

**ECM8™**  
**Electrochemical Multiplexer**  
**Operator's Manual**

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## If You have Problems

Contact us at your earliest convenience. We can be contacted via:

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If you write or fax us about a problem, provide as much information as possible.

If you have problems in installation or use of the software, it would be helpful if you called 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 ECM8 Electrochemical Multiplexer. Reasonable support includes telephone assistance covering the normal installation, use and simple programming for the ECM8 on standard AT compatible computer hardware.

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 and its software library 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.

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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.

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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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## Chapter 1 -- Safety Considerations

Your ECM8 Electrochemical Multiplexer has been 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 you should inspect it for evidence of shipping damage. If any damage is noted, please notify Gamry Instruments Inc. and the shipping carrier immediately. Save the shipping container for possible inspection by the carrier.

### Warning

**The protective grounding can be rendered ineffective if the ECM8 is damaged in shipment. Do not operate 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. Do not negate the protection of this 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.

### Warning

**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 electrical outlet type. 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. They 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. The ECM8 can be set for one of four voltages - 100 Vac, 120 Vac, 220 Vac and 240 Vac.

### 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 Vac or 120 Vac into an outlet supplying a higher voltage such as 220 Vac. 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 will 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 Vac
120	108 to 132 Vac
220	200 to 240 Vac
240	220 to 260 Vac

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 section of this chapter titled **Changing the Line Voltage Selection** 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 should be used for each AC line voltage setting. The ECM8 uses "European Style" 5mm by 20mm cylindrical fuses. Slow blow 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.

### Warning

**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.**

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.

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

Nominal Setting	Fuse
100	1 Amp
120	1 Amp
220	1/2 Amp
240	1/2 Amp

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 Powerline 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 will 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) Locate 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) Note that the line voltage selection (120 Vac, 240 Vac, etc.) is written on a plastic cylinder in the AC input module. Gently rotate this cylinder so that your desired line voltage selection will appear 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 Vac, or changing between 220 and 240 Vac, 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. Once a fuse holder is up about 1 cm you can grab it with your fingers and remove it. The fuse's value will be 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 will 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) Locate 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 your screwdriver to gently pry up the plastic portion of the fuse holders. Once the fuse holders are up about 1 cm you should be able to grab them with you 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.

### Warning

**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.

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 excessive temperature rise occurs.

### 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.

Note that there are limit conditions on the storage, shipping and operation of this equipment. The ECM8 has not been 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
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#### 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.

Clean the outside of the ECM8 enclosure with a rag dampened with either clean water or water containing a mild detergent. Do not use a wet rag or allow water 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). You should refer all service to a qualified service technician.

### Warning

**The ECM8 multiplexer must not be operated 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 AC power cord 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 from jury-rigged multiplexers built from general-purpose switch boxes.

The ECM8 has been integrated into all Gamry Instruments' electrochemical applications that run under the Gamry Framework. It allows many of the DC105 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 amps of current. An optional library of control routines is available on request. These routines are written for Microsoft C running on an AT compatible personal 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

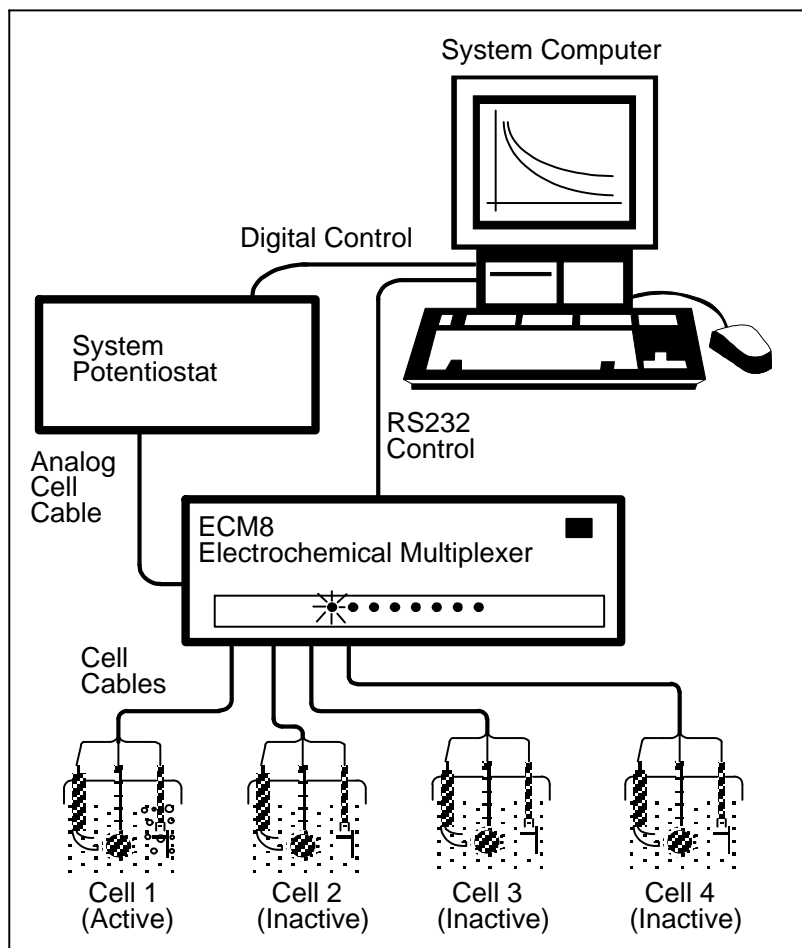
Remember, the material in this chapter is only an overview. If you are using your ECM8 with Gamry Instruments software this overview should give you sufficient understanding to make intelligent use of your ECM8.

## 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 will be shown in bold type. These keywords will be 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 RS232 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 8 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 RS232 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 RS232 connection, an IEEE484 connection, or even analog signals from a D/A and A/D computer interface sent to an analog potentiostat. Once 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 amps allowing use of the ECM8 with most high performance potentiostats. Of course the ECM8 works well with the Gamry Instruments' PC4 and PCI4 Families of Potentiostat/Galvanostat/ZRAs.

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.

The computer in Figure 2-1 does not have to be an IBM compatible. You can use any computer capable of controlling a potentiostat and having an RS232 port. However, the optional C Library routines can only be linked with a Microsoft C program running on an IBM compatible computer.

## Keyword Definitions

The following key terms will be used throughout this manual.

### Active Cell

The active cell is the cell (if any), which is 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 will be used when only the cell-switching portion of a channel is being discussed.

### Inactive Cell

The term inactive cell refers to 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 is used to describe this choice of control mode for inactive cells.

### Local Potentiostat

A simple low current potentiostat used to maintain 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 fully featured computer controlled instrument.

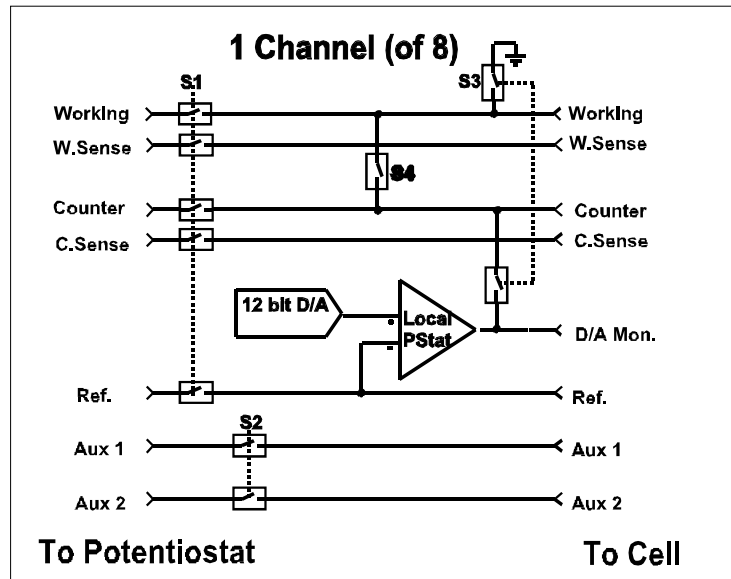
## Switching and Inactive Cell Control

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.

Each of the eight ECM8 channels is made up from 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.

Figure 2-2  
Simplified Schematic of One ECM8 Channel



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 Amps and switch 1 Amp. You can normally use the ECM8 with potentiostats rated at up to 100 volts of output compliance and 2 Amps of output current.

To avoid transients, you should 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 8 pairs of uncommitted contacts to a common input/output connector. The most common use for this set of contacts is to multiplex 8 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 3 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 op amp 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 op amp. 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.

NOTE: 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 outputting  $\pm 30$  milliamps at up to  $\pm 12$  volts. 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  $\pm 12$  volts with respect to the ECM8 chassis voltage. This is true in all operating modes including the active mode. You can damage the local potentiostat's amplifier if the reference electrode potential exceeds  $\pm 24$  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  $\pm 5$  volts. 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 volts (working versus reference electrode potential) the rear panel monitor will show a voltage of -1.2 volts.

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 due to 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  $\Omega$ . A good ZRA is much better in this regard, with electrode-to-electrode impedances in the low m $\Omega$ .

## Communications Overview

The system computer communicates with the ECM8 via an RS232 connection. RS232 is a very popular serial communications standard. Often computer manufacturers refer to RS232 ports simply as serial ports. In the world of IBM compatible computers, RS232 ports are known as COM ports. Windows, as a result of its MS-DOS heritage, supports 4 to 8 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 RS232 ports are available. In addition, USB to RS232 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 RS232 solution.

This manual refers to RS232 ports and connections when discussing ECM8 communications that are computer independent. It refers to COM ports when the discussion is specific to Windows computers.

RS232 communications can occur at various speeds, called baud rates. Both of the devices connected by an RS232 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 RS232 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.

RS232 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 RS232 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.

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

The ECM8 comes with an RS232 cable suitable for connection of an ECM8 to the 9 pin COM port on an IBM AT 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. These adapters are inexpensive and available at most computer retailers.





## Chapter 3 -- Installation

This chapter of the Gamry Instruments Inc. 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, you should check it for any signs of shipping damage. If any damage is noted, please notify Gamry Instruments, Inc. and the shipping carrier immediately. Save the shipping container for possible inspection by the carrier.

#### Warning

**The protective grounding can be rendered ineffective if the ECM8 is damaged in shipment. Do not operate 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

You can locate your ECM8 on a normal workbench surface. You will 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 flat 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. The Gamry Instruments part number for this kit is 990-00021. If you do 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 with the ECM8.

### Power Cord and Line Voltage Selection

Before you plug your ECM8 into the AC power line 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 rear panel. A small window on the AC power entry module displays the current line voltage setting. Table 3-1 shows the ranges or 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 Vac
120	108 to 132 Vac
220	200 to 240 Vac
240	220 to 260 Vac

### **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 Vac or 120 Vac into a outlet supplying a higher voltage such as 220 Vac . 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 One of this manual for detailed instructions on how to change the line voltage selection.

The AC line cord plugs into the AC power entry module on the upper right corner of the ECM8 rear panel. Once 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 you should 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 8 cell LEDs stay on after the ECM8 powers up, the ECM8 is malfunctioning.

### **Communications Test**

A special test script allows you to check communications between your computer and your ECM8. Connect the RS232 cable between the computer and the ECM8 and power up the ECM8.

Run the Gamry Framework. Select **Experimant, Named Script** on the Framework menu bar. In the dialog box, select "Multiplexer Test.exp".

In the Setup box for this script, select **Ok**. The channel LEDs on the ECM8 front panel should go on one at a time, starting with Channel 1 and ending with Channel 8. Each LED should be on for about one second.

If you get an error message or the script simply does not run:

- Check that the ECM8 is power on
- Check that the RS232 cable is installed on both ends
- Check that you are using the correct COM port on your computer

### **Connection to a Gamry Instruments PCI4 (or PC4) Potentiostat**

Connection of your ECM8 to a Gamry Instruments PCI4 potentiostat is quite simple. Gamry Instruments supplies a standard cable (P/N 985-00013) that properly connects the cell wires. This 1.5 m long cable is equipped with a male 9 pin D connector on each end.

#### **CAUTION**

**Do not substitute a generic 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 the generic cable is likely to create excessive noise and/or system oscillation.**

One end of this cable is connected to the ECM8 9 pin D connector labeled with the word POTENTIOSTAT. The other end connects to the PCI4 (or PC4) cell connector.

### **Connection to Gamry Instruments Reference 600**

Connection of your ECM8 to a Gamry Instruments Reference 600 potentiostat is quite simple. Gamry Instruments supplies a standard cable (P/N 985-00080) that properly connects the cell wires. This 1.5 m long 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 end.

#### **CAUTION**

**Do not 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 the generic cable is likely to create excessive noise and/or system oscillation.**

Note that the Reference 600 can identify the cable plugged into its cell connector. It will detect the presence of an ECM8 in your system. The Reference 600 cannot identify the cables used to connect the 8 individual cells to the ECM8.

EIS performance with an ECM8 and a Reference 600 will be optimal when all the cell cables used are 1.5 meter PCI4 type cables. All other cable may create phase and magnitude errors.

### **Connection to a Gamry Instruments FAS1 or FAS2 Femtostat**

Connection of your ECM8 to a Gamry Instruments FAS1 or FAS2 Femtostat is also simple. Gamry Instruments supplies an adapter (985-00062) that plugs into Gamry's a standard ECM8 interface cable (P/N 985-00080). This 20 cm long cable is equipped with a female 9 pin D connector on one end and color-coded FAS1 or FAS2 SMC type connectors on the other end. Note that Gamry's standard cell cable color conventions are used:

- Red for Counter Electrode
- Green for Working Electrode
- White for Reference electrode.

### **Connection to a 3rd Party Potentiostat Galvanostat**

Connecting the ECM8 to a 3<sup>rd</sup> party potentiostat/galvanostat is more of a problem. You will have to build a custom cable. See Appendix C of this manual for the pin out of the ECM8 potentiostat connector and for cable construction hints. 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. Only one cell cable is normally supplied with an ECM8.

The ECM8 cell connectors have the same pin out as the cell connector on the Gamry Instruments, Inc. PCI4 (and PC4) Potentiostat/Galvanostat.

Cell cables developed for PCI4 are therefore usable with the ECM8.

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 3<sup>rd</sup> 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, 4m and 9 m cables are available with banana plug/alligator clip termination. Specialized cables are also available, including cables designed for connection to standard 3 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.

## Appendix A -- ECM8 Specifications

Specifications apply at 25°C, 116 Vac power, and operation with PCI4 Potentiostat unless otherwise noted.

### Channel Characteristics

Modes	Active, Off, Local, Shorted	
Channel Switching Time	< 10 msec	Excluding RS232 communication time
Cell Current	2 Amps 1 Amp	maximum carried maximum switched
Input Voltage (operating)	± 12 volts	Measured versus ECM8 chassis ground.
Input Voltage (no damage)	± 24 volts	Measured versus ECM8 chassis ground.
Counter Electrode Voltage	± 120 volts	Measured versus ECM8 chassis ground.

### Channel Isolation

Current Leakage	< 2 nA max	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 volts	1 kΩ load
Applied E Range	± 5.12 Volts	Working versus Reference
Resolution	2.5 mV/bit	
Zero Offset Error	< 4 mV typical < 10 mV max	0 volts 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.

### RS232 Communications

Baud Rates	300, 600, 1200, 2400, 4800, 9600, 19200	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 Variation	± 10%	All ranges
Power	< 50 VA	Worst case

### Environmental

Operating Temperature	0 to 440 °C
Humidity	0 to 90% noncondensing

*Appendix A -- ECM8 Specifications--*

## Appendix B -- Changing The Baud Rate Setting

The ECM8 Electrochemical Multiplexer is factory set for RS232 communications at 9600 baud. This setting should be suitable for the vast majority of applications.

If you must change the ECM8 baud rate you can do so by changing DIP switches inside the ECM8 case. Follow these instructions:

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

### WARNING

**Dangerous voltages are exposed if the ECM8 chassis is opened 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 it does not get misplaced.
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 will 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's easy to find.
5. Refer to 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
19200	on	on	off	off

6. Set the switches per Table B-1.
7. Replace the ECM8 top cover and its retaining screw.
8. Replace the ECM8 power line cord. The new baud rate will become effective the next time the ECM8 is powered up.

*Appendix C -- I/O Connections for the ECM8--*



## Appendix C -- I/O Connections for the ECM8

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

### The Cell Connectors

The 8 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 8 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. This exception is 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 PCI4, 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. This table can be used for PCI4 all connections regardless of operating mode.

**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 can 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, these terminals should be left 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 due to AC pickup at the cell. This Faraday shield should generally be connected to both black cell leads.

You can add an alligator clip (provided) to each of the cell connection. 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 do decide to make your own cables, we recommend that you use coax cable for all the cell connections. Connect the shield of the coax to the pin recommended in Table C-1 on the PCI4 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	Only needed with a PCI4 style potentiostat. 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.

## Cabling the ECM8 to a Gamry Instruments PCI4 Potentiostat

Gamry Instruments provides a cable (P/N 985-00013) for connection of the ECM8 to the cell connector on a PCI4 (or PC4) Potentiostat/Galvanostat/ZRA. This cable is included with all ECM8s. It is a fairly thick cable equipped with a male 9 pin D connector on each end.

### CAUTION

**Do not substitute a generic 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 the generic cable is likely to create excessive noise and/or system oscillation.**

## Cabling the ECM8 to Third Party Potentiostats

The cable required for connection to third party potentiostats will vary 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 does use shielded wire, you should 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, the working sense pin on the ECM8 can be left open.
- You can ignore the counter sense pin on the ECM8 connector (unless the cable is intended for use with a Gamry Instruments PC4 or PCI4). Leave this pin disconnected.

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

## RS232 Connector

The ECM8 RS232 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 will 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 will not transmit data if this line is not asserted.

The ECM8 has been found to work with cables designed for connection of a computer to a modem.

## Appendix D -- RS232 Commands

### General Hardware Description

Before you can use the ECM8 RS232 commands you need to understand the ECM8's hardware organization. The ECM8 is a special purpose 8-channel multiplexer. Switching is done via banks of relays. Each of 8 channels can be connected to a computer-controlled potentiostat (typically the Gamry Instruments' PCI4). 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 8-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 8-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.

**Important Note: 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 RS232 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  $\pm 5.12$  volts. 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  $\pm 2047$ .

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, eg 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. KX08 connects the working electrode to ground. If Local_Pstat is also high for channel X, cell X will be potentiostated 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 is 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 will output zeros to all 32 hardware registers, clear the error flags, and access the D/A Update address. The net result is to open all cells and set all the D/A converters to zero volts. It will then issue a Ready prompt and await 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 will issue an asterisk (\*). If the ECM8 detects an error, it will return 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 will normally execute 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 alpha 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 linefeed combination. After the carriage return line feed, the normal Ready indication is output.

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 will generally be 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 2 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 has been received that is outside the allowed range. Examples include a register address greater than 1F or a data byte with more than 2 hex characters.

Overrun            Bit 3    Code 0x08.

RS232 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 is 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 -- Grounds 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  $\pm 12$  volts 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  $\pm 12$  volts versus earth ground.

This limitation will prevent 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  $\pm 12$  volt electrode to chassis ground limitation.

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 RS232 connection will usually reestablish 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  $\pm 12$  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 above discussion. 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. This is done by moving 8 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 opened 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 it does not get misplaced.
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 will see that all the ECM8 circuitry is contained on one large printed circuit board. All locations and directions will be 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.

CAUTION: There are also two jumpers on the right side of the ECM8's board. They 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 have the local potentiostat enabled on some channels and disabled 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 this has been done.

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