The status of the other LED indicators is not important at this time.



**Caution:** If the **Power** LED goes on, then turns off and stays off, the EIS Box 5000 is not working properly! If this power-up test fails, contact Gamry Instruments or your local Gamry Instruments representative as soon as possible.

## For the Ethernet Version of the EIS Box 5000

The EIS Box 5000 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 5000 must be powered OFF before the ethernet cable is plugged in.

## For the USB Version of the EIS Box 5000



Connect your computer to the external USB Type B port on the rear panel of the EIS Box 5000 (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 5000 (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 5000. 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 Instruments' Toolkit for instrument control. Gamry Instruments' 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

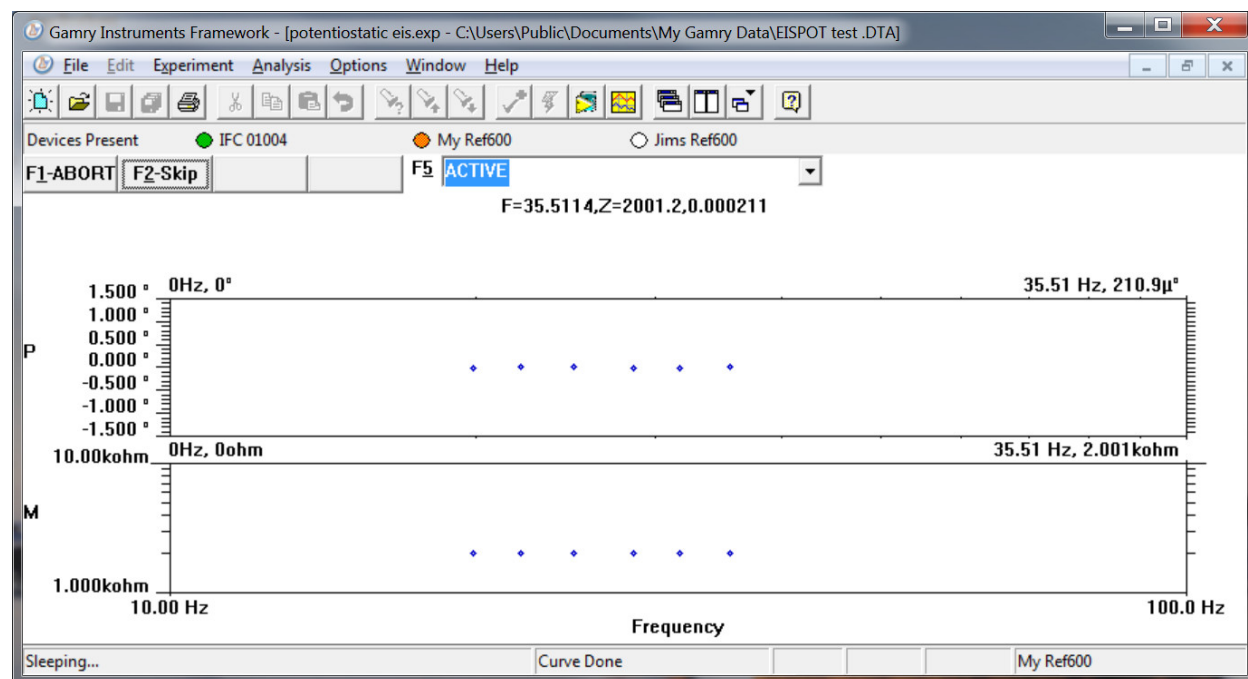
By default, the Gamry Framework shows a Device Status Bar under its main menu (see Figure 4-3). If you do not see the Device Status Bar when you run the Gamry Framework, it has been disabled in the Framework **Options** menu.

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

<b>Green</b>	The device is available to run experiments
<b>Orange</b>	The device is currently running an experiment
<b>White</b>	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 5000 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 5000. The first is the Instrument Firmware. This is the program that handles most of the functions of the EIS Box 5000. The second is the Communications Firmware. This program handles the communications between your EIS Box 5000 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](http://www.gamry.com). If you encounter a problem updating the firmware in your EIS Box 5000, 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 5000, 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 5000 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 5000 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 5000 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  $\Omega$  Calibration Cell..



**Caution:** The standard EIS Box 5000 calibration calls for an external resistive dummy cell. Your EIS Box 5000 was shipped with a 200  $\Omega$  Calibration Cell, which includes a 200  $\Omega$ , 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  $\Omega$  resistor. Its power-rating is unimportant. Some performance checks in the calibration process may fail if the resistor's inaccuracy exceeds 0.2% (4  $\Omega$ ).

Potentiostat calibration is only required infrequently. Recalibrate your EIS Box 5000 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 5000 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.

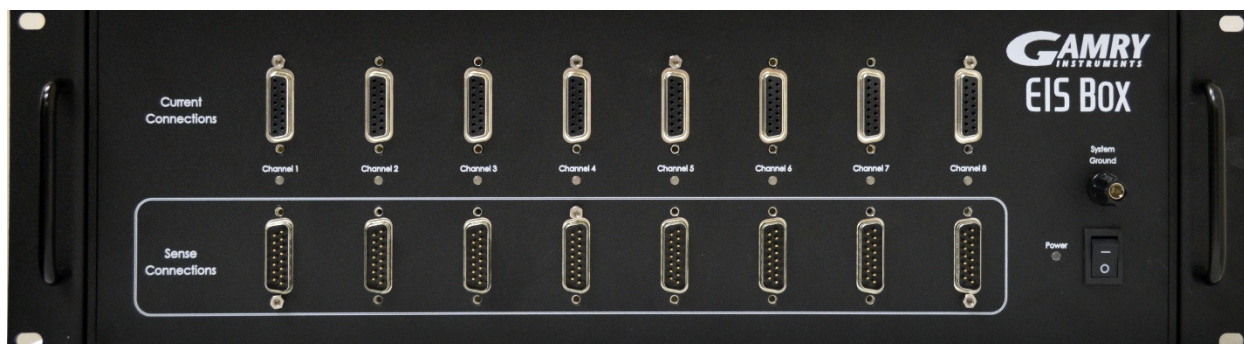


## Chapter 6: Cell Connections

### Cell Cable Overview

The EIS Box 5000 has eight channels. Each channel has two Cell Connectors on the front of the EIS Box 5000. 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 5000**



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 5000 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 5000. The male and female cables cannot be interchanged.

Every EIS Box 5000 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 5000 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 5000 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 5000'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 5000'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 5000 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 5000 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 5000 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 5000 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



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

## Fuses in the Cell Cable

The EIS Box 5000 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 5000 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 5000 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 5000 and disconnect both ends of the Counter/Working cable before checking or replacing the fuses in the cable.

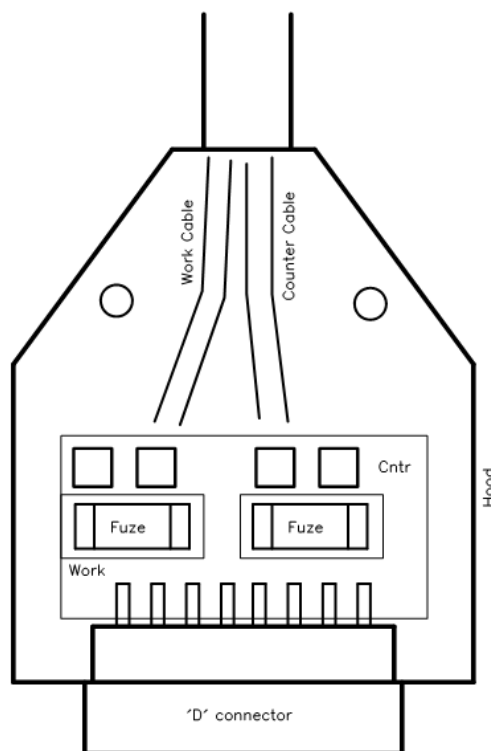
Access to the fuses requires removal of two screws on opposite sides of the hood covering the D-connector end of the Counter/Working cable. A drawing of the D-connector end of a cable with the hood opened is given in Figure 6-2. The small rectangular fuses snap into fuse-holders labeled **Work** and **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  $\Omega$ . The resistance of a good fuse is very small.



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

**Figure 6-2**  
**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 Instruments 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.



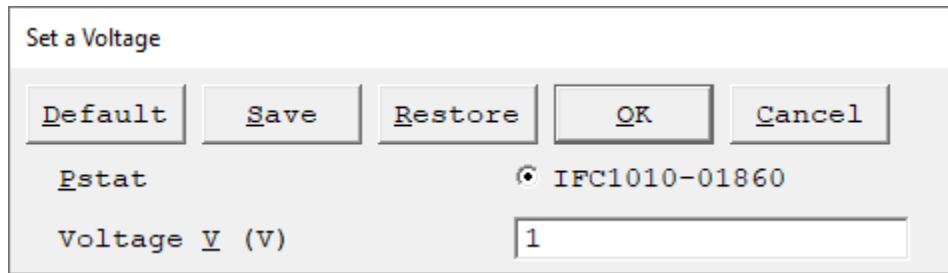
**Caution:** Always replace the fuses in an EIS Box 5000 cable with the recommended fuse. Use of an improper fuse, especially a fuse with a higher current rating, can cause instrument failure if a battery cell is improperly connected. Use of a non-approved fuse voids Gamry Instruments' factory warranty.

## 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.

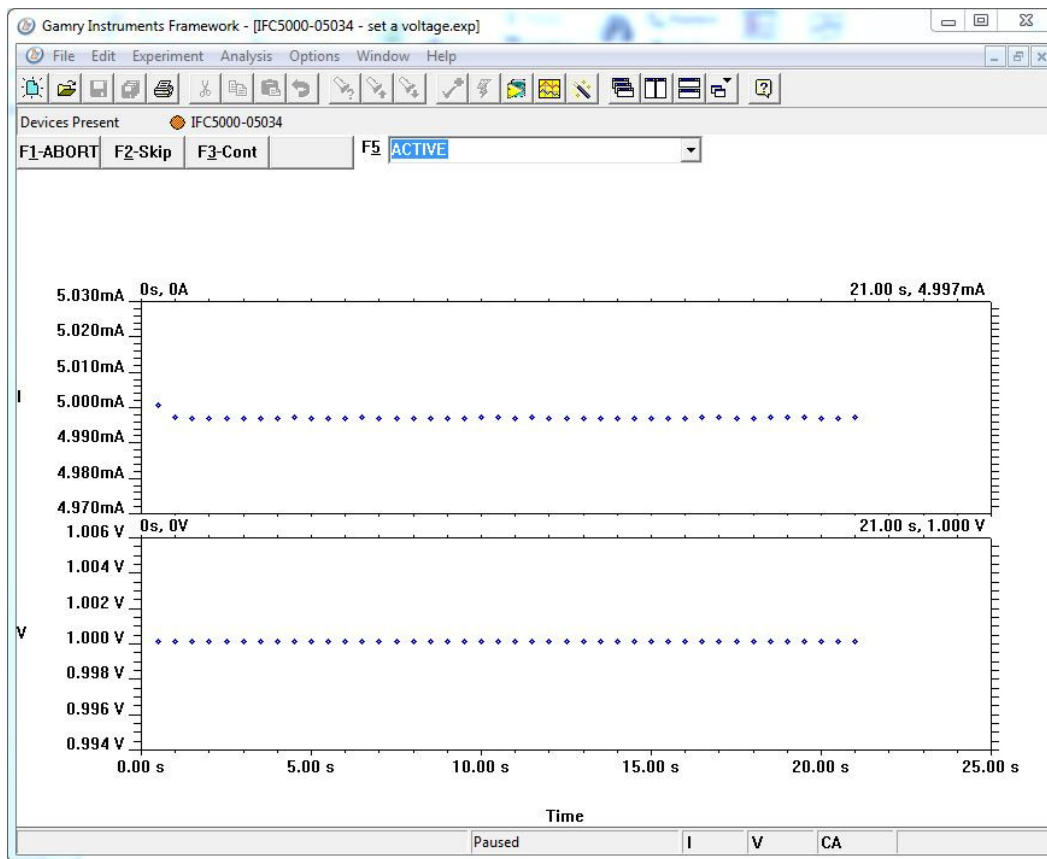
Connect the cell leads to the Calibration Cell. You do not need to place the Calibration Cell within a Faraday cage. Select the command **Experiment > Utilities > Set a Voltage** on the Framework software's menu bar. You see a **Set a Voltage** dialog box similar to this:

**Figure 6-3**  
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 6-4**  
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.

### *Cell Connections*

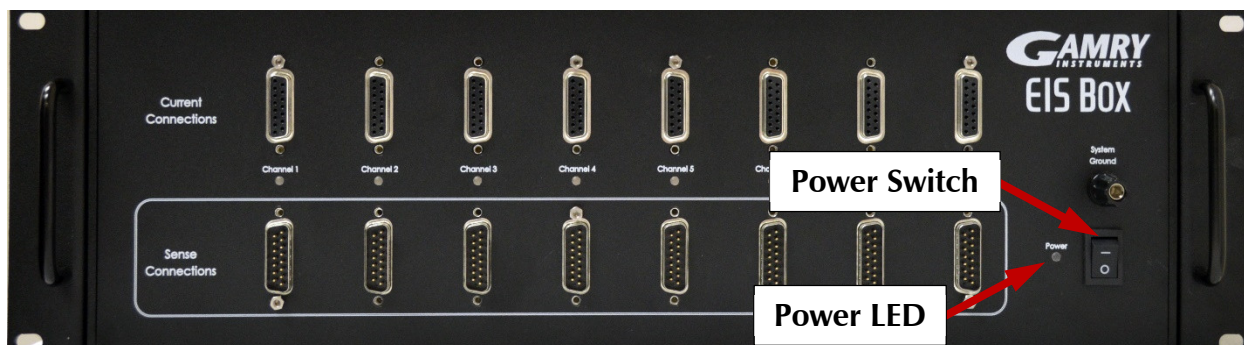
If the fuse test indicates an open fuse, and the fuses both check out a good with an ohmmeter, some other problem has occurred in the cables or the instrument. Contact Technical Support at Gamry Instruments as soon as possible.

## Chapter 7: Panel Indicators and Connectors

### Front Panel

#### Power Switch

The **Power** switch is on the far right side of the EIS Box 5000 Front Panel. Normally the blue **Power** LED illuminates when the EIS Box 5000 is powered on; see the **Power** LED description below.



#### The Power LED

The **Power** LED is on the lower right of the EIS Box 5000 front panel. It normally glows a continuous blue when the EIS Box 5000 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.

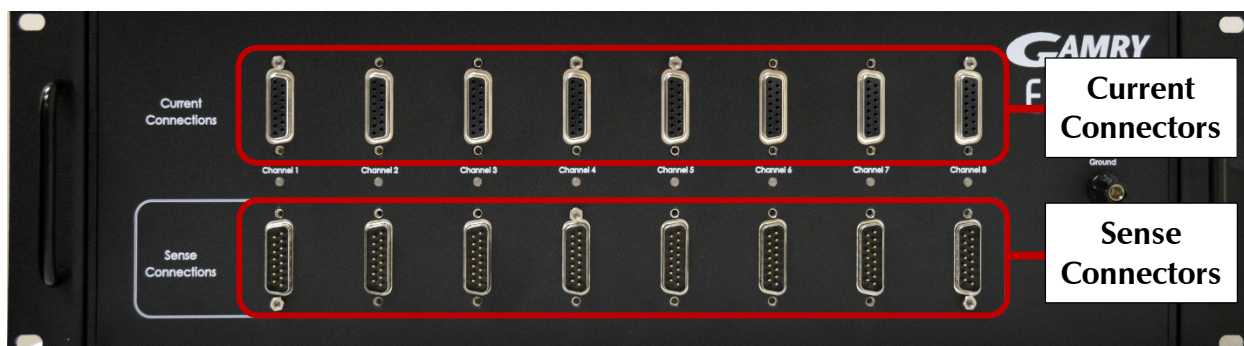


**Caution:** The **Power** LED indicates power status, and that power-up tests have passed. Never rely on the **Power** LED as a true power-status indicator. Always unplug the **Power In** connection if you suspect your EIS Box 5000 is malfunctioning.

#### Cell Connectors

The EIS Box 5000 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.



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

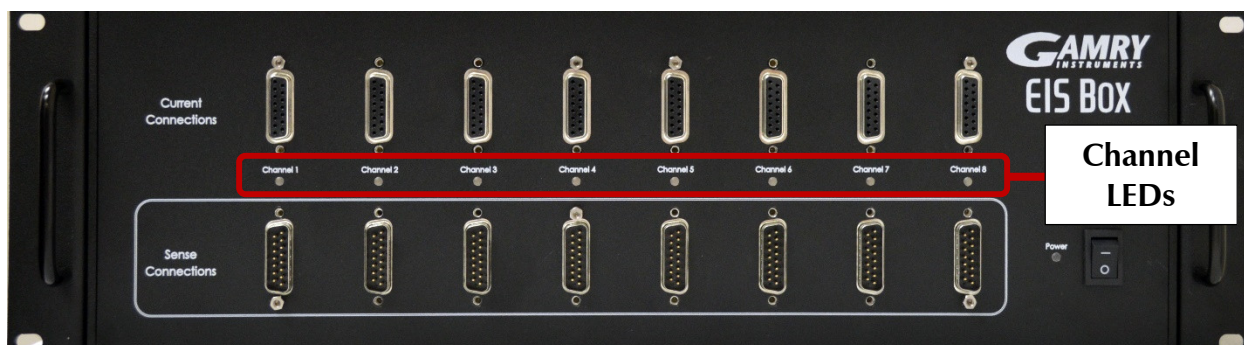
In addition to the pins used for cell connections, each EIS Box 5000 Cell Connector also uses four pins to read a cell cable ID. Gamry software can compensate for the cell-cable characteristics to attain optimal system performance in EIS (Electrochemical Impedance Spectroscopy).

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 5000 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 5000 are generally considered safe. Still, avoid touching the cell leads when the cell is on.

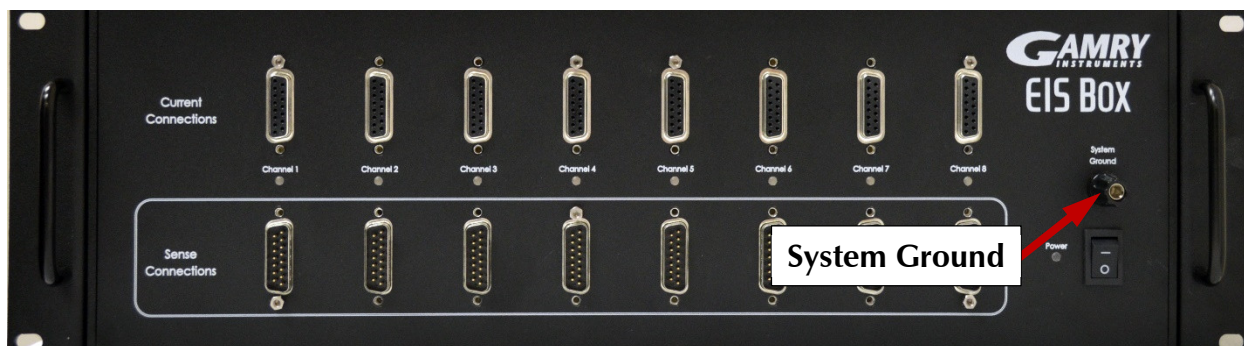
If you need to make changes to your cell leads, do so after powering down the EIS Box 5000.

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 5000 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 5000 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 5000. 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 5000 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 5000 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 5000 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

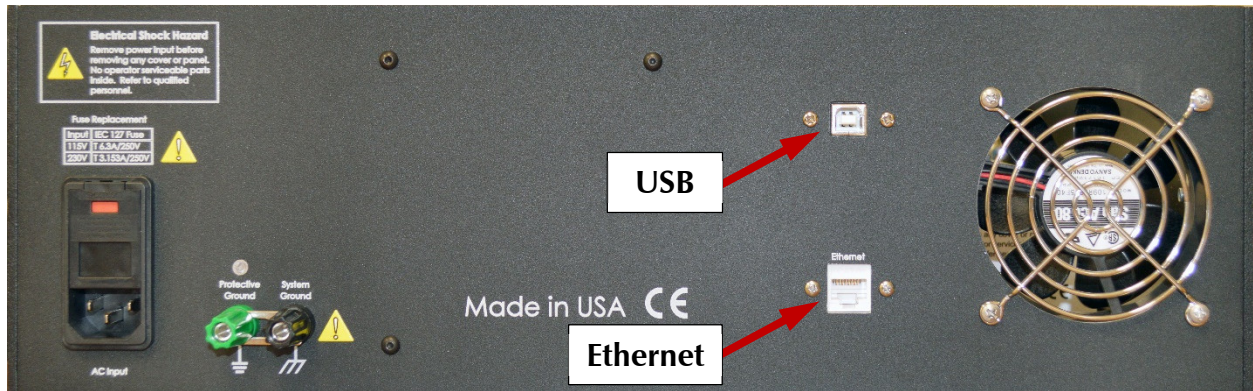
The green **Protective Ground** binding post is a convenient access point to the protective (earth) ground in the EIS Box 5000. It is connected to the third wire in the AC power cord and to the EIS Box 5000's metal chassis. This binding post can be connected to an additional earth ground to form a redundant protective ground.

A black banana-plug-to-banana-plug lead is provided with your EIS Box 5000. You may find it useful when making the earth-ground connection (if a redundant protective ground is required).

## Ethernet (for the Ethernet version of the EIS Box 5000)

The Ethernet port on the rear panel of the EIS Box 5000 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 5000. If this cable is lost, you can replace it with a cable from your local computer retailer.



## USB (for the USB Version of the EIS Box 5000)

The USB port on the rear panel of the EIS Box 5000 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 5000. 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 5000. The fuses cannot be changed with the AC line cord plugged into the EIS Box 5000.
2. Find the AC input module on the left side of the EIS Box 5000'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.
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 5000.
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 5000.



**Caution:** The AC line fuses are important components for safe operation of the EIS Box 5000. Do not replace the fuses with incorrect values or types, or in any way circumvent the fuse action. If your EIS Box 5000 routinely blows the AC line fuses it indicates a serious problem with the EIS Box 5000. Contact Gamry Instruments, Inc. for repair information.



## Appendix A: EIS Box 5000 Specifications

All specifications are at an ambient temperature of 22°C, with the EIS Box 5000 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/μs	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	TΩ	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	μV/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×, 10×, 100×		

## Current to Voltage Converter

Maximum Full-scale Range		$\pm 5$	A	Note 13
Minimum Full-scale Range		$\pm 50$ $\pm 500$ (after $100\times$ gain)	$\mu\text{A}$ nA	Note 13
Voltage across $R_m$	Typ	$\pm 100$	mV at full scale	Note 14
Output Voltage (at Monitor and ADC in)	Typ	$\pm 3.0$	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 $\mu\text{A}$ 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	$\pm 100$	% 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	$\pm 10$	nA	Note 22

## EIS Box 5000 Specifications

Dimensions		41.5 W × 45.7 D × 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 (maximum carried)	A	
Counter electrode voltage	Max	±6.5 (measured versus EIS Box 5000 chassis ground)	V	

## Channel Isolation

Current leakage	Max	<2 (to active channel pin from any source)	nA	
Impedance		>500 (equiv. impedance to EIS Box 5000 chassis ground) <20	MΩ pF	

### 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 kΩ 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 5000 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 5 A 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 GΩ 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 5000.

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  $\Omega$  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  $\pm 6$  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  $\pm 0.5$  mV.
13. There are six hardware current ranges, separated in sensitivity by decades. The ranges are 50  $\mu\text{A}$ , 500  $\mu\text{A}$ , 5 mA, 50 mA, 500 mA and 5 A full scale. The  $\times 10$  and  $\times 100$  gains add two virtual ranges of 5  $\mu\text{A}$  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 5000. 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 I/E stability 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  $\Omega$  resistor and measuring current noise on the 500  $\mu\text{A}$  scale. 1  $\mu\text{V}$  of voltage noise creates a current of 1  $\mu\text{A}$ . 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 $\Omega$  resistor, PSTAT mode, CA speed is normal, I/E stability is slow, I/E range is 50  $\mu\text{A}$ , I-channel filter is 5 Hz, and I-channel gain is 100.

## Appendix B: EIS Box 5000 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 5000'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 $\Omega$ 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 $\Omega$ resistor in the cell end of the cable. Custom cell cables are likely to require a similar resistor.

## Appendix C: Certifications



### Declaration of Conformity: No. DOC-2018-CE-EISBOX5000

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name and Location:

Gamry Instruments  
734 Louis Drive  
Warminster, PA 18974  
USA

This declaration is for the Gamry Instruments product model: EIS Box 5000

The declaration is based upon compliance with the following directives:

- EMC Directive 2014/30/EU
- Low Voltage Safety Directive 2014/35/EU

The declaration is based upon product compliance with the following standards as defined in report number R-2944P-1 from Retlif Testing Laboratories, Inc. for EMC test and analysis and report number R-2944P-2 from Retlif Testing Laboratories, Inc. for safety analysis.

EMC Standards	Title	Class/ Criteria
EN 61326-1:2013 Table 1	EMC – Electrostatic discharge, Immunity	
EN 61326-1:2013 Clause 7.2	EMC – Emissions	B

Low Voltage Directive Safety Standards	Title
EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements

Signature

November 13, 2018

Date

Dr. Gregory A. Martinchek, PhD  
Title: President

Formal signed declaration is on file at Gamry, Inc.

# Certificate of Conformance

<b>CERTIFICATE OF CONFORMANCE</b> <b>EUROPEAN COMMUNITY</b> <b>COUNCIL DIRECTIVE 2014/30/EU</b>																							
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																						
<p>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.</p> <p>This certificate is hereby issued to the above named grantee and is valid only for the equipment identified below.</p>																							
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																						
<p>Note(s):</p> <ol style="list-style-type: none"> <li>1) See attached report R-2944P-1 for details and/or conditions pertaining to this certificate.</li> <li>2) Conforms to the emissions requirements of EN 61326-1:2013; Clause 7.2: <table border="0"> <tr> <td>CISPR 11 Edition 5.0: 2009, A1: 2010</td> <td>Conducted Emissions, Group 1, Class B</td> </tr> <tr> <td>CISPR 11 Edition 5.0: 2009, A1: 2010</td> <td>Radiated Emissions, Group 1, Class B</td> </tr> <tr> <td>IEC 61000-3-2: 2005, A1: 2008, A2: 2009</td> <td>Harmonics</td> </tr> <tr> <td>IEC 61000-3-3: 2008</td> <td>Flicker</td> </tr> </table> </li> <li>3) Conforms to the immunity requirements of EN 61326-1:2013; Table 1: <table border="0"> <tr> <td>IEC 61000-4-2: 2008</td> <td>Electrostatic Discharge</td> </tr> <tr> <td>IEC 61000-4-3: 2008, A1: 2007, A2: 2010</td> <td>Radiated Immunity</td> </tr> <tr> <td>IEC 61000-4-4: 2004, A1: 2010</td> <td>EFT/Burst, Power Ports and I/O Ports</td> </tr> <tr> <td>IEC 61000-4-5: 2005</td> <td>Surge Immunity, Power Ports</td> </tr> <tr> <td>IEC 61000-4-6: 2008</td> <td>Conducted Immunity, Power Ports and I/O Ports</td> </tr> <tr> <td>IEC 61000-4-8: 2009</td> <td>Power Frequency Magnetic Fields</td> </tr> <tr> <td>IEC 61000-4-11: 2004</td> <td>Voltage Dips and Interrupts</td> </tr> </table> </li> </ol>		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	IEC 61000-4-2: 2008	Electrostatic Discharge	IEC 61000-4-3: 2008, 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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IEC 61000-4-11: 2004	Voltage Dips and Interrupts																						

## Certifications



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October 26, 2018

Ms. Michelle Taylor  
Gamry Instruments  
734 Louis Drive  
Warminster, PA 18974

Dear Ms. Taylor,

Enclosed you will find Retlif Testing Laboratories Test Report Number R-2944P-1, which covers the EMC testing of your EIS Box, Model Number: EIS Box 5000, Serial Number: 04501. This testing was performed and test report generated in accordance with your Purchase Order Number: 2018-0751.

The following table is a brief description of the test methods performed and results obtained on the EIS Box. Please refer to the Test Program Summary page for an overview of all testing performed.

Test Method	Test Results
CISPR 11, Conducted Emissions, Class B	Complied*
CISPR 11, Radiated Emissions, Class B	Complied*
IEC 61000-3-2, Harmonics	Complied
IEC 61000-3-3, Voltage Fluctuation and Flicker	Complied
IEC 61000-4-2, Electrostatic Discharge	Complied
IEC 61000-4-3, Radiated Immunity	Complied*
IEC 61000-4-4, Electrical Fast Transient/Burst, Power Ports	Complied
IEC 61000-4-4, Electrical Fast Transient/Burst, I/O Ports	Complied
IEC 61000-4-5, Surge Immunity, Power Ports	Complied
IEC 61000-4-6, Conducted Immunity, Power Ports	Complied*
IEC 61000-4-6, Conducted Immunity, I/O Ports	Complied*
IEC 61000-4-8, Magnetic Immunity	Complied
IEC 61000-4-11, Voltage Dips, Interrupts and Variations	Complied

\*Modifications were performed in order to demonstrate compliance.

Thank you for the opportunity to be of service to you. Should you have any questions regarding the enclosed report, please feel free to contact me.

Sincerely,

Retlif Testing Laboratories

*Patricia Harris*

Patricia Harris  
Publications  
[pharris@retlif.com](mailto:pharris@retlif.com)  
Enc. (as stated)



**40 YEARS OF TESTING EXCELLENCE**

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## Certifications



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November 13, 2018

Ms. Michelle Taylor  
Gamry Instruments  
734 Louis Drive  
Warminster, PA 18974

Dear Ms. Taylor,

Enclosed you will find Retlif Testing Laboratories Report Number R-2944P-2 covering the safety testing which was performed on your EIS Box, Model Number: EIS Box 5000, Serial Number: 04501. This testing was performed and test report generated against your Purchase Order Number: 20118-0751.

The following table is a brief description of the test methods performed and results obtained on the EIS Box. Please refer to the Test Program Summary page for an overview of all testing performed.

Test Method	Test Results
Clause 4.4.2.3, Protective Conductor	Complied
Clause 5.1.3 c), Mains Supply	Complied
Clause 5.3, Durability of Markings	Complied
Clause 6.2.1, Determination of Accessible Parts	Complied
Clause 6.3, Touch Current	Complied
Clause 6.7.2.1, Clearances and Creepages Mains Circuits	Complied
Clause 6.8.2, Humidity Preconditioning	Complied
Clause 6.8.3.1, The a.c Voltage Test	Complied
Clause 9.1, 9.2, Single Fault Condition	Complied
Clause 10.1, Surface Temperature Limits for Protection Against Burns	Complied

Thank you for the opportunity to be of service to you. Should you have any questions regarding the enclosed report or the actual testing of your sample, please do not hesitate to contact me.

Sincerely,

Retlif Testing Laboratories

Patricia Fiore  
Publications  
pfiore@retlif.com

Enc. (as stated)



**40 YEARS OF TESTING EXCELLENCE**

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Washington Regulatory Compliance  
1600 North Oak Street, #1710  
Arlington, VA 22209 USA  
Tel: (703) 528-3895



## Declaration of Conformity: No. DOC-2022-UKCA-EISBOX5000

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name and Location:

Gamry Instruments  
734 Louis Drive  
Warminster, PA 18974  
USA

This declaration is for the Gamry Instruments product model: EIS Box 5000

The declaration is based upon compliance with the following directives:

- EMC Directive 2014/30/EU
- Low Voltage Safety Directive 2014/35/EU

The declaration is based upon product compliance with the following standards as defined in report number R-2944P-1 from Retlif Testing Laboratories, Inc. for EMC test and analysis and report number R-2944P-2 from Retlif Testing Laboratories, Inc. for safety analysis.

EMC Standards	Title	Class/ Criteria
EN 61326-1:2013 Table 1	EMC – Electrostatic discharge, Immunity	
EN 61326-1:2013 Clause 7.2	EMC – Emissions	B

Low Voltage Directive Safety Standards	Title
EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements

Signature

September 2, 2022

Date

Dr. Gregory A. Martinchek, PhD  
Title: President

Formal signed declaration is on file at Gamry, Inc.



## Appendix D: Comprehensive Index

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