ECM8™

Electrochemical Multiplexer

Operator's Manual

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, contact us via e-mail 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 & 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 ECM8 Electrochemical Multiplexer, please call from a phone next to your computer, where you can type and read the monitor while talking to us.

We will be happy to provide a reasonable level of free support for registered users of the ECM8 Electrochemical Multiplexer. Reasonable support includes telephone assistance covering the normal installation, use, and simple customization of a computerized system containing an ECM8 Electrochemical Multiplexer 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 ECM8 Electrochemical Multiplexer 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.

Limited Warranty

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 ECM8 Electrochemical Multiplexer 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.

Gamry Instruments, Inc. reserves the right to make revisions to the system at any time without incurring any obligation to install same on systems previously purchased. All system specifications are subject to change without notice.

There are no warranties which extend beyond the description herein. This warranty is in lieu of, and excludes any and all other warranties or representations, expressed, implied or statutory, including merchantability and fitness, as well as any and all other obligations or liabilities of Gamry Instruments, Inc; including but not limited to, special or consequential damages.

This Limited Warranty gives you specific legal rights and you may have others which vary from state to state. Some states do not allow for the exclusion of incidental or consequential damages.

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Disclaimers

Gamry Instruments, Inc. cannot guarantee that the ECM8 will work with all computer systems, operating systems, and third-party potentiostat hardware.

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

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Table of Contents

Chapter 1： Safety Considerations

Your ECM8 Electrochemical Multiplexer is supplied in a safe condition. This chapter of the ECM8 Operator's Manual contains some information and warnings that you must follow to insure continued safe operation of the ECM8.

Inspection

When you receive your ECM8 Electrochemical Multiplexer,inspect it for evidence of shipping damage. If you note any damage, please notify Gamry Instruments Inc. and the shipping carrier immediately. Save the shipping container for possible inspection by the carrier.

> ⚠️ **Warning:** An ECM8 damaged in shipment can be a safety hazard. Do not operate a damaged apparatus until a qualified service technician has verified its safety. Tag a damaged ECM8 to indicate that it could be a safety hazard.

Protective Grounding and Product Safety

As defined in IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, the ECM8 is a Class I apparatus. Class I apparatus is only safe from electrical-shock hazards if the case of the apparatus is connected to a protective earth ground.

In the ECM8 this protective-ground connection is made via the ground prong in the AC line cord. When you use the ECM8 with an approved line cord, the connection to the protective earth ground is automatically made prior to making any power connections.

> ⚠️ **Warning:** Do not negate the protection of theECM8's earth ground by any means. Do not use the ECM8 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.

The ECM8 is 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 electrical outlet. You must always use a line cord with a CEE 22 Standard V female connector on the instrument end of the cable. This is the same connector used on the US standard line cord supplied with your ECM8.

⚠ **Warning:** If you replace the line cord, you must use a line cord with the same polarity as that supplied with the ECM8. An improper line cord can create a safety hazard, which could result in personal injury or death.

The wiring polarity of a properly wired connector is shown in Table 1-1 for both US line cords and European line cords that follow the "harmonized" wiring convention.

Table 1-1
Line Cord Polarities and Colors

	Line	Neutral	Earth Ground
US	Black	White	Green
European	Brown	Light Blue	Green/Yellow

If you have any doubts about the line cord for use with your ECM8, please contact a qualified electrician or instrument service technician for assistance. He or she can perform a simple continuity check that can verify the connection of the ECM8 chassis to earth and thereby check the safety of your ECM8 installation.

Line Voltages and Fuses

Before plugging in your ECM8 Electrochemical Multiplexer you must check that its AC line voltage selector is set for the voltage of your AC power line (mains). The ECM8 can be set for one of four mains settings: 100 V AC, 120 V AC, 220 V AC and 240 V AC.

⚠ **Warning:** You can damage an ECM8 by attempting to operate it from an incorrect line voltage. It is particularly dangerous to plug a unit set for an AC line voltage of 100 V AC or 120 V AC into an outlet supplying a higher voltage such as 220 V AC. The resulting damage can create a fire or shock hazard.

The voltage setting appears in a window in the AC power input module on the rear panel of the ECM8. Looking at the ECM8 from the rear, you see the AC input module on the upper left-hand corner of the panel. Note the number that appears in the small window. It is the nominal line voltage setting. Table 1-2 shows the range of input voltage for each nominal line voltage setting.

Table 1-2
AC Voltage Ranges for Each Nominal Line-voltage Setting

Nominal Setting	Allowed Range
100	90 to 110 V AC
120	108 to 132 V AC
220	200 to 240 V AC
240	220 to 260 V AC

If the ECM8's line voltage setting is not appropriate for your power line voltage, you must change the setting before you can use the unit. The **Changing the Line-voltage Selection** section gives step-by-step instructions on how to change the line voltage setting.

The ECM8 depends on fuses in the AC line input to prevent electrical shock and fire hazards in the unlikely case of a catastrophic failure of the ECM8 power supply. Two fuses are used, one for each side of the AC line. Table 1-3 shows the value of the fuses that you use for each AC line-voltage setting. The ECM8 uses "European Style" 5 mm × 20 mm cylindrical fuses. Slow-blowing fuses that are designed to meet IEC Publication 127 Sheet III are required. Littelfuse 218 series and Bussman GDC series fuses are two possible replacements.

> **⚠ Caution:** The AC line fuses are important components for safe operation of the ECM8. Do not replace the fuses with incorrect values or types, or in any way circumvent the fuse action. If your ECM8 routinely blows the AC line fuses it indicates a serious problem with the ECM8. Contact Gamry Instruments, Inc., for repair information.

Table 1-3
AC Line Fuse for Each Nominal Line Voltage Setting

Nominal Setting	Fuse
100 V	1 A
120 V	1 A
220 V	1/2 A
240 V	1/2 A

Gamry Instruments has attempted to ship your ECM8 configured for the line voltage in your area. This includes both the line-voltage setting and the fuses installed in the ECM8. Spare fuses appropriate for your line voltage have also been included. If an error was made in the fuse selection, please contact your local sales representative to get the correct fuses.

Step-by step-instructions for changing the AC line fuses in an ECM8 are shown in the section of this chapter titled "Changing the AC Power Line Fuses".

Changing the Line-voltage Selection

This section of the ECM8 manual gives step-by-step instructions for changing the AC power-line voltage setting used by the ECM8. 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 ECM8. The line voltage cannot be changed with the AC line cord plugged into the ECM8.

2. Find the AC input module on the upper left-hand corner of the ECM8 rear panel. It can be identified by the line-cord connector built into it.

3. Notice the line-voltage setting that appears in the small window on the AC input module.

4. 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.

5. The line-voltage selection (120 V AC, 240 V AC, etc.) is written on a plastic cylinder in the AC input module. Gently rotate this cylinder so that your desired line-voltage selection appears in the window when the AC input module is closed again.
    If you are curious how a plastic cylinder can change a voltage setting, this cylinder is also a cam that moves metal contacts in the AC input module.

6. Check that you have the correct fuses for your new line-voltage setting, and change the fuses if necessary.

    If you are changing between 100 and 120 V AC, or changing between 220 and 240 V AC, you do not need to change the fuses. All other changes require a fuse change. See Table 1-3 for the correct fuse for each line voltage setting.

    If you are uncertain of the fuse value that you currently have in the ECM8, you can easily remove the fuses and check them. Use your screwdriver to gently pry up the two plastic arrows in the line-voltage selector. These arrows are on top of fuse holders. After a fuse holder is up about 1 cm you can grab it with your fingers and remove it. The fuse's value is written on the fuse. When you replace the fuse and its holder, make sure the arrow points towards the bottom of the ECM8.

7. Close the cover of the AC input module. It should snap into place.

8. Check the line-voltage setting displayed in the small window on the AC input module. It must be the one that you desire. If it is not, repeat steps 4 through 8 of this procedure.

Replacing the AC Power-line Fuses

This section of the ECM8 manual gives step-by-step instructions for changing the AC power-line fuses in your ECM8 Electrochemical Multiplexer. 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 ECM8. The fuses cannot be changed with the AC line cord plugged into the ECM8.

2. Find the AC input module on the upper left-hand corner of the ECM8 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 ECM8.

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 ECM8.

> ⚠ **Caution:** The AC line fuses are important components for safe operation of the ECM8. Do not replace the fuses with incorrect values or types, or in any way circumvent the fuse action. If your ECM8 routinely blows the AC line fuses it indicates a serious problem with the ECM8. Contact Gamry Instruments, Inc., for repair information.

Ventilation

Your ECM8 Electrochemical Multiplexer was designed to operate at ambient temperatures between 0°C and 40°C.

> ⚠ **Caution:** Be careful when operating the ECM8 in an enclosed space (such as an enclosed relay rack or NEMA enclosure). The temperature within the enclosure must not exceed 40°C. You may need to provide ventilation holes or even forced air cooling for the enclosure if the temperature rises excessively.

Defects and Abnormal Stresses

You should treat your ECM8 Electrochemical Multiplexer 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 ECM8 or any other apparatus if you think it could be hazardous. Have it checked by qualified service personnel.

There are limit conditions on the storage, shipping and operation of this equipment. The ECM8 is not designed for outdoor use.

Storage
Ambient Temperature	−20°C to 60°C
Relative Humidity	Maximum 90% non-condensing

Shipping
Same as storage plus
Acceleration	Maximum 30 G

Operation
Ambient Temperature	10°C to 40°C
Relative Humidity	Maximum 90% non-condensing

Cleaning

Disconnect the ECM8 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 ECM8 enclosure. Alternatively, you may use isopropyl alcohol. Do not use a wet rag or allow fluid to enter the ECM8 enclosure. Do not immerse the ECM8 in any type of cleaning fluid (including water). Do not use any abrasive cleaners.

Service

Your ECM8 Electrochemical Multiplexer has no user-serviceable parts inside (the baud rate switch is an exception; see Appendix C). Refer all service to a qualified service technician.

Warning: Never operate the ECM8 with any cover or panel on the chassis open. Dangerous AC line voltages are present at several points within the ECM8 chassis, including PC board traces. Always remove the power connection before opening the ECM8 case.

RFI Warning

Your ECM8 Electrochemical Multiplexer generates, uses, and can radiate radio-frequency energy. The radiated levels are low enough that the ECM8 should present no interference problem in most industrial laboratory environments. The ECM8 is likely to cause radio-frequency interference if operated in a residential environment.

Electrical Transient Sensitivity

Your ECM8 Electrochemical Multiplexer was designed to offer reasonable immunity from electrical transients. However, in severe cases, the ECM8 could malfunction or even suffer damage from 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 ECM8):

- Placing your ECM8 on a static-control work surface may help. 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 ECM8):

- Try plugging your ECM8 into a different AC-power branch circuit.

- Plug your ECM8 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 from electronic devices and mandating several safety requirements. Gamry Instruments, Inc. has modified its instruments, including the ECM8, to comply with these standards.

The relevant CE regulations include EN55022 Class B and EN60950.

Chapter 2：Introduction

The ECM8 Electrochemical Multiplexer was developed to increase the throughput of your electrochemical testing program. It allows one potentiostat/galvanostat/ZRA to drive up to eight electrochemical cells. Under the control of an external computer, the ECM8 connects one cell at a time to the potentiostat, which makes an electrochemical measurement on that cell.

The ECM8 was specially designed for the needs of electrochemists. Extra features such as sense line and shield-switching, and control of inactive cells separate the ECM8—designed specifically for electrochemists—from other general-purpose switching devices.

The ECM8 has been integrated into all Gamry Instruments' electrochemical applications that run under the Gamry Framework. It allows many of the DC Corrosion measurement applications to increase their throughput by testing multiple cells in a single test run. In this system a sophisticated Microsoft Windows® program is used to control both the ECM8 and a Gamry Instruments' potentiostat.

However, the ECM8 is not restricted to use in corrosion testing or use with Gamry Instruments hardware or software. It was designed to work with other potentiostats, including those sourcing as much as two amperes of current. An optional library of control routines is available on request. These routines are written for Microsoft® C running on a host computer. Source code and a complete manual are provided so that the routines can be modified or transported to other computers and/or compilers.

This chapter of the ECM8 Operator's Manual provides an overview of the operation of the ECM8. It discusses the following topics:
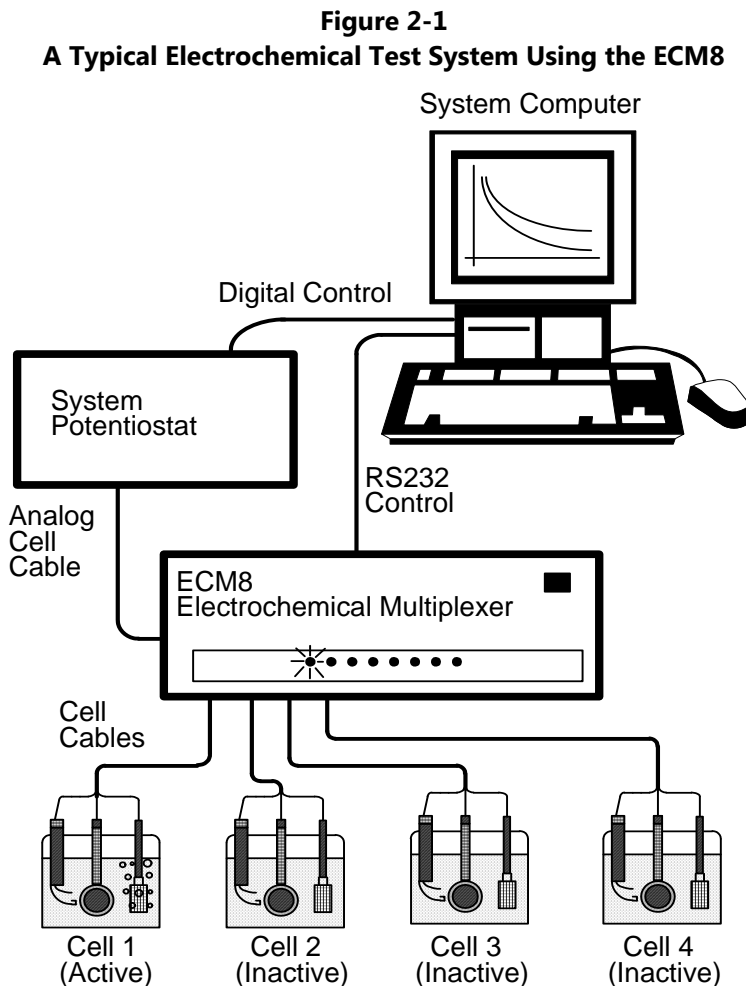
- Operation overview

- Switching and inactive cell control

- Communications overview

The material in this chapter is only an overview. If you are using your ECM8 with Gamry Instruments software this overview should give you sufficient understanding to make intelligent use of your ECM8.

Operation Overview

Figure 2-1 shows a "typical" electrochemical test system built around an ECM8 Electrochemical Multiplexer. Only four cells are shown in this figure, although up to eight cells can be connected simultaneously. The label on the block marked as a potentiostat is slightly misleading. Most potentiostats can also be used as a galvanostat or as a ZRA (zero-resistance ammeter) in an ECM8 system.

In the description of this figure, keywords are in bold type and are defined in the next section.

Figure 2-1
A Typical Electrochemical Test System Using the ECM8

The **system computer** is a critical component of the system. It controls the ECM8 by sending it simple commands through an RS-232 serial connection.

The most important function of these commands is to select which cell is **active** (connected to the **system potentiostat**). You can think of an ECM8 as a complex switch. One of the eight cell cables on the ECM8 is switched so that it connects to the potentiostat's cell cable. All of the wires (including sense leads and shields) in the cell cable are switched. Other RS-232 commands select the ECM8's control mode for the cells that are **inactive** (not presently connected to the potentiostat).

The **system computer** also controls the **system potentiostat**. The control may take the form of a bus interface, an RS-232 connection, an IEEE 484 connection, or even analog signals from a D/A and A/D computer interface sent to an analog potentiostat. When a cell is connected to the **system potentiostat** 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 **system potentiostat** are responsible for taking the measurement and storing it.

The **system potentiostat** in Figure 2-1 is shown as a "black box". The ECM8 is designed to work with virtually any potentiostat. The relays in the ECM8 can carry currents up to 2 A, allowing use of the ECM8 with most high-performance potentiostats.

In a typical ECM8 experiment, the **system computer** cycles through the cells. Each cell is connected in turn to the **system potentiostat** 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

The following key terms are used throughout this manual.

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.

Aux A/D

> The term Aux A/D is used to describe an optional switch in each ECM8 channel. This switch allows connection of two BNC connector contacts associated with that channel to a common BNC connector. The term Aux A/D is used for this switch because the original use for this switching system is multiplexing a signal from each channel to the single Auxiliary A/D input often found on potentiostats.

> The connectors and relays used for the **Aux A/D** function are no longer included in the standard ECM8. They can be ordered as a factory-installable option.

> The **Aux A/D** switches are not restricted to use as an Auxiliary A/D multiplexer. It can also be used as a demultiplexer or for other switching applications.

Cell

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

Channel

> An ECM8 contains eight channels. A channel includes cell-switching, an Aux A/D switch (optional), a local potentiostat and a D/A converter. 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 system potentiostat. Inactive is a slightly misleading term, since an inactive cell can actually be potentiostated by the ECM8's local potentiostat on that channel.

Inactive Mode

> Inactive cells can be open, connected to a local potentiostat, or shorted. The term inactive mode describes this choice of control mode for inactive cells.

Local Potentiostat

> A simple low-current potentiostat that maintains potential control on inactive cells. Unlike the system potentiostat, the local potentiostat is incapable of making electrochemical measurements.

System Computer

> The computer responsible for coordinating operation of an ECM8-based electrochemical test system, not to be confused with the very simple micro-controller buried within the ECM8.

System Potentiostat

This is the potentiostat responsible for making electrochemical measurements on the cells used in the experiment. The system potentiostat is typically a full-featured, computer-controlled instrument.
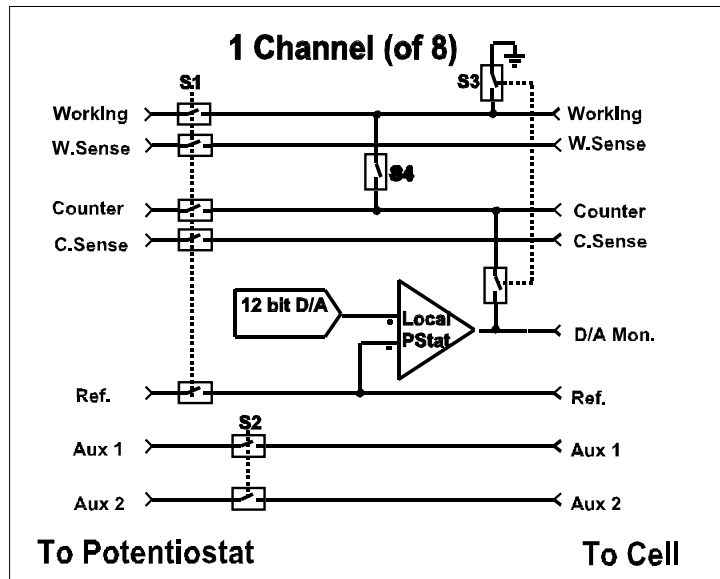
Switching and Inactive Cell Control

In the Operation Overview, we said you can think of the ECM8 as a complex switch. This section of the manual describes the ECM8-switching in some detail. In addition, control modes for inactive cells are discussed.

Figure 2-2
Simplified Schematic of One ECM8 Channel

Each of the eight ECM8 channels is made up of an independent set of switches and control circuits. Figure 2-2 is a simplified schematic diagram for one channel of the ECM8. Switches connected with dotted lines are always switched together and are therefore treated as one multi-pole switch. All the switches are under control of the system computer. Shield relays are not shown.

The cell cable from the system potentiostat is connected at the left side of the schematic. The system-potentiostat cell cable is also connected to all of the other channels. The system computer must insure that only one cell at a time is connected to the system potentiostat.

Switch S1 controls which cell is active. S3 and S4 control the inactive mode of the cell on this channel.

Looking at the schematic, you can see that switch S1 connects this channel's cell to the system potentiostat. An active channel always has S3 and S4 open. The relays in S1 are rated to carry 2 A and switch 1 A. You can normally use the ECM8 with potentiostats rated at up to 100 V of output compliance and 2 A of output current.

To avoid transients, always turn off the cell at the system potentiostat prior to switching S1. The ECM8 switches all its relays nearly simultaneously (even those in different channels), but there is still about 1 millisecond in which the relay pattern in the ECM8 is in neither the initial or final configuration. Switching transients as the ECM8 switches channels with a "live" potentiostat can be particularly severe because the system potentiostat's feedback goes through one of the S1 relays. To avoid the problem, turn off the cell at the system potentiostat before switching channels.

The switch labeled S2 is part of the **Aux A/D** option. It connects one of eight pairs of uncommitted contacts to a common input/output connector. The most common use for this set of contacts is to multiplex eight signals to the one auxiliary A/D input on a system potentiostat. The BNC connectors for this function are therefore labeled "Auxiliary A/D Input""on the ECM8 rear panel. The holes for these BNC connectors are filled with plugs if the **Aux A/D** option is not installed. The system computer must make sure that S2 is closed for only one channel at a time.

Switch S2 is controlled independently of S1, although they are often switched together. It is possible to connect your system potentiostat to the cell on Channel 3 and simultaneously select the Auxiliary A/D connection for Channel 6.

You have a choice of three different control schemes for inactive cells. These are tabulated in Table 2-1 along with the active mode.

Table 2-1
ECM8 Control Modes

Mode	S1	S3	S4
Active	Closed	Open	Open
Open	Open	Open	Open
Local potentiostat	Open	Closed	Open
Shorted	Open	Open	Closed

The inactive control mode labeled "open" is the simplest. In this mode the cell is disconnected and isolated from both the system potentiostat and the ECM8. No cell current can flow between any electrodes. This is the most common inactive mode in corrosion studies, where the cell behavior at open circuit is of interest.

The inactive control mode labeled "local potentiostat" is used to maintain potential control between readings made with the system potentiostat. If you know something about operational amplifiers and potentiostats, you may recognize that the operational amplifier in Figure 2-2 is wired as a simple potentiostat. With S3 closed, the working electrode is connected to the ground on the ECM8 circuit board and the counter electrode is connected to the output of an operational amplifier. The feedback for this amplifier is taken from the cell's reference electrode. This mode can be used whenever it is important to maintain potential control between readings. One experimental example is tests on amperometric chemical sensors.

The ECM8's local potentiostat can be disabled via jumpers inside the ECM8 chassis. This is done to allow operation with cells that contain a grounded electrode. See Appendix E for details. If this has been done, the local potentiostats will not work.

Unlike a typical system potentiostat, the local potentiostat is very limited in capability. The amplifier in this local potentiostat is not a large power amplifier. Its output is *typically* capable of generating ±30 mA at up to ±12 V. The local potentiostat has no cell switch other than S3, and it cannot measure current.

Notice that the reference electrode is always connected to the local potentiostat amplifier. You must make sure that the reference electrode potential does not go beyond ±12 volts with respect to the ECM8 chassis voltage. This is true in all operating modes including the active mode.

> ⚠️ **Caution:** You can damage the local potentiostat's amplifier if the reference electrode potential exceeds ±24 volts versus the ECM8 chassis.

The cell can be potentiostated at a voltage that is set via the D/A converter seen in Figure 2-2. This is a 12-bit converter operating at a resolution of 2.5 mV per bit. The maximum voltage available is ±5 V. Notice that the D/A voltage is also brought out to a rear-panel monitor point. The monitor point for each channel is a BNC connector labeled **D/A Monitor** on the panel. The polarity of this monitor point is inverted with respect to the local potentiostat's voltage. If you set the potentiostat for +1.2 V (working versus reference electrode potential) the rear-panel monitor shows a voltage of −1.2 V.

The final inactive mode is label "shorted" in Table 2-1. In this mode a relay shorts the working and counter electrodes. This mode was added so that the ECM8 could be used in galvanic corrosion studies. In a galvanic corrosion experiment the current flow between two electrically connected metals is measured. The device that makes this measurement is called a zero-resistance ammeter (ZRA).

In the shorted inactive mode the two metals are connected, even when the system ZRA is measuring other channels. The shorted mode is subject to some errors at high currents because of the resistance in relays, wires, and connectors. With a 1.5 m Gamry Instruments cell cable, the resistance between the two electrodes should be less than 0.2 Ω. A good ZRA is much better in this regard, with electrode-to-electrode impedances in the low mΩ.

Communications Overview

The system computer communicates with the ECM8 via an RS-232 connection. RS-232 is a very popular serial communications standard. Often computer manufacturers refer to RS-232 ports simply as serial ports. In the world of Windows®-based computers, RS-232 ports are known as COM ports. Windows, as a result of its MS-DOS® heritage, supports four to eight COM ports, addressed as COM1 through COM4 (or COM8).

If your computer does not include any COM ports, you can often still use it with an ECM8. PCI plug-in cards with RS-232 ports are available. In addition, USB-to-RS-232 converters that mimic the operation of a COM port are also quite common. Contact Gamry's technical support staff or your local Gamry representative if you need help identifying an appropriate RS-232 solution.

This manual refers to RS-232 ports and connections when discussing ECM8 communications that are computer-independent. It refers to COM ports when the discussion is specific to Windows computers.

RS-232 communications can occur at various speeds, called baud rates. Both of the devices connected by an RS-232 connection must be set for the same baud rate. The ECM8 is factory-set for 9600 baud, which should prove adequate for most applications. At 9600 baud, an RS-232 link transmits one 8 bit character roughly every millisecond. Gamry's Framework applications all use 9600 baud as their default baud rate.

You can change the ECM8 baud rate using a DIP switch on the ECM8 printed circuit board. Appendix B contains a list of the available baud rates and detailed instructions on changing the baud-rate switch.

 Warning: Always unplug the ECM8 power cord before opening the ECM8 chassis. Dangerous voltages are exposed in the ECM8 with its top cover removed.

Consult your computer manual for instructions on changing your computer's baud rate. Modern computers set the baud rate in software so it is generally easier to change your computer's baud rate to 9600 baud rather than change the ECM8 baud rate.

RS-232 communications have several other parameters that must be set correctly to insure proper communications. Both communicating devices must be set for the same number of data bits, stop bits, and parity. The ECM8's communication parameters are fixed at 8 data bits, one stop bit, and no parity. Your computer's communication parameters should be set to the same values.

All RS-232 communications to the ECM8 are done via the exchange of ASCII characters. Appendix D describes the command formats. If you use the Gamry Framework to control your ECM8, you can ignore all this detail.

RS-232 cabling is unfortunately not very well standardized. You can find the pin-out of the ECM8's RS-232 connector in Appendix C. The ECM8's RS232 port has been wired as an RS-232 DCE (data communications element), similar to a modem. Your computer's RS-232 port is normally wired as a DTE (data terminal element). In most cases, an RS-232 cable that connects a modem to your computer will successfully connect the ECM8 to your computer.

The ECM8 comes with an RS-232 cable suitable for connection of an ECM8 to the 9-pin COM port on a Windows®-compatible computer. If you need to connect the ECM8 to a 25-pin COM port, you can use this cable with a 25-to 9-pin adapter. Such adapters are inexpensive and available at most computer retailers.

Chapter 3 ： Installation

This chapter of the ECM8 Electrochemical Multiplexer Operator's Manual covers normal installation of the ECM8. Both installation as part of a Gamry Framework-based electrochemical-measurement system and installation as a component in a user-configured system are discussed.

Initial Visual Inspection

After you remove your ECM8 from its shipping carton, check it for any signs of shipping damage. If you note any damage, please notify Gamry Instruments, Inc. and the shipping carrier immediately. Save the shipping container for possible inspection by the carrier.

Warning: An ECM8 damaged in shipment can be a safety hazard. Do not operate a damaged apparatus until a qualified service technician has verified its safety. Tag a damaged ECM8 to indicate that it could be a safety hazard.

Physical Location

Place your ECM8 on a normal workbench surface. You probably want to have access to the rear of the instrument because all cable connections are made from the rear. The ECM8 is not restricted to operation in a horizontal position. You can operate it on its side, or even upside-down.

You can also rack mount your ECM8 using its optional rack-mounting kit (Gamry Instruments part number 990-00021). If you rack-mount your ECM8, make sure that the internal temperature within the rack does not exceed the 40°C ambient-temperature limit of the ECM8. Be particularly careful if a computer or other heat-dissipating equipment is mounted in the same rack as the ECM8.

Power-cord and Line-voltage Selection

Before you plug your ECM8 into the AC power line (mains), make sure that the ECM8 line-voltage selector is set for the AC power-line voltage in your area.

Looking at the ECM8 from the rear, the line-voltage selector is located on the upper-right corner of the ECM8's rear panel. A small window on the AC power-entry module displays the current line-voltage setting. Table 3-1 shows the ranges of AC power-line voltages for each setting of the line-voltage selector.

Table 3-1
AC Voltage Ranges for Each Nominal Line-voltage Setting

Nominal Setting	Allowed Range
100	90 to 110 V AC
120	108 to 132 V AC
220	200 to 240 V AC
240	220 to 260 V AC

⚠️ **Warning:** You can damage an ECM8 by attempting to operate it from an incorrect line voltage. It is particularly dangerous to plug a unit set for an AC line voltage of 100 V AC or 120 V AC into an outlet supplying a higher voltage such as 220 V AC. The resulting damage can create a fire or shock hazard.

If the AC line voltage selection is not correct for your power supply voltage, it **must** be changed. Refer to Chapter 1 of this manual for detailed instructions on how to change the line voltage.

The AC line cord plugs into the AC power-entry module on the upper-right corner of the ECM8's rear panel. After you are sure that the AC line-voltage selection is correct, you may plug the ECM8 into a source of AC power.

Power-up Test

Before you make any other connections to your ECM8, check that the ECM8 is at least partly functional. One quick test is to check the eight LED indicators on the front panel of the instrument. Watch these LEDs as the ECM8 is powered up. The LEDs should flash on momentarily, then go out. If any of the eight cell LEDs stay on after the ECM8 powers up, the ECM8 is malfunctioning.

Connection to Gamry Instruments Reference 600 and Interface 1000

Connection of your ECM8 to a Gamry Instruments Reference 600 or Interface 1000 potentiostat is quite simple. Gamry Instruments supplies a standard cable (part number 985-00080) that properly connects the cell wires. This 1.5 m cable is equipped with a male 9-pin D-connector on the ECM8 end and a male 25-pin D-connector on the Reference 600 or Interface 1000 end.

⚠️ **Caution:** Never substitute a generic 25-to-9-pin cable designed for computer interconnection for this cable. The Gamry Instruments' cable includes individual shielding for several signals in this cable. Use of a generic cable is likely to create excessive noise and system

The Reference 600 or Interface 1000 can identify the cable plugged into its cell connector. It detects the presence of an ECM8 in your system. The Reference 600 or Interface 1000 cannot identify the cables used to connect the eight individual cells to the ECM8.

EIS performance with an ECM8 and a Reference 600 or Interface 1000 is optimal when all the cell cables are 1.5 m cables. All other cables may create errors in phase and magnitude.

Connection to Gamry Instruments Reference 3000

Connect the dual ends of the Y-cable (part number 985-00108) to the appropriate jacks on the front of the Reference 3000. Attach the single end of the Y-cable to the 985-00080 (PC5-to-ECM8 cable). Attach the other end of the 985-00080 cable to the **POTENTIOSTAT** connector on the back of the ECM8.

Connection to a Third-party Potentiostat/Galvanostat

Connecting the ECM8 to a third-party potentiostat/galvanostat is more of a problem: You have to build a custom cable. See Appendix C of this manual for the pin-out of the ECM8 potentiostat

connector and for hints on cable construction. We strongly recommend that you contact us prior to constructing the cable.

Cell Cables

Each cell to be tested in an experimental run requires a cell cable. Newer ECM8 mulitplexers are shipped with eight cell cables. Older ECM8 instruments were formerly shipped with only one cell cable.

When you are using the ECM8 with a Gamry Instruments potentiostat, cell-cable connections to the cell are made in the manner described in the potentiostat's Operators Manual. Cell connections when the ECM8 is used with a third-party potentiostat may not follow the normal Gamry conventions, so you should contact Gamry Instruments to obtain special instructions if this is your situation.

1.5 m, 4 m and 9 m cables are available with banana-plug/alligator-clip termination. Specialized cables are also available, including cables designed for connection to standard three-terminal corrosion-monitoring probes. Contact us for more information.
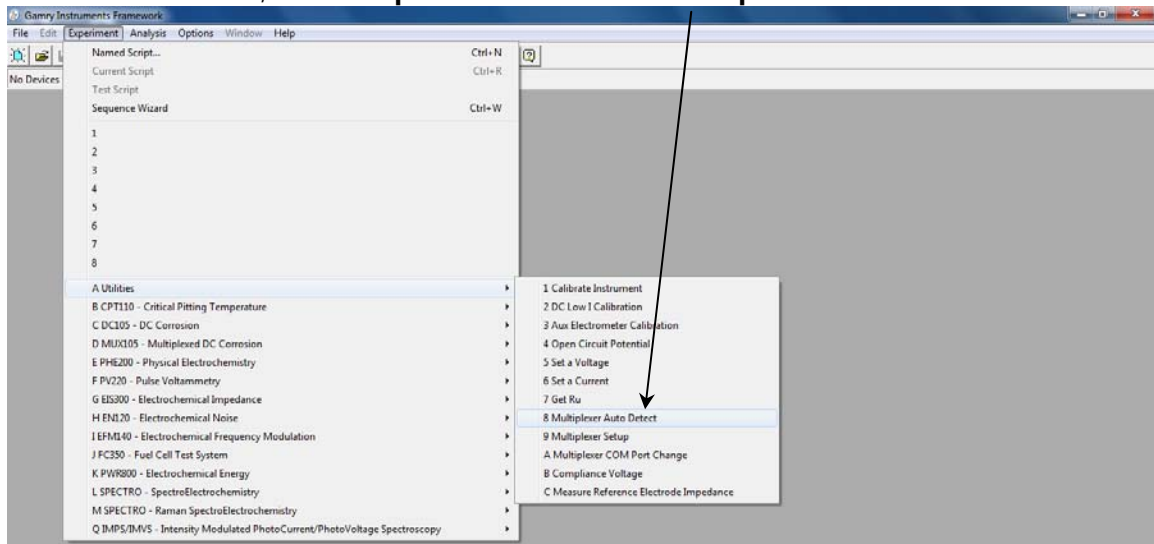
If you need to design a cell cable for your specific needs, refer to the pin-out of the ECM8 cell cable in Appendix C of this manual.
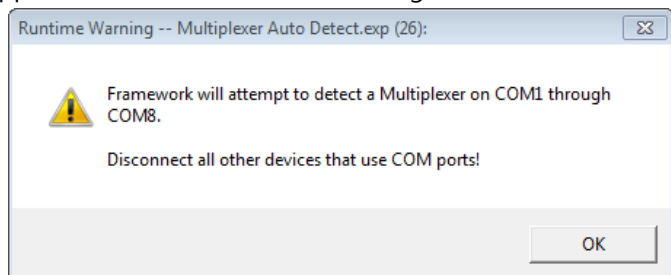
Software Installation

The installation process for the Gamry Framework also installs Gamry's Framework application packages and installs any multiplexed scripts that are available for those applications.

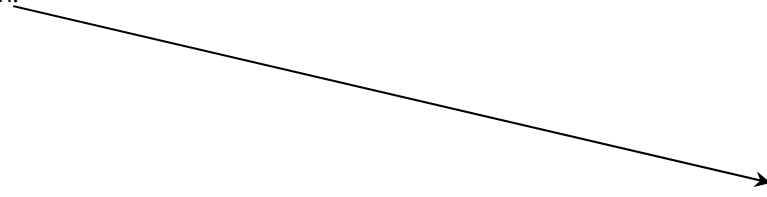## Test the Communications and Run Your Experiment

1. Be sure your host computer is on, the multiplexer is on, and your potentiostat is on.

2. Run the Gamry Framework software.

3. In the main menu bar, choose **Experiment** > **Utilities** > **Multiplexer Auto Detect**.

The **Multiplexer Auto Detect** window appears, and the automatic detecting software runs, searching for the COM port. A window appears.
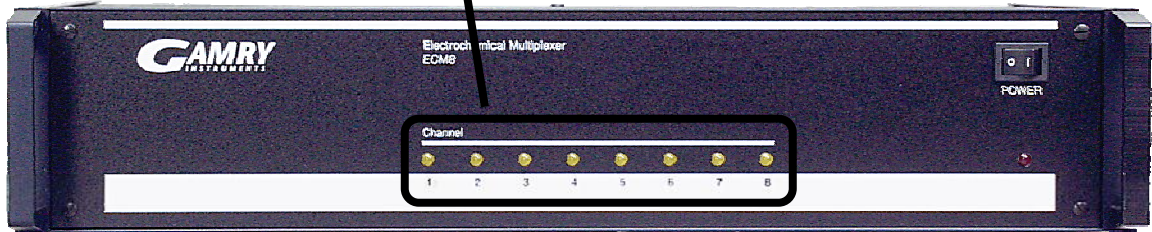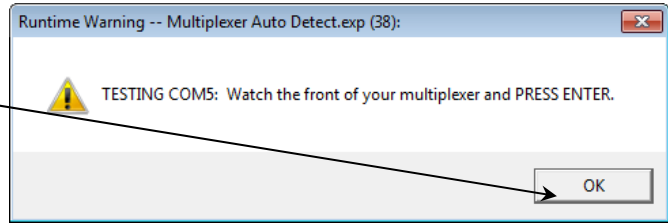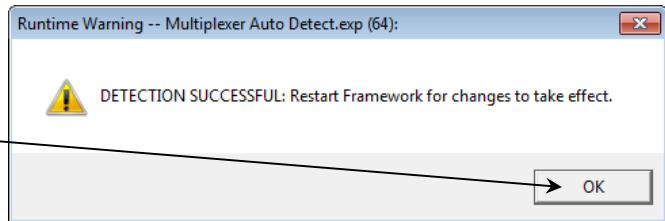
4. Click the **OK** button.

A window informs you that the test will begin.

5. Click the **OK** button, and watch the eight amber LEDs on the front of the multiplexer illuminate in sequence three times. Listen for the simultaneous clicks of the relays.

> Runtime Warning -- Multiplexer Auto Detect.exp (38):
>
> ⚠ TESTING COM5: Watch the front of your multiplexer and PRESS ENTER.
>
> OK

A window asks you to restart Framework.

6. Click the **OK** button. Connect the included cell cables to the desired channels on the back of the multiplexer, then restart Framework.

> Runtime Warning -- Multiplexer Auto Detect.exp (64):
>
> ⚠ DETECTION SUCCESSFUL: Restart Framework for changes to take effect.
>
> OK

7. In the Framework software, run the desired multiplexed experiment.

8. Activate the checkboxes corresponding to the active channels on the multiplexer. When a particular channel runs, the amber LED for that channel illuminates.
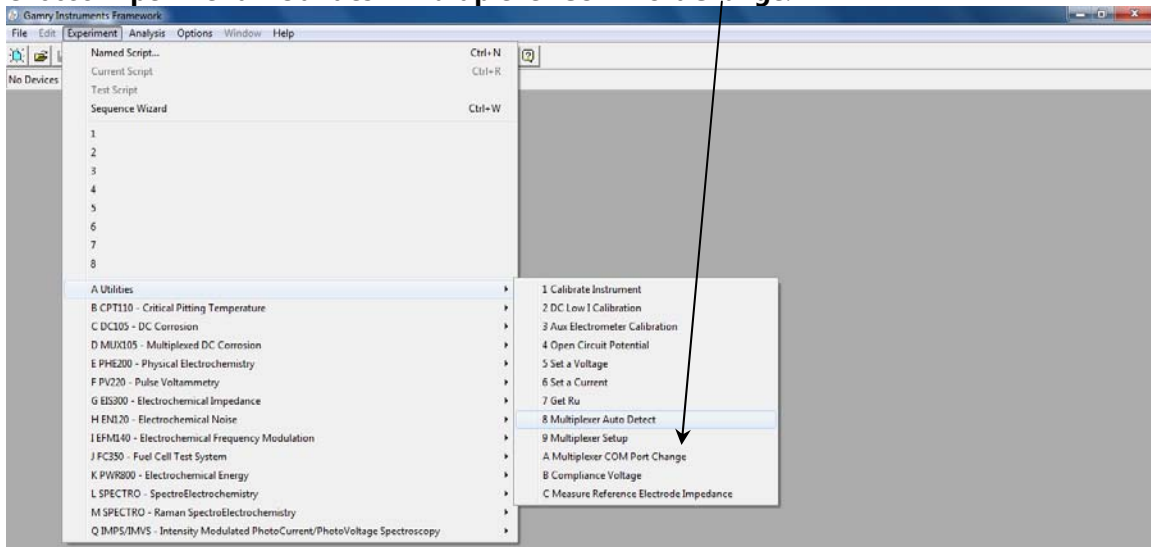
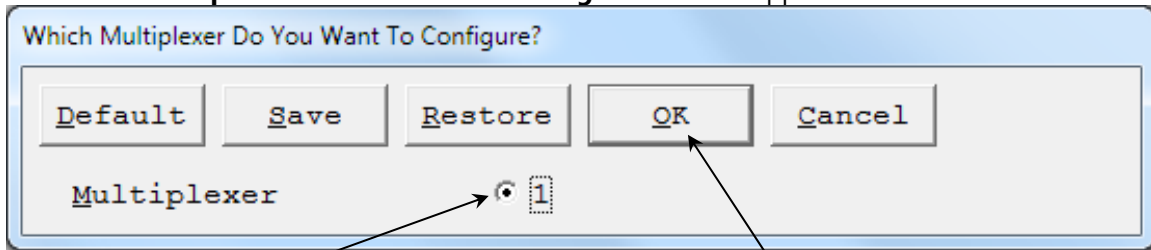| Channel	Identifier	System	Area	Notes
☐ 1	Test1	DEFAULT	1	☐
☐ 2	Test2	DEFAULT	1	☐
☐ 3	Test3	DEFAULT	1	☐
☐ 4	Test4	DEFAULT	1	☐
☐ 5	Test5	DEFAULT	1	☐
☐ 6	Test6	DEFAULT	1	☐
☐ 7	Test7	DEFAULT	1	☐
☐ 8	Test8	DEFAULT	1	☐

> **→DON'T FORGET!**
>
> If you are running AC experiments (e.g., EIS), you must run AC calibration of your potentiostat with the multiplexer connected. For all DC experiments calibration is not needed.

To Change the Multiplexer COM Port

1. Choose **Experiment** > **Utilities** > **Multiplexer COM Port Change**.

2. The **Which Multiplexer Do You Want To Configure?** window appears.

3. Choose the desired radio button (if there is a choice), then click the **OK** button.

Appendix A: ECM8 Specifications

Specifications apply at 25°C, 116 V AC power, and operation with a Gamry Instruments potentiostat unless otherwise noted.

Channel Characteristics

Modes	Active, Off, Local, Shorted	
Channel switching time	<10 ms	Excluding RS-232 communication time.
Cell current	2 A	Maximum carried
	1 A	Maximum switched
Input voltage (operating)	±12 V	Measured versus ECM8 chassis ground.
Input voltage (no damage)	±24 V	Measured versus ECM8 chassis ground.
Counter electrode voltage	±120 V	Measured versus ECM8 chassis ground.

Channel Isolation

Current leakage	<2 nA maximum	To active channel pin from any source.
Impedance	>500 MΩ <20 pF	Equiv. impedance to ECM8 chassis ground.

Local Potentiostat

Compliance-current	±20 mA	500 Ω load
Compliance-voltage	±11 V	1 kΩ load
Applied E Range	±5.12 V	Working versus Reference
Resolution	2.5 mV/bit	
Zero-offset error	<4 mV typical <10 mV max	0 V output into 10 kΩ load
Gain error	<0.2%	10 kΩ load
Reference input current	<50 pA	

Note: Applied voltage error is sum of zero-offset error and gain error.

RS-232 Communications

Baud rates	300, 600, 1200, 2400, 4800, 9600, 19 200	Set via DIP switches
Default	9600	Factory setting
Handshake	Hardware via RTS and CTS	

Power Input

Input voltage ranges	100, 120, 220, 240 V rms	Selectable
Allowed voltage	±10%	All ranges

variation
Power   <50 VA   Worst
                                                             case

Environmental
Operating temperature   0 to 440°C
Humidity   0 to 90% noncondensing

Appendix B: Changing the Baud-rate Setting

The ECM8 Electrochemical Multiplexer is factory-set for RS-232 communications at 9600 baud. This setting should be suitable for the vast majority of applications.

If you must change the ECM8 baud-rate, you change the DIP switches inside the ECM8 case. Follow these instructions:

1. Remove the ECM8 power cord from the ECM8's rear-panel power-entry module.

    ⚠️ **Warning:** Dangerous voltages are exposed if the ECM8 chassis is open while the power cord connected to a source of AC power. To prevent a shock hazard that could result in personal injury or even death, **always** unplug the ECM8 from its AC power source before removing any panel or cover.

2. The ECM8 top cover is held in place by one screw at the middle rear of the cover. Remove this screw, making sure that you do not lose it.

3. Slide the ECM8 top cover backwards and off the chassis. You may need to loosen (do not remove!) the set of screws on one side of the ECM8 if the cover does not slide off easily.

4. You see that all the ECM8 circuitry is contained on one large printed circuit board. Viewing this board from the front of the ECM8, the baud-rate DIP switch is on the right rear corner of the board. It is the only DIP switch anywhere on the board, so it is easy to find.

5. See Table B-1 for the DIP-switch setting required for your desired baud rate.

Table B-1
Baud Rate DIP Switch Settings

Baud Rate	switch 1	switch 2	switch 3	switch 4
300	off	on	off	off
600	on	off	off	off
1200	on	on	on	off
2400	off	on	on	off
4800	on	off	on	off
9600	off	off	on	off
19 200	on	on	off	off

6. Set the switches according to Table B-1.

7. Replace the ECM8 top cover and its retaining screw.

8. Replace the ECM8 power-line cord. The new baud rate becomes effective the next time the ECM8 is powered up.

Appendix C: I/O Connections for the ECM8

The ECM8 back panel is covered with connectors. This appendix discusses these connectors and their pin assignments in detail.

The Cell Connectors

The eight cell connectors (one for each channel) are located on the ECM8 rear panel. Each cell connector is a 9-pin female D-shaped connector. The pin-out of all eight connectors is identical. The signal assignment for each pin is shown in Table C-1.

Most of the pins in the ECM8 cell connector are switched to pins on the potentiostat connector when the cell is active. Only one pin is **not** switched: the ground pin. It is always connected to the system potentiostat's(floating) ground.

Table C-1
Cell Connectors

Pin	Signal Name	Use
1	Working Sense	Connected to the working electrode in cases where the system potentiostat uses a differential electrometer. This pin can be left open when the ECM8 is used with a potentiostat that uses a single-ended electrometer.
2	WS Shield	The shield for the working sense input. Left open at the cell end of the cell cable.
3	Working Electrode	Connected to the working electrode. The cell current flows through this pin.
4	WE Shield	The shield for the working electrode input. Left open at the cell end of the cell cable.
5	Ground	The system potentiostat's ground. Can be used to shield the cell if very low currents need to be measured. Also recommended as a shield for the counter electrode cable.
6	Ref Electrode	Connected to the reference electrode.
7	Ref Shield	The shield for the reference-electrode cable. Left open on the cell end of the cell cable.
8	Counter Sense	With a potentiostat, used to sense the potential of the counter electrode. Allows accurate ZRA mode even with significant cell current through counter lead's resistance.
9	Counter Electrode	Connected to the cell's counter electrode. The cell current flows through this connection.

Normal Cell-cable Connections

Normally you can use one of Gamry Instruments' standard cell cables to connect each channel's connector to its cell. Gamry supplies cables that are 1.5 m, 4.5 m or 9 m in length. Special-purpose cables are also available.

The standard cell cable terminates in banana plugs and one pin jack. Table C-2 identifies each terminal of the cable and its connections to the cell.

Table C-2
Normal 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	Pin Jack	Reference Sense	Connect to reference electrode
Red	Banana Plug	Counter Electrode	Connect to counter electrode
Orange	Banana Plug	Counter Sense	Connect to counter electrode
Long Black	Banana Plug	Floating Ground	Leave open or connect to a Faraday shield
Short Black	Banana Plug	Chassis (Earth) Ground	Leave open or connect to a Faraday shield

The working electrode is the specimen being tested. You make two connections to the working electrode. One of the two connections, with the blue banana plug, is used to sense the voltage at the working electrode when you use the ECM8 with a system potentiostat that includes a differential electrometer. If you are using a system potentiostat with a single-ended electrometer, you may leave this wire disconnected. The green working-electrode connection carries the cell current.

Connect the white pin jack to the cell's reference electrode, generally an SCE or Ag/AgCl reference electrode. Connect the red (and orange) banana plug to the counter or auxiliary electrode.

The longer black lead is connected to the system potentiostat's ground. The shorter black lead is connected to earth ground. In most cases, leave these terminals disconnected at the cell end. When you do so, take care that they do not touch any of the other cell connections.

When you are measuring very small currents, you may find that a metal enclosure completely surrounding your cell (a *Faraday shield*) will significantly lower the current noise caused by AC pickup at the cell. Connect this Faraday shield to both black cell leads.

You can add an alligator clip (provided) to each of the cell connections. The alligator clips simply slide onto the banana plugs. If you need to permanently change the terminations on your cell cable, feel free to remove the existing terminations and replace them with your desired termination.

In a few cases, you may find that you need to modify the cell cable or make a special-purpose cable. By far the easiest changes involve modifying a standard cell cable. If you decide to make your own cables, we recommend that you use coaxial cable for all the cell connections. Connect the shield of the coaxial cable to the pin recommended in Table C-1 on the potentiostat end, and leave the shield open on the cell end.

Cell cables longer than 3 meters may result in degraded instrument performance. Increased noise and decreased stability both can occur. However, with most cells, the instrument will work acceptably with an extended cell cable, so our advice is go ahead and try it.

The Potentiostat Connector

The ECM8 potentiostat connector is used to connect the ECM8 to the system potentiostat. The pin-out of this connector is very similar to that of the cell connectors.

Table C-3
Potentiostat Connector

Pin	Signal Name	Use
1	Working Sense	Only needed if the system potentiostat uses a differential electrometer. Connect this pin to the negative input of the potentiostat's differential electrometer. This pin can be left open when the ECM8 is used with a potentiostat that uses a single-ended electrometer.
2	WS Shield	The shield for the working sense input. Connect to the shield of the potentiostat's working sense lead (if any).
3	Working Electrode	Connected to the potentiostat's working electrode input.
4	WE Shield	The shield for the working electrode input. Connect to the shield of the potentiostat's working sense lead.
5	Ground	The system potentiostat's (floating) ground.
6	Ref Electrode	Connect to the reference-electrode input on the system potentiostat.
7	Ref Shield	The shield for the reference-electrode cable. Connect to the shield of the potentiostat's reference lead.
8	Counter Sense	Connect to the potentiostat's counter-sense input (if it has one).
9	Counter Electrode	Connected to the potentiostat's counter-electrode lead. Shield this wire with the potentiostat ground.

Connecting the ECM8 to Third-party Potentiostats

The cable required for connection to third-party potentiostats varies with the potentiostat. The following suggestions may help you in constructing the cable.

- In many cases the easiest way to build the cell cable is to modify a cell cable supplied by the potentiostat's manufacturer. Spare cables are generally available.

- Connect each of the electrode connections to its corresponding pin on the ECM8 potentiostat connector. For example, the potentiostat's working-electrode lead is connected to the ECM8 connector's working-electrode pin.

- Most commercial potentiostats use shielded leads for all of the cell connections. If the potentiostat uses shielded wire, use shielded wire for your custom cable. Connect the pins labeled shield (Working Electrode Shield, Reference Shield, etc.) on the ECM8 connector to the corresponding potentiostat cable shield. If there is no shield on the potentiostat's cell lead, you can leave the corresponding ECM shield pin disconnected.

- If the potentiostat does not have a working-electrode sense lead, you can leave the working-sense pin on the ECM8 open.

- You can ignore the counter-sense pin on the ECM8 connector (unless the cable is intended for use with a Gamry Instruments potentiostat). Leave this pin disconnected.

If an Auxiliary A/D connection is required, connect the ECM8's **POTENTIOSTAT Aux A/D Input** connector to the corresponding connector on the potentiostat.

RS-232 Connector

The ECM8 RS-232 connector is a female 25-pin D-type connector.

Table C-4
RS232 Connector Pin Assignments

Pin	Name	Use
2	Receive Data	Input of data to ECM8.
3	Transmit Data	Data output from the ECM8.
4	Clear to Send	A control input to the ECM8. The ECM8 does not transmit data if this line is not asserted.
5	Request to Send	An output from the ECM8. The ECM8 asserts this line only when it is ready to accept data.
6	Data Set Ready	A control output. This line is always asserted.
7	Ground	Connects the grounds of the ECM8 and the driving computer.
8	Data Terminal Ready	A control output from the ECM8. The ECM8 asserts this line whenever it is operational.
20	Data Carrier Detect	A control input to the ECM8. The ECM8 does not transmit data if this line is not asserted.

The ECM8 works with cables designed for connection of a computer to a modem.

Appendix D: RS-232 Commands

General Hardware Description

Before you can use the ECM8 RS-232 commands, you need to understand the ECM8's hardware organization. The ECM8 is a special purpose eight-channel multiplexer. Switching is done via banks of relays. Each of eight channels can be connected to a computer-controlled potentiostat. Unused channels can be open-circuited, shorted, or connected to a simple local potentiostat. The voltage applied by the local potentiostat is set via a 12-bit D/A converter.

The ECM8 has two types of I/O registers associated with each channel. Each register is write-only. The first type is an eight-bit relay control register. Bit assignments for this register are detailed in the register map (found in the next section). The second type is a 16-bit register made up from two eight-bit registers. This register contains the 12-bit 2's-compliment D/A value. Scaling on this register is 2.5 mV/bit. D/A outputs do not become effective immediately. A secondary I/O read or write to an UPDATE address updates all the D/A converters simultaneously.

In total, the ECM8 requires 32 bytes for its registers. It also uses one additional location to update the D/A converters simultaneously. The location of the registers in the microcontroller's address space is controlled via a programmable logic device. The current address assignments are shown in the register map.

> The ECM8 does not immediately change its hardware in response to a command string changing the contents of a register. The new register settings are stored in a "shadow"{ buffer in the ECM8 until an update command is received by the ECM8. When the update command is received, all the ECM8 registers are updated nearly simultaneously.

The RS-232 interface has a fixed format of 8 bits, no parity, and one stop bit. The baud rate is set via three DIP switches, with allowed settings from 19.2 kbaud down to 300 baud. Hardware-handshaking via DTR and CTS is implemented.

Register Map

Addresses in the ECM8 are determined by two numbers. The first is the base address, which defines the start of a 33-byte range of addresses. The second is the register offset, which defines the register's position within the range. Each channel of the multiplexer uses 4-byte-wide registers, so the register offsets repeat every four addresses.

The base address of the ECM8 is set for 8000 hex.

The register offsets are shown in Table D-1.

The D/A LSB and MSB are used to set the potential of a channel's local potentiostat. The 16-bit value made up from the two bytes is a 2's compliment integer. The scaling is 2.5 mV/bit, so the allowed range in 12 bits is ± 5.12 V. The ECM8 does not do any error-checking on the D/A value other than the number of hex characters. The system computer must insure that the value does not exceed ± 2047.

The Relays register is used to configure one channel of the multiplexer. The relays perform three functions.
- They determine which channel, if any, is currently connected to the driving potentiostat.
- They also determine the mode in which inactive cells are idled.
- Finally, they determine which Auxiliary A/D input is connected to the system potentiostat.

Bit assignments within the Relays register are shown in Table D-2. An X refers to the channel being addressed. Relays with an X in their designation, e.g., KX01, exist on each channel. Substitute the channel number (one through eight) to find the number of the relay that is actually activated. A cell is referred to as *active* when it is connected to the system potentiostat, and *inactive* when it is not. Inactive cells have three modes: open, locally potentiostated, and galvanic corrosion.

Table D-1
ECM8 Hardware Register Offsets

Offset	Channel	Register
0	1	D/A LSB
1	1	D/A MSB
2	1	Relays
3	1	Spare
4	2	D/A LSB
5	2	D/A MSB
6	2	Relays
7	2	Spare
8	3	D/A LSB
9	3	D/A MSB
A	3	Relays
B	3	Spare
C	4	D/A LSB
D	4	D/A MSB
E	4	Relays
F	4	Spare
10	5	D/A LSB
11	5	D/A MSB
12	5	Relays
13	5	Spare
14	6	D/A LSB
15	6	D/A MSB
16	6	Relays
17	6	Spare
18	7	D/A LSB
19	7	D/A MSB
1A	7	Relays
1B	7	Spare
1C	8	D/A LSB
1D	8	D/A MSB
1E	8	Relays
1F	8	Spare
20	NONE	UPDATE

Table D-2
Bit Assignments in the ECM8 Relay Registers

Bit 0	Galv_Corr	A one in this bit closes KX09. This relay should only be closed on inactive cells. KX09 shorts together the counter and working electrodes of the cell. This allows galvanic corrosion to occur.
Bit 1	Work_GND	A one in this bit closes KX08. This relay should only be closed on inactive cells. KX09 connects the working electrode to ground. If Local_Pstat is also high for channel X, cell X is potentiostatted by the local potentiostat.
Bit 2	Local_Pstat	A one in this bit closes KX07. This relay should only be closed on inactive cells. KX07 connects the cell's counter electrode to the output of the local potentiostat. Work_GND must also be high on channel X for the potentiostat to work properly.
Bit 3	Aux_A/D	A one in this bit closes KX05 and KX06. This connects the Aux A/D cable of channel X to the Aux A/D input of the driving potentiostat. This bit is normally set along with the Active bit for the channel.
Bit 4	Active	A one in this bit closes KX01, KX02, KX03, KX04, AND KX10. This connects cell X to the system potentiostat.

Normal Operating modes have the bit patterns in Table D-3.

Table D-3
ECM8 Operating Mode Bit Patterns

Mode	High Signals	Hex code
Active Cell	Aux_A/D and Active	18
Inactive—Open circuit	None	00
Inactive—Local Potentiostat	Local_Pstat and Work_GND	06
Inactive—Galvanic Corr.	Galv_Corr	01

The UPDATE register address generates a strobe to update all the local potentiostat D/A converters simultaneously. This location can be read or written to. The data written or read are unimportant. This register is not generally accessed directly by an applications program. Instead it is accessed by the ECM8's controller as part of the U (update) command processing.

General ECM8 Firmware Description

On power up, the ECM8 generates zeros to all 32 hardware registers, clears the error flags, and accesses the D/A Update address. The net result is to open all cells and set all the D/A converters to zero volts. It then issues a Ready prompt and awaits commands as described below.

Software commands for the ECM8 are in alphanumeric ASCII. The protocol is as follows:

On power up and at the successful conclusion of each command, the ECM8 issues an asterisk (*). If the ECM8 detects an error, it returns a question mark in place of the asterisk. The question mark for an error is only output once for any error condition. The controlling program normally executes an E (error) command to discover the source of the error. Either the (*) or (?) indicates a Ready condition, with the ECM8 ready for more input. The system computer should not send a new command until a ready prompt is received.

Commands are sent to the ECM8 as ASCII strings terminated by a line-feed. All control characters other than tab and line-feed are ignored. Uppercase and lowercase alphabetic characters, numeric characters, and the ASCII space character are also valid. One or more ASCII tab or space characters separate fields within a command.

With the exception of the E (error) command and the V (version) command, commands do not generate output from the ECM8, other than the Ready (*) or Error indications (?). The E and V commands generate a hex number, which is terminated with a carriage-return line-feed combination. After the carriage-return line-feed, the normal Ready indication is generated.

All numbers input or output are in uppercase hex (0,1,2...,A,B,C,D,E,F).

Hardware-setting commands do not cause an immediate change in the hardware. Instead they generate a change in a region of the ECM8 micro-controller RAM that shadows the register contents. Changes to the RAM are not output to the hardware until a U (update) command is received.

Commands

E   Error

The error command is used to determine the source of an error. It is generally issued after an Error indication in the ready prompt. The E command clears the error flags.

The ECM8 responds to the E command by transmitting a two-character ASCII string corresponding to the error flags register. The contents of the register are expressed in uppercase hex. The string is terminated by a CR-LF and the normal Ready prompt.

The error flags register contains the following bits.

Syntax Error   Bit 0.   Code 0x01.
                This bit is set whenever the input string cannot be decoded as a valid ECM8 command.

Out of Range   Bit 2   Code 0x04.
                A parameter is received that is outside the allowed range. Examples include a register address greater than 1F or a data byte with more than two hex characters.

Overrun   Bit 3   Code 0x08.
                RS-232 input has exceeded the buffer size in the ECM8.

I   Initialize

The initialize command resets the ECM8 to the power on condition. Zeros are output to the I/O registers, the error flags are cleared, and a ready prompt is output.

N   Nul

The nul command is used to check for a ready status when the previous ready prompt has been lost. The ECM8 responds to the nul command by issuing a ready prompt.

R   Register

The register command works with the update command to perform the actual ECM8 control functions. Typically, one or more changes in the hardware settings are requested via register commands. All of the accumulated changes then happen via an update command.

The syntax of the register command is

        R XX YY

XX is a register offset in ASCII hex. Its allowed range is zero to 1F. Both digits must be transmitted.

YY is the new register contents in ASCII hex. Its allowed range is zero to FF. Both digits must be transmitted.

The register command does not actually write to the ECM8 hardware. It simply stores the new value in a RAM shadow of the hardware.

U   Update

The update command is used to write the shadow RAM registers to the ECM8 hardware. When this command is received, the data are written as quickly as possible and the UPDATE address location is accessed to update the D/A converters.

V   Version

The controlling computer uses the version command to determine the revision level of the ECM8 hardware. The ECM8 responds to the version command with a two-byte uppercase ASCII string. The string contains a byte number expressed in hex.

Appendix E: Grounding and Floating Operation

Overview

As shipped from the factory, the ECM8 has not been configured for use with "floating" potentiostats. As you can see from the specifications, in normal operation all the electrodes except the counter electrode are limited to potentials ±12 V versus the ECM8 chassis ground. The ECM8 chassis is connected to the protective earth line in the power cord, so the potential is limited to ±12 V versus earth ground.

This limitation prevents the ECM8 from working with cells where the counter electrode must be earth-grounded. Some autoclaves use the earth-grounded wall of the autoclave as the counter electrode. You should be able to use the ECM8 with cells that have an earth-grounded working electrode, as long as the potentials of the ECM8's earth ground and the cell's earth ground are reasonably close together.

The ground pin on the ECM8's potentiostat connector is not connected to the ECM8's chassis ground. It is quite possible to have a several-volt difference between these grounds without any adverse effects on measurements made through the ECM8. Larger ground differences are likely to cause a violation of the ±12 V electrode-to-chassis-ground limitation.

> ⚠️ **Warning:** It is very dangerous to defeat the ECM8's connection to the protective earth ground. The earth-ground protection is there for operator safety in case of a severe power-supply problem with the instrument. Even if you do break the earth-ground connection in the AC power cord, the RS-232 connection usually re-establishes an earth ground.

If you really need to multiplex cells with earth-grounded counter electrodes, see the next section. It tells how you can move jumpers in the ECM8 to remove the ±12 volt limitation. Unfortunately, this change also disables the local potentiostats in the ECM8.

Disabling the ECM8 Local Potentiostats

Under many circumstances, the ECM8 cannot operate with cells that contain earth-grounded electrodes. See the Overview above. The reference-electrode connection in the ECM8's local potentiostats is the cause of the problem.

Fortunately, you can disable the local potentiostats, thereby eliminating the problem with floating operation. Disable the local potentiostats by moving eight jumpers inside the ECM8 chassis. Follow these instructions to disable the ECM8's local potentiostats:

1. First, remove the ECM8 power cord from the ECM8's rear-panel power-entry module.

> ⚠️ **Warning:** Dangerous voltages are exposed if the ECM8 chassis is open with the power cord connected to a source of AC power. To prevent a shock hazard that could result in personal injury or even death, always unplug the ECM8 from its AC power source before removing any panel or cover.

2. The ECM8 top cover is held in place by one screw at the middle rear of the cover. Remove this screw, making sure that you do not lose it.

3. Slide the ECM8 top cover backwards and off the chassis. You may need to loosen (do not remove!) the set of screws on one side of the ECM8 if the cover does not slide off easily.

4. All the ECM8 circuitry is contained on one large printed circuit board. All locations and directions are given assuming that you are looking over the ECM8's front panel towards the ECM8's rear panel.

   The local potentiostat jumpers are near the back of the instrument. There are eight jumpers, one for each channel. They are located in a gap within the "field" of relays on the ECM8 printed circuit board. There are also two jumpers on the right side of the ECM8's board.

> ⚠️ **Caution:** These jumpers are near the ECM8's microprocessor, a large 40-pin integrated circuit. **Do not change the position of these jumpers.**

   Each jumper is located on one side of a set of three pins. If the jumper is on the leftmost pair of pins, the local potentiostat is **enabled**. If the jumper is on the rightmost pair of pins, the local potentiostat is **disabled**.

5. If you need local potentiostat operation and don't need floating operation, move the jumper on each channel to the left side. If you need floating operation and don't need the local potentiostats, move the jumper to the right side.

   You can enable the local potentiostat on some channels and disable it on others.

6. Replace the ECM8 top cover and its retaining screw.

7. Replace the ECM8 power line cord.

8. If you have disabled some or all of the ECM8's local potentiostats, we recommend that you label the outside of your ECM8 to show that you have done this.

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