

# **Model 283**

# **Potentiostat/Galvanostat**

**User's Guide**

**Advanced Measurement Technology, Inc.**  
a/k/a Princeton Applied Research, a subsidiary of AMETEK®, Inc.

# WARRANTY

Princeton Applied Research\* warrants each instrument of its own manufacture to be free of defects in material and workmanship. Obligations under this Warranty shall be limited to replacing, repairing or giving credit for the purchase price, at our option, of any instrument returned, shipment prepaid, to our Service Department for that purpose within ONE year of delivery to the original purchaser, provided prior authorization for such return has been given by an authorized representative of Princeton Applied Research.

This Warranty shall not apply to any instrument, which our inspection shall disclose to our satisfaction, to have become defective or unworkable due to abuse, mishandling, misuse, accident, alteration, negligence, improper installation, or other causes beyond our control. This Warranty shall not apply to any instrument or component not manufactured by Princeton Applied Research. When products manufactured by others are included in Princeton Applied Research equipment, the original manufacturer's warranty is extended to Princeton Applied Research customers.

Princeton Applied Research reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF. 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 PRINCETON APPLIED RESEARCH, INCLUDING, BUT NOT LIMITED TO, SPECIAL OR CONSEQUENTIAL DAMAGES. NO PERSON, FIRM OR CORPORATION IS AUTHORIZED TO ASSUME FOR PRINCETON APPLIED RESEARCH ANY ADDITIONAL OBLIGATION OR LIABILITY NOT EXPRESSLY PROVIDED FOR HEREIN EXCEPT IN WRITING DULY EXECUTED BY AN OFFICER OF PRINCETON APPLIED RESEARCH.

## SHOULD YOUR EQUIPMENT REQUIRE SERVICE

A. Contact the Customer Service Department (865-482-4411) or your local representative to discuss the problem. In many cases it will be possible to expedite servicing by localizing the problem.

B. If it is necessary to send any equipment back for service, we need the following information.

1. Model number and serial number.
2. Your name (instrument user).
3. Your address.
4. Address to which the instrument should be returned.
5. Your telephone number and extension.
6. Symptoms (in detail, including control settings).
7. Your purchase order number for repair charges (does not apply to repairs in warranty).
8. Shipping instructions (if you wish to authorize shipment by any method other than normal surface transportation).

C. U.S. CUSTOMERS — Ship the equipment being returned to:

Advanced Measurement Technology, Inc.      PHONE: 865-482-4411  
801 S. Illinois Avenue                      FAX: 865-483-2133  
Oak Ridge, TN 37831  
ATTN: Customer Service

D. CUSTOMERS OUTSIDE OF U.S.A. — To avoid delay in customs clearance of equipment being returned, please contact the factory or the nearest factory distributor for complete shipping information.

---

Copyright © 2002, Advanced Measurement Technology, Inc. All rights reserved.

\*Princeton Applied Research is a registered trademark of Advanced Measurement Technology, Inc. All other trademarks used herein are the property of their respective owners.

# TABLE OF CONTENTS

Safety Instructions and Symbols .....	vii
Cleaning Instructions .....	vii
1. INTRODUCTION .....	1
1.1. Overview .....	1
1.2. Controlling the Model 283 .....	1
1.2.1. Front-Panel Control .....	1
1.2.2. Remote Computer Control .....	1
1.3. Operating Modes .....	2
1.3.1. Potentiostatic .....	2
1.3.2. Galvanostatic .....	2
1.4. About This Manual .....	3
2. Safety Considerations .....	5
2.1. Overview .....	5
2.2. Power Cord .....	5
2.3. Line Voltage .....	5
2.3.1. Introduction .....	5
2.3.2. Confirming the Line Voltage Setting .....	5
2.3.3. Line Voltage Selection .....	6
2.3.4. Changing Fuse .....	6
2.4. Cell Safety .....	6
2.5. Defects and Abnormal Stresses .....	6
2.6. Ventilation .....	7
3. Installation & Initial Checks .....	9
3.1. Introduction .....	9
3.2. Installation .....	9
3.2.1. Inspection .....	9
3.2.2. Power Cord Plug .....	9
3.2.3. Location .....	9
3.2.4. Power Voltage Selection and Line Fuses .....	9
3.3. Initial Checks Procedure .....	10
3.3.1. Introduction .....	10
3.3.2. Connections .....	10
3.3.3. Power-Up and Cell Safety .....	11
3.3.4. Procedure .....	11
4. Front Panel .....	15
4.1. Introduction .....	15
4.2. Cell Group .....	15
4.2.1. Introduction .....	15
4.2.2. COUNTER .....	15
4.2.3. WORKING .....	19
4.2.4. REFERENCE .....	19
4.2.5. SENSE .....	19
4.2.6. OVERLOAD Indicators .....	20
4.2.7. CELL Indicator .....	20
4.2.8. CELL ON Key .....	20
4.3. Display/Control Group .....	20
4.3.1. Introduction .....	20
4.3.2. Mode key .....	21

4.3.3.	System key	21
4.3.4.	LCD Display	22
4.3.5.	F1 Through F5 Function keys	23
4.3.6.	Value knob	23
4.3.7.	Prev and Next Parameter keys	23
4.4.	Interface Group	23
4.5.	Current Range Group	24
4.5.1.	Introduction	24
4.5.2.	Full-Scale Current Range Indicators, 100 mA through 1 nA	24
4.5.3.	↑↑ key	24
4.5.4.	↓↓ key	24
4.5.5.	AUTO Switch and Indicator	24
4.6.	BNC Connectors	25
4.6.1.	Introduction	25
4.6.2.	EXT IN	25
4.6.3.	E MONITOR	26
4.6.4.	I MONITOR	26
4.6.5.	MUX	26
4.6.6.	A/D INPUT 1 & A/D INPUT 2	27
4.6.7.	OUTPUT	27
4.6.8.	D/A OUTPUT	27
4.7.	Gnd Connector	27
4.8.	Cell Safety Switch	27
4.9.	Dummy Cell Connectors	27
4.10.	Power Switch	28
5.	Back Panel	29
5.1.	Introduction	29
5.2.	Power Input	29
5.3.	Accessory Power	29
5.4.	Auxiliary Interface	29
5.5.	RS-232 Connector	30
5.6.	IEEE-488 Connector	30
5.7.	PA Monitor	30
5.8.	A & B Connectors	30
5.9.	Expansion Interface	30
6.	Getting Started	31
6.1.	Introduction	31
6.2.	Polarity Convention	31
6.3.	Operating Modes	32
6.3.1.	Introduction	32
6.3.2.	Potentiostatic	32
6.3.3.	Galvanostatic	32
6.3.4.	Scanning and Stepping Transitions	32
6.4.	Controls and Indicators	33
6.5.	Using the LCD Menu Screens	33
6.5.1.	Introduction	33
6.5.2.	Common Screen Elements	34
6.5.3.	Setting Parameters	34
6.5.4.	Bottom Row Functions	34
6.6.	Setting Communications Parameters	35
6.6.1.	Introduction	35
6.6.2.	[System Interface] Menu Screen	35
6.6.3.	[System Interface] Menu Line 3 Parameters	35
6.7.	Common Experiment Parameters	36
6.7.1.	[System Default] Menu Screen	36
6.7.2.	[System Default] Menu Line 3 Parameters	37

6.8. Resetting Parameters to Default Values	38
6.8.1. Introduction	38
6.8.2. To reset only the experiment parameters	39
6.8.3. To reset both groups of parameters	39
6.9. Calibrating the Model 283	39
6.10. Determining Installed Options	40
6.11. Error Messages	40
6.12. Connecting a Pen Recorder or Oscilloscope	42
6.13. Adding an External Signal	43
6.14. Connecting a Model 303A SMDE	43
6.15. Connecting a Model 616 or 636 Rotating Electrode	43
6.16. Supplying Accessory Power	44
7. Running Potentiostatic Experiments	45
7.1. Introduction	45
7.2. Potentiostatic Modes	45
7.3. Setting Fixed-Potential Experiment Parameters	46
7.4. Setting Scanned-Potential Experiment Parameters	47
7.5. Setting Stepped-Potential Experiment Parameters	47
7.6. Running Your Experiment	48
7.6.1. Introduction	48
7.6.2. F1 (Coulombs or offset I)	48
7.6.3. F2 (Q-Reset)	48
7.6.4. F3 (Start or Stop)	48
7.6.5. F4 (Hold or Resume)	48
7.6.6. F5 (Reverse or Bypass)	49
7.7. Error Messages	49
8. Running Galvanostatic Experiments	51
8.1. Introduction	51
8.2. Galvanostatic Modes	51
8.3. Setting Cell Current: Special Considerations	52
8.4. Setting Cell Current in a Fixed-Current Experiment	52
8.5. Setting Scanned-Current Experiment Parameters	52
8.6. Setting Stepped-Current Experiment Parameters	53
8.6.1. Introduction	53
8.6.2. F1 (Coulomb or offset I)	53
8.6.3. F2 (Q-Reset)	53
8.6.4. F3 (Start or Stop)	54
8.6.5. F4 (Hold or Resume)	54
8.6.6. F5 (Reverse or Bypass)	54
8.7. Error Messages	54
9. Circuit Description	55
9.1. Introduction	55
9.2. Potentiostat Operation	55
9.3. Galvanostat Operation	57
9.4. Signal Conditioning	59
9.5. Ancillary Functions	59
9.5.1. E & I Suppression	59
9.5.2. Auxiliary Inputs	59
9.5.3. Output DACs	59
10. Maintenance and Service	61
10.1. Introduction	61
10.2. Battery Replacement	61
10.3. Service	61

APPENDIX A. Specifications .....	63
APPENDIX B. Technical Reference .....	65
B.1. Introduction .....	65
B.2. Front-Panel Parameters and Commands .....	65
APPENDIX C. Connector Pinouts .....	85
C.1. Auxiliary Interface (Mating Connector DB9S) .....	85
C.2. Accessory Power Connector .....	86
C.3. IEEE-488 GPIB Interface .....	87
C.4. RS-232C Interface .....	87
C.5. Expansion Interface .....	88
APPENDIX D. Model 398 Impedance Plots .....	89
D.1. Introduction .....	89
D.2. Plots .....	89
INDEX .....	95

# Safety Instructions and Symbols

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

**DANGER** Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.

**WARNING** Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

**CAUTION** Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

## Cleaning Instructions

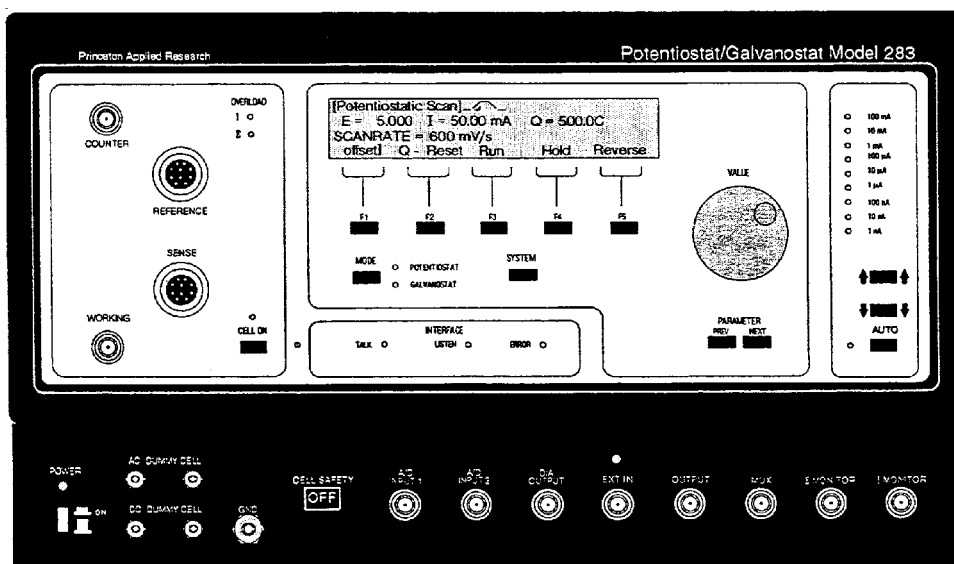
**WARNING** Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

To clean the instrument exterior:

- Unplug the instrument from all voltage sources.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

**CAUTION** To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

- Allow the instrument to dry before reconnecting the power cord.




---

## FCC NOTICE

This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with this manual, may cause interference to radio communications. As temporarily permitted by regulation, operation of this equipment in a residential area is likely to cause interference, in which case the user at his own facility will be required to take whatever measures may be required to correct the interference.

---



# 1. INTRODUCTION

---

## 1.1. Overview

The Princeton Applied Research Model 283 Potentiostat/Galvanostat is a powerful and versatile instrument for the electrochemistry researcher. It can be controlled either directly from its front panel or from a personal computer.

This instrument uses the latest design advances to provide high performance, ease of use, and great versatility in electrochemical measurements. Its  $\pm 80$  V compliance and  $\pm 100$  mA output capability allow rapid and accurate potential or current control in virtually any electrochemical cell. Component selection, shielding, grounding, and circuit design are all carefully optimized for minimum internal electronic noise, giving high sensitivity and a quiet output signal. Low-pass filters virtually eliminate noise arising in the cell itself.

A high-performance current-to-voltage converter circuit is included for accurate, rapid, low-drift current measurements, free of degradation from cell-cable resistance, capacitance, and inductance. The new self-calibration in the Model 283 feature assures the accuracy of your data, while BNC connectors conveniently placed on the front panel make all signals of interest available for analog recording.

---

## 1.2. Controlling the Model 283

### 1.2.1. Front-Panel Control

You can conduct a wide variety of static or scanning experiments directly from the front panel of the Model 283. Its controls have been ergonomically designed for ease of use and maximum flexibility. The large, convenient parameter input knob, pushbuttons, and alphanumeric liquid crystal display streamline the process of setting up your experiment.

After the experiment begins, the display panel presents continuously updated information on its progress, including the parameters in effect and the cell voltage and current. A simple touch of a button implements such advanced features as automatic current ranging and current-interrupt iR compensation.

### 1.2.2. Remote Computer Control

For even greater versatility, you can control the Model 283 from a personal computer via an IEEE-488 (GPIB) or RS-232 interface. This enables you to take advantage of the Electrochemical Command Set, a group of over 100 mnemonic software instructions that make it easy to create your own experiments. The Electrochemical Command Set, which is built into the Model 283's read-only memory, has been specifically developed for research electrochemistry, dc corrosion measurements, and electrochemical impedance measurements. These commands place unprecedented flexibility in the hands of the electro chemist. They provide:

- Access to most Model 283 front-panel functions.
- Control of all timing functions.
- Application of pulse and staircase waveforms.
- Automatic acquisition of data with or without current auto-ranging.
- Data averaging in real-time.
- Internal storage and arithmetic data manipulation on your lab computer.

These commands and all necessary instructions for operating the Model 283 from an external computer are described in the separately bound *Model 283 Command Set Handbook*.

The Instruments HeadStart™ Creative Electrochemistry Software - included free with the Model 283 - provides a simple way to access the Electrochemical Command Set. HeadStart is easy to use and runs on any IBM PC or fully compatible personal computer. To learn how to use it, refer to the HeadStart instruction manual included with the Model 283.

The Model 283 is also completely compatible with the standard PARI electrochemical software. So you can also run your experiments with any of our dedicated software packages, such as the Model 270/250 Research Electrochemistry Software, the Model 352 Corrosion Measurement and Analysis Software, or the Model 398 Impedance Software running on an IBM PC or fully compatible computer connected to the Model 283.

When controlled by HeadStart or any of the standard PARI electrochemical software, the Model 283 can control the on/off status and speed of a Model 616 or 636 Rotating Electrode System or send Purge, Stir, and Dispense signals to the Model 303A Static Mercury Drop Electrode.

The Model 283 is fully equipped to conduct experiments controlled from your computer. It includes:

- A 14-bit digital-to-analog convert for dc bias applications.
- A 16-bit digital-to-analog converter for versatile waveform generation.
- A 12-bit analog-to-digital converter to measure current and potential.
- An on-board microprocessor to perform the experiment defined by the Command Set.
- On-board memory to store the programmed parameters and data point values.

When the programmed experiment is finished, the data can be transferred to the computer for plotting or further processing.

---

## 1.3. Operating Modes

### 1.3.1. Potentiostatic

In this mode, the Model 283 controls the potential at the working electrode with respect to the reference electrode. The potential at the counter electrode is driven to the potential required (consistent with the  $\pm 80$  V compliance of the control amplifier) to establish the desired working electrode potential. The range over which the working electrode potential can be controlled is  $\pm 10$  V, of which  $\pm 8$  V can be used in a single experiment.

### 1.3.2. Galvanostatic

In Galvanostatic operation, the Model 283 controls the current between the counter and working electrodes at the specified fraction of the selected current range (up to the maximum of two times the current range). The counter electrode is driven to the potential required (consistent with the  $\pm 80$  V compliance of the control amplifier) to establish the desired cell current. The reference electrode is not used in the control loop, but is usually used to measure the potential at some point in the electrochemical cell.

---

## 1.4. About This Manual

This *User's Guide* provides details of the physical and electrical characteristics of the Model 283, and describes how to operate it as a stand-alone instrument controlled from its front panel. Instructions for operating the unit remotely from a personal computer or workstation, via either the RS-232 or GPIB (IEEE-488) interface port, are given in the separately bound *Model 283 Command Set Handbook*. The *HeadStart Creative Electrochemistry Software Instruction Manual* shows you how to use HeadStart.

The *Model 283 Command Set Handbook* gives, in addition to the command descriptions, detailed explanations of GPIB (IEEE-488) and RS-232 communications and how to set the communications parameters. It also includes an application note on waveform programming, one of the most useful functions of the Model 283.

This User's Guide is organized into ten chapters and three appendices as follows.

- Chapter 1: Simple overview of the instrument
- Chapter 2: Important safety precautions for operating this instrument
- Chapter 3: Installation and a simple rote checkout procedure
- Chapter 4: Front-panel controls, connectors and indicator lights
- Chapter 5: Back panel
- Chapter 6: Operating considerations common to both potentiostatic and galvanostatic operation as well as basic experiment parameters that seldom require changing.
- Chapter 7: Potentiostatic experiments
- Chapter 8: Galvanostatic experiments
- Chapter 9: Circuit description
- Chapter 10: Maintenance and Service
- Appendix A: Specifications
- Appendix B: Technical Reference
- Appendix C: Connector Pinouts
- Appendix D: Model 398 Impedance Plots



# 2. Safety Considerations

---

## 2.1. Overview

This instrument has been supplied in a safe condition. To ensure its continued safe operation, please read the following sections.

---

## 2.2. Power Cord

For safe operation, the Model 283 must be electrically connected to earth ground through a suitable protective conductor. This connection is made via the earth ground prong of the Model 283's power cord plug. Thus the power cord plug must be inserted into a socket outlet provided with the required earth ground contact. The protective action must not be defeated by the use of an extension cord without a protective conductor, by use of an "adapter" that doesn't maintain earth ground continuity, or by any other means.

Wherever possible, the instrument is furnished with a power cord plug that is compatible with the type of power socket in use where the instrument will be operated. If you have to provide a power cord, it should be an approved type with a standard IEC connector at one end for connection to the Model 283.

**Warning!** *If it is necessary to replace the power cord or the power cord plug, the replacement cord or plug must have the same polarity as the original. Otherwise a safety hazard from electrical shock which could result in personnel injury or death, might result.*

The wires in the power cord supplied by PARI are color-coded to denote polarity. Whatever the actual plug configuration, the black wire should be the line or active conductor (also called "live" or "hot"), the white wire should be neutral, and the green wire should be earth ground.

---

## 2.3. Line Voltage

### 2.3.1. Introduction

Before plugging in the power cord, make sure that the Model 283 is set to the voltage of the ac power supply. The Model 283 is equipped with a tapped power transformer that allows operation over a wide range of possible line voltages. The transformer configuration is determined by the rear-panel Corcom power-input module, as explained in the following paragraphs.

**Caution!** The Model 283 may be damaged if it is set for operation from 110 or 120 V and operated from a source of 220 V or 240 V power.

### 2.3.2. Confirming the Line Voltage Setting

Look through the clear plastic cover on the ac power input module, located at the lower-right corner of the rear panel. Behind the plastic cover is the power line fuse and a small PC board. The line voltage for which the instrument is set is printed on the PC board in a position that is visible through the plastic cover.

If the Model 283 isn't set for the voltage available at your site, make the necessary changes in the selected voltage before connecting the 283 to a power source. Section 2.3.3, which follows, explains how this is done.

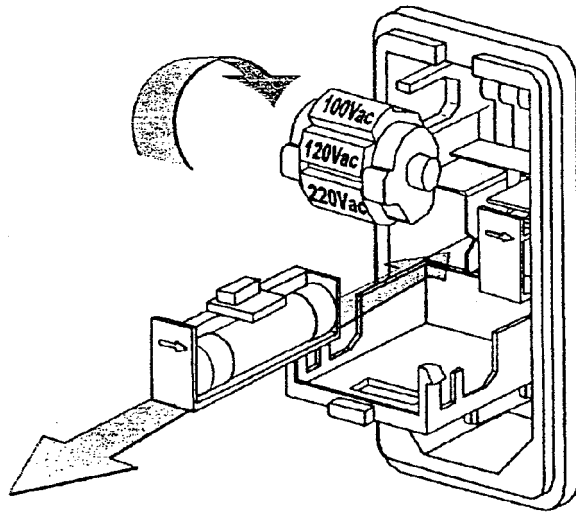


Fig. 2. Corcom Module.

### 2.3.3. Line Voltage Selection

To change selected voltage: disconnect the power cord; open cover of the power entry module on rear of the instrument using a small blade screwdriver or similar tool. Insert the tool into the voltage selection slot and remove wheel from unit; select desired voltage; replace wheel into unit and close cover, making sure the selected voltage appears in connector window. See Fig. 2.

### 2.3.4. Changing Fuse

To change the fuse: disconnect the power cord; open cover of the power entry module on rear of the instrument using a small blade screwdriver or similar tool. Remove fuse holder and replace fuse. If changing to the metric type fuse, change the fuse holder to the metric version and insert the proper fuse as specified in the manual. After replacing the fuse/fuse holder, insert the fuse holder into the unit and close cover. See Fig. 2.

---

## 2.4. Cell Safety

**Warning!** With a compliance of 80 V and the ability to deliver currents as high as 100 mA, the Model 283 is capable of delivering dangerous, even lethal, electrical shocks. Users must always exercise caution when connecting the cell cables or performing any operation that brings them into contact with cell potentials. Moreover, it is absolutely essential that the front-panel **CELL SAFETY** switch be in the **OFF** position whenever operations are being performed. Mat can bring the user into contact with cell potentials. The front-panel **CELL ON** key (small pushbutton just below the Cell On indicator) can be used to turn the cell connections on and off when the **CELL SAFETY** switch is **ON**. However, the **CELL ON** key should **NOT** be relied on for operator safety.

---

## 2.5. Defects and Abnormal Stresses

**Warning!** If your instrument has been damaged, its protective grounding may not work. Do not operate damaged equipment! Tag it to indicate to a potential user that it is unsafe to operate.

The ground protection is likely to be impaired if, for example, the instrument:

- Shows visible damage.
- Fails to perform the intended measurement.
- Has been subjected to prolonged storage under unfavorable conditions.
- Has been subjected to severe transport stresses.

The instrument should not be used until its safety has been verified by qualified service personnel.

---

## **2.6. Ventilation**

To maintain a safe operating temperature, it is necessary to allow some free space (minimum 10 cm) at the sides and rear of the instrument so that adequate air circulation can occur. Moreover, there must be adequate circulation between the space at the bottom and back of the instrument and the general laboratory circulation to allow effective cooling. In a typical installation, these requirements are satisfied with a large safety margin. If the Model 283 is operated in an enclosed space, some additional effort to assure adequate ventilation may be required.





# 3. Installation & Initial Checks

---

## 3.1. Introduction

This chapter guides you through installing the Model 283 and running through a simple rote test procedure using the internal 10 k $\Omega$  dc dummy cell. This demonstrates whether the 283 is functioning properly as well as helping acquaint you with the operation of the instrument. No special test equipment is required. The checks are adequate for determining that the instrument has arrived in good working order and is functioning normally. They are not intended to demonstrate that the instrument meets specifications. Each Model 283 receives a careful checkout before leaving the factory and, if no shipping damage has occurred, will perform within the limits of the specifications.

If any problems are encountered in carrying out these checks, contact the factory or the factory-authorized representative in your area for aid.

The check-out procedure in this chapter should not be construed as detailed operating instructions. Subsequent chapters discuss in detail the considerations germane to making successful measurements.

---

## 3.2. Installation

### 3.2.1. Inspection

Inspect your Model 283 for shipping damage. If any is noted, immediately notify PARI and file a claim with the carrier. Save the shipping container for inspection by the carrier.

**Warning!** *If you have received a damaged instrument, its protective grounding may not work. Do not operate damaged equipment! Tag it to indicate to a potential user that it is unsafe to operate.*

### 3.2.2. Power Cord Plug

The rear panel is equipped with a standard IEC 320 socket and a suitable power cord is supplied with the instrument.

### 3.2.3. Location

Before setting up and connecting your instrument, give some thought to finding a safe and convenient location for it. The Model 283 can be operated on almost any laboratory bench. With an ambient temperature range of 0°C to 45°C, it is highly tolerant to environmental variables, needing only to be protected from exposure to corrosive agents and adverse weather conditions.

**Note:** *Review the discussion of ventilation in Section 2.6, Ventilation, of Chapter 2, Safety Considerations.*

### 3.2.4. Power Voltage Selection and Line Fuses

Before plugging in the power cord, ensure that the Model 283 is set to the voltage of the ac power supply.

**Note:** *Review the discussion of line voltage selection in Section 2.3, Line Voltage, of Chapter 2, Safety Considerations.*

---

## 3.3. Initial Checks Procedure

### 3.3.1. Introduction

The following steps program the Model 283 to do a controlled-potential experiment on the internal 10 k $\Omega$  dummy cell resistor. A scan starting at 0 V, advancing to 1 V, and then returning to 0 V will be applied. The current in the resistor will track this voltage, starting at zero, increasing in the negative direction to -100  $\mu$ A, and then decreasing to zero again. A voltage corresponding to this current will appear at the I MONITOR connector. The current through the resistor and the voltage across it will be displayed throughout the experiment on the LCD panel.

**Note:** Analog components cannot be made to exhibit exactly their rated values, especially under varying temperature conditions. Thus analog components have tolerance ratings that specify acceptable ranges above and below their nominal values. The 10 k $\Omega$  dummy cell resistor, for example, has a very tight 0.01% tolerance, which means that its actual resistance in the circuit could be anywhere between 9,999 and 10,001  $\Omega$ . Also, residual drift or noise in the Model 283 itself can contribute a small additional deviation in both the current and potential indications. As a result of these uncertainty factors, the current indications on the LCD panel may vary a bit from the values stated in this procedure.

### 3.3.2. Connections

1. Before proceeding to the dummy cell connections, be sure that the **Cell Safety** switch, located near the bottom of the front panel adjacent to the A/D Input 1 connector, is in the OFF position. Note that this is a push-button toggle switch that changes state each time it is pressed. The state, **ON** or **OFF** is always displayed on the front of the switch.

**Note:** Review Section 2.4, Cell Safety, in Chapter 2, Safety Considerations.

2. Identify the four cell cables supplied with the instrument, as follows.

**Counter Electrode cable:** Coaxial cable with BNC connector at one end and a red pin jack and alligator clip at the other end.

**Working Electrode cable:** Coaxial cable with BNC connector at one end and a green pin jack and alligator clip at the other end.

**Reference Electrode cable:** Large diameter cable characterized by a gray grooved grip and 10 pin connector at one end and terminated in a pod having a white pin jack at the front and a red one at the back.

**Sense cable:** Large diameter cable characterized by a gray grooved grip and 10 pin connector at one end and terminated in a pod having a gray pin jack at the front and a green one at the back.

3. Connect the four cables to their corresponding front-panel connectors as follows.

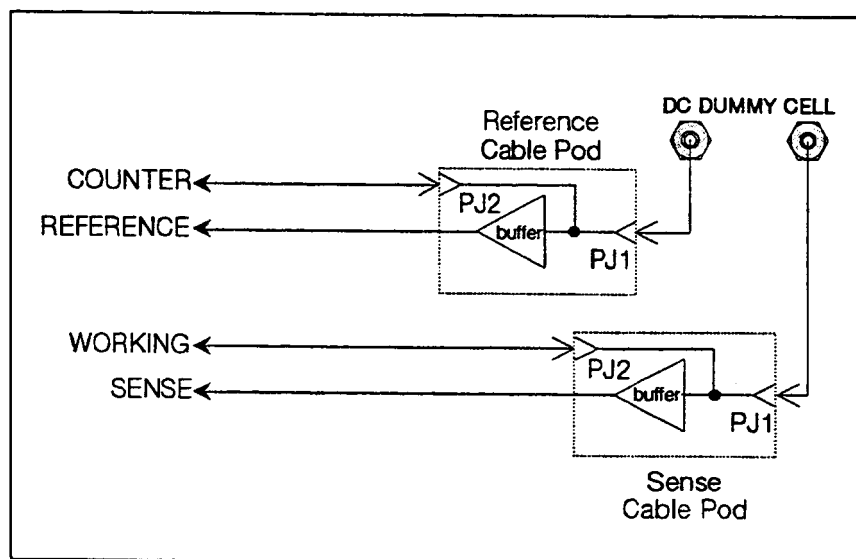
**Counter Electrode cable** to the **Counter** front-panel connector.

**Working Electrode cable** to the **Working** front-panel connector.

**Reference Electrode cable** to the **Reference** front-panel connector. Grasp the connector on the cell cable by the grooved grip, turn it so the red dot aligns with the red mark on the CELL connector, and press it into place. *To disconnect the cell cable connector, grasp the grooved grip and pull straight out.*

**Sense cable** to the **Sense** front-panel connector. Grasp the connector on the cell cable by the grooved grip, turn A so the red dot aligns with the red mark on the CELL connector, and press it into place. *To disconnect the cell cable connector, grasp the grooved grip and pull straight out.*

4. Note the **DC Dummy** Cell pin jacks, located towards the lower left of the panel. The cell cables should be connected to the internal dc dummy cell as shown in Fig. 3.



**Fig. 3. Initial Checks Cable Connections.**

- a. Using a short clip-lead terminated in a pin jack at each end, connect one of the pin jacks on the pod at the end of the **Reference Electrode** cable to the left-hand **DC Dummy** pin jack.
- b. Connect the pin jack at the end of the **Counter Electrode** cable to the other pin jack on the **Reference Electrode** cable pod.
- c. Using a short clip-lead terminated in a pin jack at each end, connect one of the pin jacks on the pod at the end of the **Sense** cable to the right-hand **DC Dummy Cell** pin jack.
- d. Connect the pin jack at the end of the **Working Electrode** cable to the other pin jack on the **Sense** cable pod.

### 3.3.3. Power-Up and Cell Safety

Plug the power cord into a convenient source of ac power. Then press the **Power** pushbutton, located at the lower left of the front panel, to turn on the power to the 283.

Press the **Cell Safety** switch to reverse its state. It should display the word **ON**.

### 3.3.4. Procedure

1. Press the **MODE** key, located below the LCD display, until the [Potentiostatic Scan] menu is displayed on the LCD display. The **POTENTIOSTAT** indicator should be lit, indicating that the Model 283 is in the controlled-potential mode.

2. Press the PREV or NEXT PARAMETER key until E INIT = appears on the third line of the LCD display. Then, turn the VALUE knob until E INIT = 0.000V is displayed. This enters 0 V as the programmed starting potential for the scan to be performed.

As you would expect, the faster you turn the VALUE knob the faster the parameter value changes. But note that the relationship between knob speed and value change does not remain linear. Above a certain knob speed the processor "shifts gears" and changes to a higher ratio of parameter change to knob speed. This allows you to make large changes in the value of a parameter by spinning the knob rapidly.

3. Press the NEXT PARAMETER key once. "E MID =" should appear on the third line of the LCD display. Then, turn the VALUE knob until E MID = 1.000V is displayed. This establishes 1.000 V as the scan vertex potential.
4. Press the NEXT PARAMETER key again. "E FINAL =" should appear on the third line of the LCD display. Then, turn the VALUE knob until E FINAL = 0.000V is displayed. This establishes the scan-end potential at 0 V (which was also the starting potential).
5. Press the NEXT PARAMETER key again. "T INIT =" should appear on the third line of the LCD display. Then, turn the VALUE knob until T INIT = 10.0s is displayed. This enters 10 s as the time for which E INIT (0 V) will be applied before beginning the scan.
6. Press the NEXT PARAMETER key again. "T MID =" should appear on the third line of the LCD display. Then, turn the VALUE knob until T MID = 10.0s is displayed. This establishes 10 seconds as the time for which the mid or vertex potential (E MID) will be applied.
7. Press the NEXT PARAMETER key again. "T FINAL =" should appear on the third line of the LCD display. Then, turn the VALUE knob until T FINAL = 10.0s is displayed. This establishes 10 seconds as the time for which the scan-end potential (E FINAL) will be applied.
8. Press the NEXT PARAMETER key again. "SCAN RATE =" should appear on the third line of the LCD display. Then, turn the VALUE knob until SCAN RATE = 20.0 mV/s is displayed. (The scan rate is the rate of change of the applied potential.)
9. Press the NEXT PARAMETER key again. "CYCLES =" should appear on the third line of the LCD display. Then, turn the VALUE knob until CYCLES = FULL is displayed. This programs the Model 283 to scan the potential applied at the working electrode between E INIT, E MID, and E FINAL for one complete cycle, with the scan rate and time delays you have specified, and then end the experiment. FULL CYCLE is defined in Appendix B under Cycle Control.
10. Press the NEXT PARAMETER key again. "CELL @ END =" should appear on the third line of the LCD display. Then, turn the VALUE knob until CELL @ END = E FINAL is displayed. This will cause the cell to remain at the scan-end potential (E FINAL) after the scan is complete.
11. The current auto-range feature should be turned off for this test. Make sure the AUTO indicator at the lower right side of the front panel is not lit. If it is, press the AUTO pushbutton to turn off current auto-ranging.
12. Press the [↑↑] or [↓↓] key above the AUTO pushbutton as necessary to light the 100  $\mu$ A full-scale current range indicator.
13. Press the CELL ON key to enable the cell connector. The CELL ON indicator just above it should light, showing that the cell is connected.

The Model 283 is now ready to run the experiment, using its internal dummy cell resistor as a substitute for an actual cell. The programmed sequence will be initiated in the following step.

14. Press "Start". (Note that on this menu the F3 key now is assigned the "Star" function.) The following should be observed.
  - a. Once start has been initiated, F3's function is reassigned as "Stop". You can press F3 to stop your experiment at any time. (F3 will be assigned the "Star" function again, and you may press it at any time to restart the checkout sequence.)
  - b. The initial potential (0 V) and the resulting current (0  $\mu$ A) are indicated on the second line of the LCD display.

*Note: As previously mentioned, there may be some small deviation from the nominal value.*

- c. After the programmed initial delay interval (T INIT = 10.0s), the scan will begin and the displayed potential and current will begin to increase. The potential will start at 0 V (E INIT) and increase gradually to 1 V (E MID). It will remain at 1 V for 10 seconds (T MID). Then, it will gradually decrease to 0 V (E FINAL). It will remain at 0 V for 10 more seconds (T FINAL).

The current will track this voltage, starting at zero, increasing in the negative direction to -100  $\mu$ A, and then decreasing to zero again.

15. Press the CELL ON key once to disconnect the cell. The associated indicator light should extinguish.
16. Press the CELL SAFETY switch, re-establishing the secure mode in which the CELL ON key will not complete the cell connections.
17. Press the Model 283 POWER switch to turn off power to the unit. The indicator lights will extinguish and the LCD panel will blank.

This completes the initial checks. If the Model 283 behaved as indicated above, you can be reasonably confident that all its circuits are functioning normally.



# 4. Front Panel

## 4.1. Introduction

This chapter serves as a reference to the front and rear panels. (Operation is discussed in subsequent chapters) In that regard, Fig. 5 which shows the front panel with identifying callouts, provides a convenient but brief overview. The remainder of the chapter discusses the panel features in more detail. To as great a degree as possible the discussion topics track the panel-feature groupings as delineated on the front panel.

## 4.2. Cell Group

### 4.2.1. Introduction

As illustrated in Fig. 4, there are four Cell connectors, COUNTER, WORKING, REFERENCE, and SENSE. Cables are supplied with the Model 283 for making the connections between these connectors and the cell. The Cell On key and Overload indicators are also located in this area. All are discussed in the following paragraphs.

### 4.2.2. COUNTER

The COUNTER BNC connector supplies the output of the Power Amplifier to the front panel. The Counter Electrode cable (BNC cable terminated in red pin jack and alligator clip) is used to make the connection to the Counter Electrode at the cell. Fig. 7 illustrates the connections for the cell cables in potentiostatic operation. As indicated, the Counter Electrode cable connects directly to the Counter Electrode in standard three-electrode operation. Also shown are the connections for two-electrode operation, in which the Counter Electrode and Reference Electrode are jumpered together. In that configuration the Counter Electrode cable connects to one of the two pin jacks on the Reference Cable pod, the other pin jack being connected to the Reference Electrode of the cell, and to the Counter Electrode via the jumper already mentioned (jumper to be supplied by user).

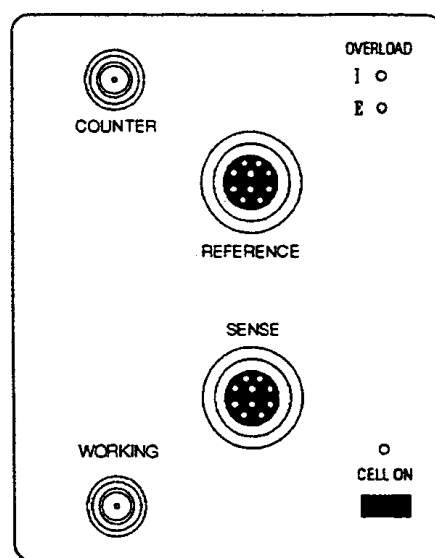


Fig. 4. Cell Group.

Fig. 8 shows the cell connections for galvanostatic operation. As indicated, the Counter Electrode cable connects directly to the Counter Electrode at the cell.

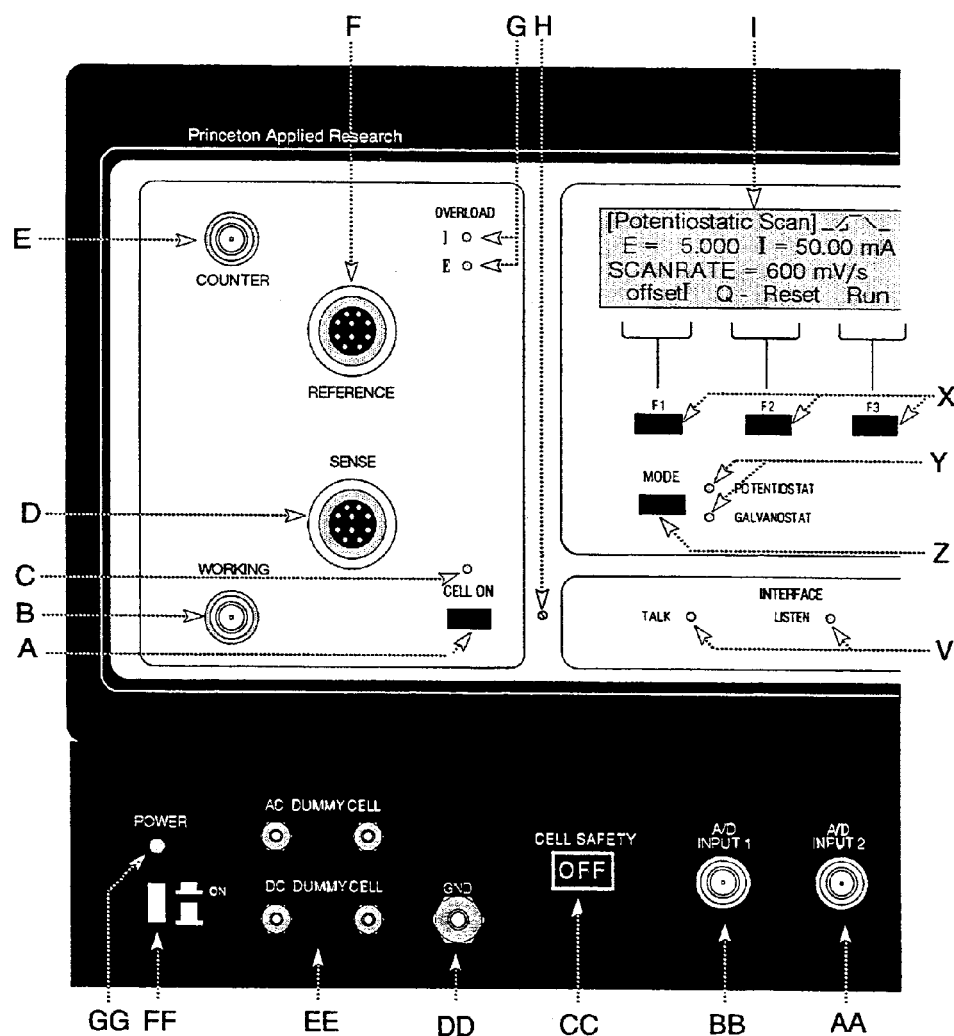


Fig. 5. Model 283 Front Panel.

A: CELL ON key: Turns cell connections ON and OFF as indicated by CELL ON indicator. CELL SAFETY switch must be ON to activate cell.

B: WORKING connector: Working Electrode cable (color-coded green) connects here.

C: CELL ON indicator: Lights when cell is connected.

D: SENSE connector: Sense cable (color-coded gray) connects here.

E: COUNTER connector: Counter Electrode cable (color-coded red) connects here.

F: REFERENCE connector: Reference Electrode cable (color-coded white) connects here.

G: OVERLOAD indicators: I overload if current exceeds two times selected range. E overload if cell control loop is out of control.

H: CONTRAST adjustment: Sets display contrast level.

I: DISPLAY: Indicates instrument status and parameters.

J: VALUE knob: Sets parameter values.

K: CURRENT range indicators: Indicate selected Current Range.

L: CURRENT range pushbuttons: Under manual control, allow current range to be selected.

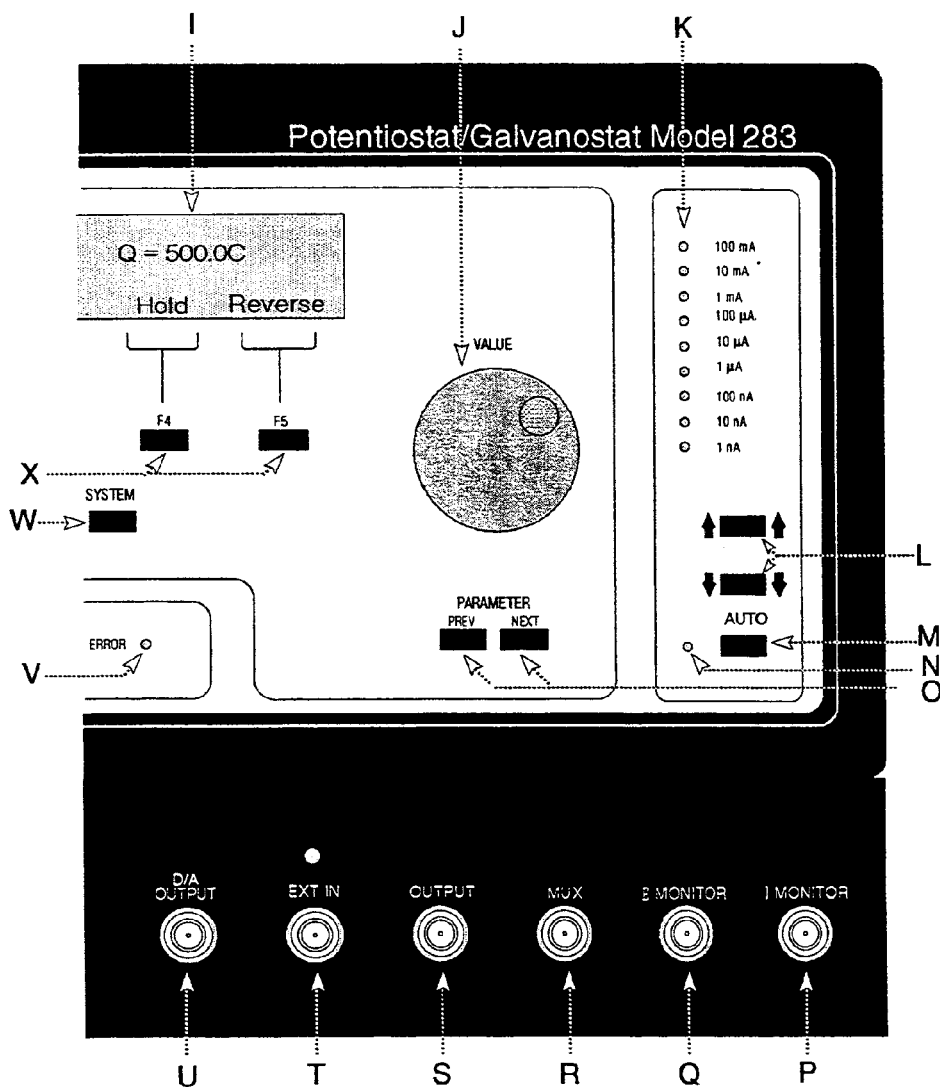
M: AUTO key. Selects automatic or manual current ranging.

N: AUTO indicator: Lights when auto current ranging is selected.

O: PARAMETER PREV & NEXT keys: Select next available or previous available parameter for display.

P: I MONITOR: Voltage analog of cell current; 1 V = f.s.





Q: E MONITOR: Working Electrode potential (vs Reference Electrode); corrected for  $R_u$ .

R: MUX: Ac coupled analog of potential or current as selected by MIE command.

S: OUTPUT: Voltage set by SETOUT2 command provided at this connector.

T: EXT IN: Externally derived control signal can be applied here. Associated indicator lights when input is "on".

U: D/A OUTPUT: Voltage set by SETOUT command provided at this connector.

V: INTERFACE indicators: Report communications status during control from computer via IEEE488 GPIB bus.

W: SYSTEM key: Allows access to the [System Interface] menu from any potentiostat or galvanostat menu.

X: F1 thru F5 keys: Soft control keys whose functions change according to display status. Functions are indicated on display.

Y: MODE indicators: Indicate whether instrument is in potentiostat or galvanostat mode.

Z: Allows selection of potentiostat or galvanostat operation.

AA: A/D INPUT 2: Auxiliary input signal applied here and selected by AUXSEL 1 command can be acquired during scan.

BB: A/D INPUT 1: Auxiliary input signal applied here and selected by AUXSEL 0 command can be acquired during scan.

CC: CELL SAFETY switch: Cell cannot be turned on when this switch is set to OFF.

DD: GND: Convenient source of ground potential.

EE: DC DUMMY CELL and AC DUMMY CELL: Internal dummy cells can be accessed via these pin-jacks.

FF: POWER switch: Ac power to instrument controlled by this switch.

GG: POWER indicator: Lights when instrument is powered.

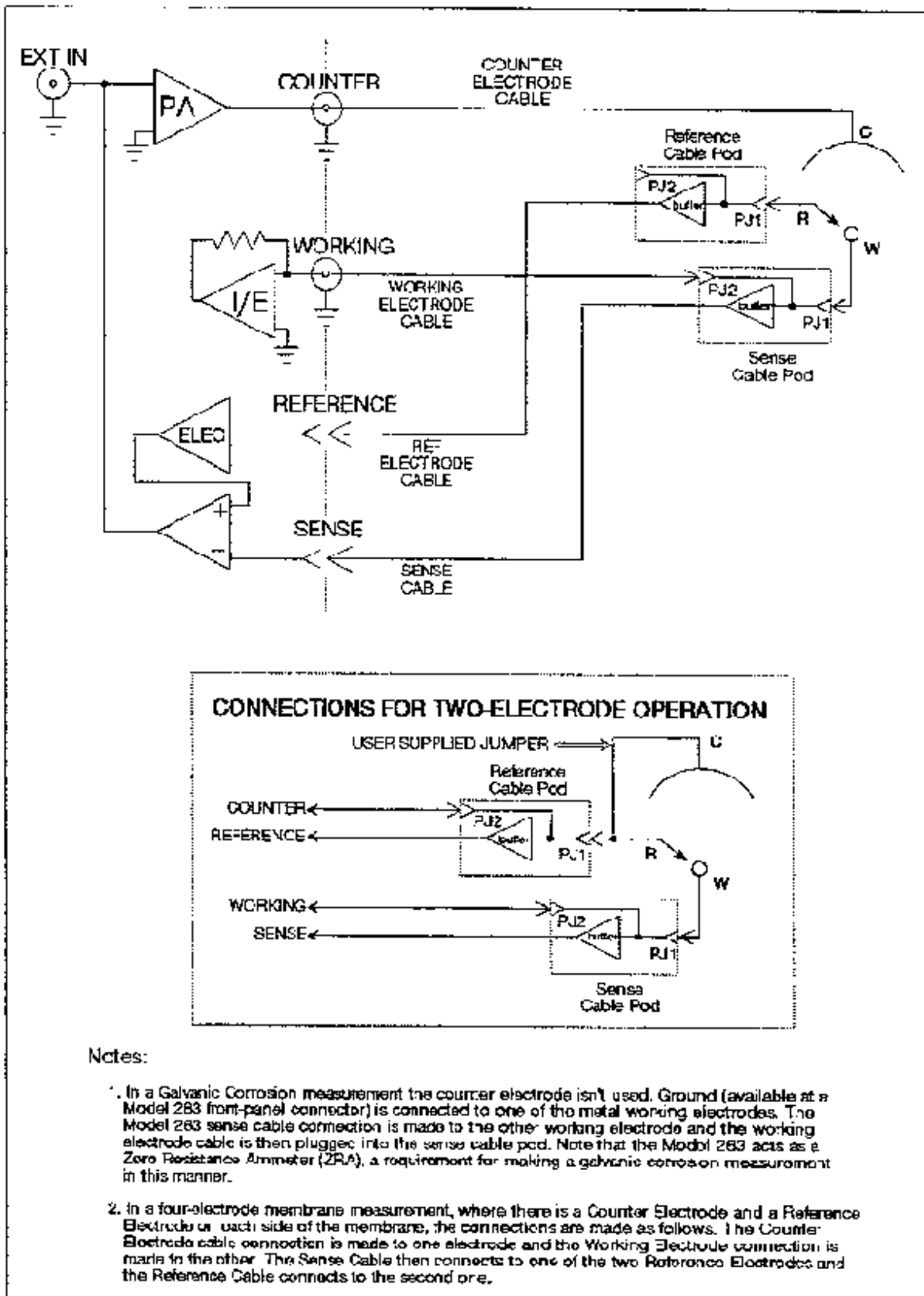


Fig. 7. Potentiostat Mode Cell Connections.

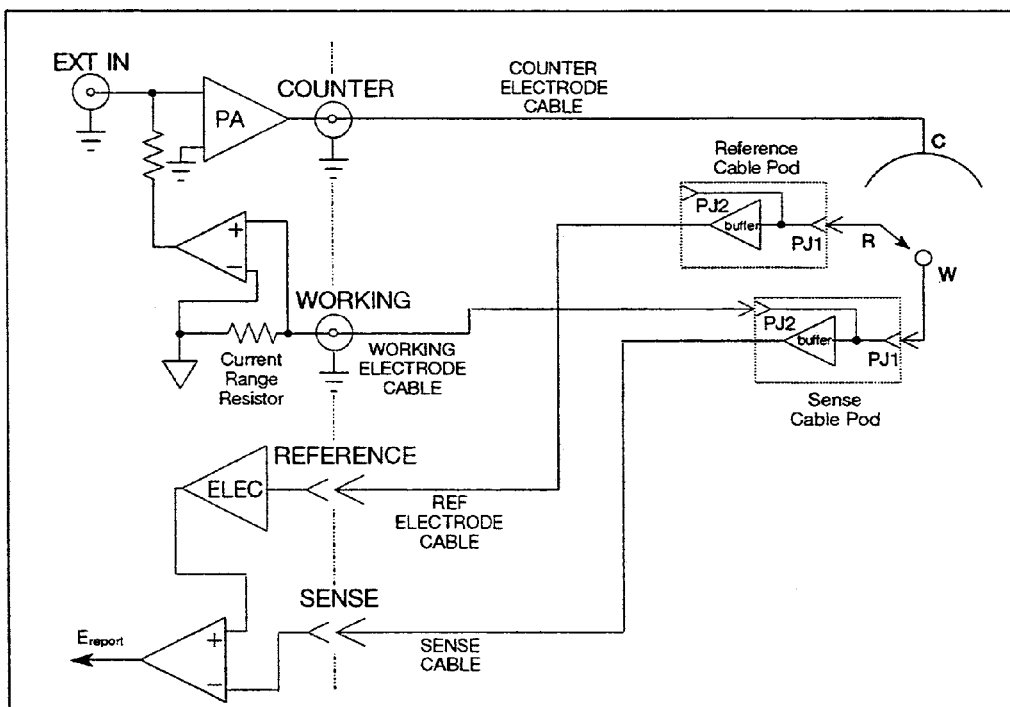


Fig. 8. Galvanostat Mode Cell Connections.

#### 4.2.3. WORKING

This connector's function depends on the operating mode. In potentiostat mode (Fig. 7), the working-electrode current is applied to the input of the I/E converter. In galvanostat mode (Fig. 8), this connector completes the working-electrode-current feedback path to the summing junction of the power amplifier. In both modes the Working Electrode cable (BNC cable terminated in a green pin jack and an alligator clip) connects to one of the pin jacks on the Sense Cable pod. The other pin jack of the Sense Cable pod connects directly to the Working Electrode at the cell by the shortest possible path. There are no special working-electrode considerations for two-electrode potentiostatic operation.

#### 4.2.4. REFERENCE

The path from the Reference Electrode to one of the two inputs of the differential electrometer is completed via this connector with the Reference Electrode cable (heavy cable with gray grip at the connector end and, at the other end, a pod having a white pin jack at the front and a red one at the back). As shown in Figs. 7 and 8, the pin-jack connections at the pod depend on the configuration. In standard three-electrode operation as a potentiostat, one of the pin jacks at the pod connects directly to the Reference Electrode by the shortest possible path and the second pin jack isn't used. In two-electrode operation, the second pin jack is used for the Counter Electrode cable connection. When operating as a galvanostat, the Reference cable can be connected as shown to monitor the potential, keeping in mind that the cell current is controlled in galvanostatic operation and the potential reading is simply ancillary information.

#### 4.2.5. SENSE

The Sense connector, as shown in Figs. 7 and 8, completes the sense path to the Working Electrode via the Sense cable (heavy cable with gray grip at the connector end and, at the other

end, a pod having a gray pin jack at the front and a green one at the back). As indicated in the figures, one of the Sense Cable pin jacks on the pod connects to the Working Electrode of the cell by the shortest possible path. The Working Electrode cable plugs into the other pin jack.

#### 4.2.6. OVERLOAD Indicators

The *I OVERLOAD* indicator lights if the working electrode current exceeds two times the full-scale current range. This does not mean that the cell control loop is out of control. For example, suppose the Model 283 were programmed to establish a potential of +0.752 V, and that under the established conditions, a cell current of 0.5 mA occurred. If the current range were 1  $\mu$ A, 10  $\mu$ A, or 100  $\mu$ A, the current monitoring circuits would be driven to the limit and the *I OVERLOAD* indicator would light, even though the cell would still be controlled at +0.752 V.

Unlike with the *I OVERLOAD* indicator, a lighted *E OVERLOAD* indicator always means that the cell control loop is out of control. That is, the control amplifier has reached its maximum compliance Voltage of  $\pm 80$  V, and the potential of the working electrode with respect to the reference electrode is not as programmed. This could result from a connection error (open cell connection), an electrode problem, or an unacceptably high solution resistance.

#### 4.2.7. CELL Indicator

This indicator lights whenever the internal cell relay is closed. The cell relay is controlled either by the CELL ON key or by the CELL command sent from an attached computer.

#### 4.2.8. CELL ON Key

The CELL ON key controls the cell relay, which determines whether the control amplifier is connected to the cell. *Note: The CELL SAFETY switch must set to **ON** before the Cell On key can activate the cell connections.* When the CELL ON key is off (CELL indicator not illuminated), the control amplifier is disconnected from the cell and there is zero cell current, allowing the cell connections to be made safely. When the CELL **ON** key is on (CELL indicator lit), the control amplifier is connected to the cell.

The cell relay also can be controlled by a software command from an attached computer.

The cell control loop remains controlled even when the cell isn't on. Having the cell off does not cause an overload condition.

---

### 4.3. Display/Control Group

#### 4.3.1. Introduction

In local operation, the 283 is controlled and the experiment status monitored using this group. In addition to the LCD display, the group includes the soft-keys F1 through F5, the MODE and SYSTEM keys, the VALUE knob, used to set parameter values, and the two Parameter keys, PREV and NEXT. Fig. 9 is provided as a convenient reference for the Display/Control Group discussions that follow.

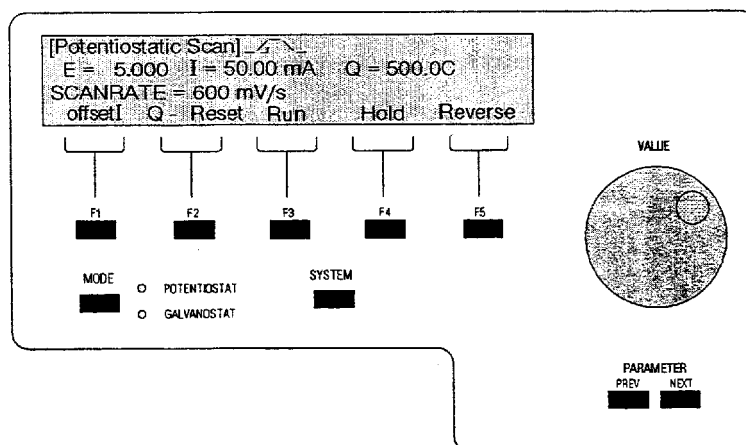


Fig. 9. Display/Control Group.

#### 4.3.2. Mode key

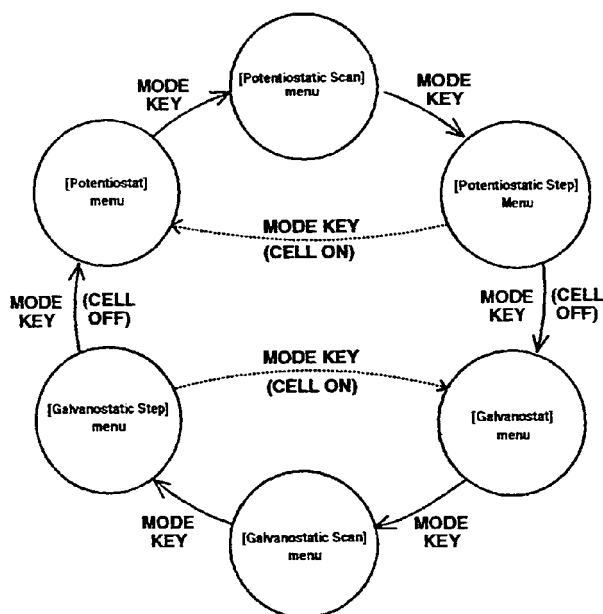
This key selects the basic operating mode of the Model 283: POTENTIOSTAT or GALVANOSTAT - and selects either a discrete step or a gradual scan between applied voltage or current levels. An indicator lamp lights to show whether the POTENTIOSTAT or GALVANOSTAT mode has been selected, and the appropriate menu screen appears on the LCD panel. Fig. 10 shows the sequence in which the experiment menu screens appear when you repeatedly press the MODE key.

Note that you cannot switch between potentiostatic and galvanostatic operation during an experiment, as this would require basic changes in the entire system configuration. Thus, when the cell is on, you cannot change between potentiostatic and galvanostatic menus. If the [Galvanostatic Step] menu is displayed, pressing the MODE key will switch to the [Galvanostat] menu. Similarly, if the [Potentiostatic Step] menu is displayed, pressing the MODE key will switch to the [Potentiostat] menu.

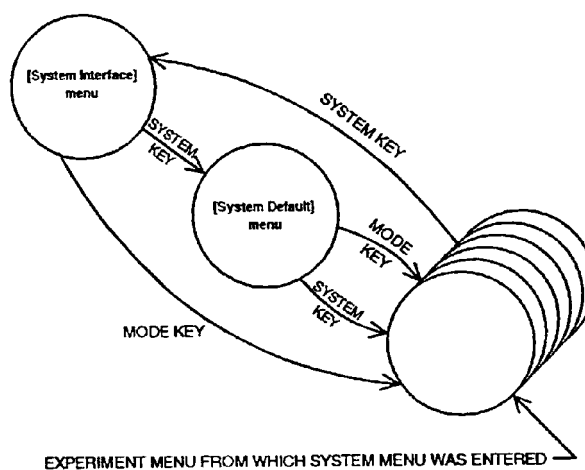
The MODE key also can be used to move from the [System Default] menu screen on the LCD display to one of the potentiostat or galvanostat menus (see Fig. 11). The MODE key is disabled during remote-control operation.

#### 4.3.3. System key

In local control, the SYSTEM pushbutton allows you to access the [System Interface] menu screen on the LCD panel from any potentiostat or galvanostat menu (see Fig. 11). It also moves you from the [System Interface] menu to the [System Default] menu and from the [System Default] menu to a potentiostat or galvanostat menu.



**Fig. 10. Order Of Menu Screens That Appear When You Press The Mode Key From Any Potentiostatic or Galvanostatic Screen.**



**Fig. 11. Moving Among The System, Function, & Potentiostatic or Galvanostatic Screens.**

#### 4.3.4. LCD Display

The four-line liquid crystal display provides continuous information on the experiment in progress, including the parameters set and the voltage and current measurements being taken. The information shown depends on which of the several available menu screens is displayed. In local control, the MODE and SYSTEM keys above the display allow you to cycle through the screens (see Chapters 6, 7 & 8).

In the event of a system malfunction, the LCD panel will display an error message describing the problem and sometimes directing the operator to take the required action. For an explanation of these error messages, refer to Section 6.1 1. Remote-control software error messages are explained in the *Model 283 Command Set Handbook*.

### 4.3.5. F1 Through F5 Function keys

In local control (when you are controlling the Model 283 from its front panel), these "soft" keys perform various actions before and during an experiment. You use them to start your experiment and control its progress. You can also use them to recalibrate the instrument (see Section 6.9) and reset the experiment parameters to their default values (Section 6.8).

The function assigned to each key is displayed on the bottom line of the LCD panel. These functions may change if you switch to another menu screen.

When the Model 283 is under control of an external computer, F1 through F4 have no functions assigned. Pressing F5 will return you to local control and bring up either the [Potentiostat] or [Galvanostat] menu screen.

### 4.3.6. Value knob

In local control, this knob sets the value of any experiment parameter selected with the PREV and NEXT PARAMETER keys. The parameter being set is displayed on the third line of the LCD display.

The VALUE knob provides tactile feedback and has a speed sensing feature to make parameter setting easy and intuitive. As you would expect, the faster you turn the knob the faster the parameter value changes. But note that the relationship between knob speed and value change does not remain linear. Above a certain knob speed the processor "shifts gears" and changes to a higher ratio of parameter change to knob speed. This allows you to make large changes in the value of a parameter by spinning the knob rapidly.

To prevent someone from inadvertently changing the value of a parameter by brushing against the VALUE knob, you can disable the knob after using it. You can specify the period of time it wafts after its last use before becoming inactive (the "timeout" period). The Knob Timeout parameter is set from the [System Interface] menu screen. See Appendix B for a more detailed explanation of the timeout parameter and how to set it.

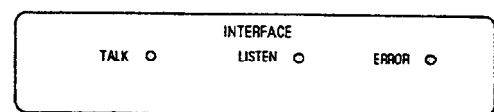
### 4.3.7. Prev and Next Parameter keys

In local control, these keys allow you scroll through the available parameters one at a time. **Next** moves forward through the list, selecting and displaying the next available parameter each time it is pressed. **Prev** moves backwards through the list, selecting and displaying the last available parameter each time it is pressed. The selected parameter is always displayed on the third line of the LCD panel and, while displayed, its value can be changed with the VALUE knob.

---

## 4.4. Interface Group

This group contains three indicators that have significance during GPIB communications and that can be helpful in program development. The function of each as follows.



**Fig. 12. Interface Group.**

**TALK:** Means that the 283 has data ready to send to the computer. This indicator goes out when all of the data has been transferred.

**LISTEN:** Means that the 283 has detected the first character of a transmission from the computer. This indicator extinguishes when the terminator marking the end of the transmission is detected.

**ERROR:** Indicates that a communications error has occurred.

## 4.5. Current Range Group

### 4.5.1. Introduction

This group allows you to select automatic or manual current ranging. If manual current ranging is selected, it additionally allows you to select the current range.

### 4.5.2. Full-Scale Current Range Indicators, 100 mA through 1 nA

These indicator lamps monitor the Model 283's full-scale current range. One of the nine available current ranges is always selected. A cell current equal to the selected current range gives 1 V at the I MONITOR connector.

In local control, the full-scale current range can be selected either manually by the operator or automatically by the Model 283. In the Manual mode, the range is selected with the arrow keys under the indicator lamps. The ↑↑ key moves the selection upwards through the available ranges. The ↓↓ key moves it downwards.

### 4.5.3. ↑↑ key

In the Manual current ranging mode (under local control), this key is used to increase the full-scale current range of the Model 283. Pressing this key steps the full-scale current range to the next higher range available. The current range set is shown by illumination of the corresponding indicator lamp. This key has no effect when AUTO current ranging is on.

### 4.5.4. ↓↓ key

In the Manual current ranging mode (under local control), this key is used to decrease the full-scale current range of the Model 283. Pressing this key steps the full-scale current range to the next lower range available. The current range set is shown by illumination of the corresponding indicator lamp. This key has no effect when AUTO current ranging is on.

### 4.5.5. AUTO Switch and Indicator

In the Potentiostat mode (local control), the AUTO switch is used to select manual or automatic adjustment of the current range. Pushing the switch toggles between the auto and manual modes. The AUTO Indicator lamp is lit when AUTO is selected.

Note that automatic current ranging is restricted to operation in the Potentiostat mode, with 100 nA being the most sensitive range the Model 283 can automatically select. Auto-ranging cannot be selected in the Galvanostat mode.

In the AUTO current range mode, the Model 283 automatically seeks the full-scale current range that causes the I MONITOR potential to be between 15% and 190% of full scale; that is, between 150 mV and 1.9 V. If cell current is less than 150 nA, the 100 nA range will be selected. If the instrument is on the 10 mA range and cell current is greater than 19 mA, the 100 mA range will be selected. This process occurs after each point is acquired, with the constraint that it can only change one range at a time. Data could be lost if the data amplitude is changing faster than it can be tracked by the auto-ranging function.

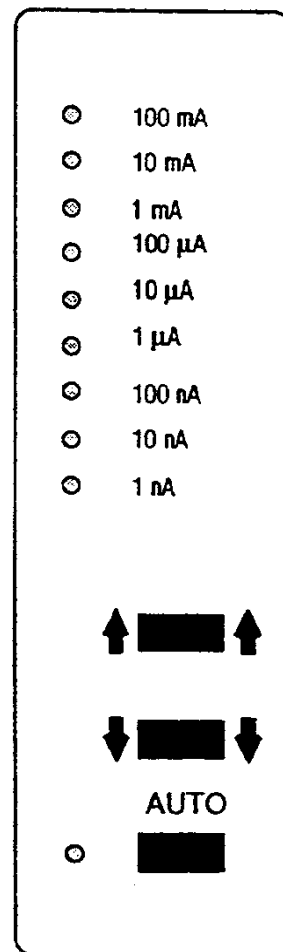


Fig. 13. Current Range Group.



You can set a limit to the automatic current ranging by adjusting the I AUTO LIMIT parameter on the [System Default] menu (see **Current Range, Full Scale** in Appendix B). The full-scale current range will not go below the I AUTO LIMIT you set.

The I/E Filter (if selected) can cause unpredictable effects on your experiment if AUTO current ranging is in use. If I/E FILTER = ON is selected (from the [System Default] menu screen), we recommend manual current ranging. For additional information see **Filters** in Appendix B.

---

## 4.6. BNC Connectors

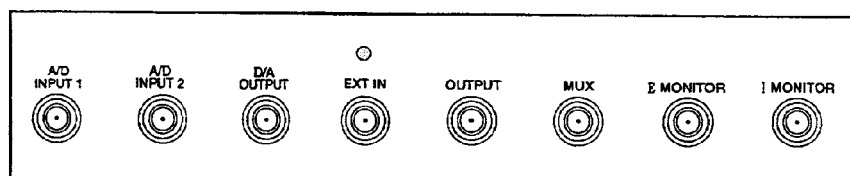


Fig. 14. BNC Connectors.

### 4.6.1. Introduction

In addition to the Counter and Working BNC connectors in the Cell Group, there is a row of eight BNC connectors near the lower edge of the instrument that provide a variety of control and monitoring functions as follows.

### 4.6.2. EXT IN

This BNC connector has two separate but similar functions: External Input and Oscillator Input. The main difference between these functions is that, in the OSC IN mode, the gain of the applied signal can be scaled up or down, while the EXT INPUT mode always applies unity gain to the input signal.

This connector can be made active (turned on) or inactive either with the front panel controls or by software commands from an external computer. From the front panel, it can be controlled with either the EXT INPUT or the OSC IN setting on the [System Default] menu (see "Adding an External Signal" in Section 6.13). Remote control from an attached computer is described in the *Model 283 Command Set Handbook*. Note that both EXT INPUT and OSC IN cannot be set to ON at the same time.

When this connector is active (associated indicator lighted), an analog control voltage applied to it will be summed with the output of the digital-to-analog converters (DACs), which are set at the front panel or from an attached PC. The control signals could be generated by, for example, a PARI Model 175 Universal Programmer to provide rapid scanning and true analog cyclic voltammetry. Other waveform generators, a lock-in amplifier, or a frequency response analyzer could also be used.

In potentiostatic operation, all of the control potentials add algebraically. *Fig. 25 in Chapter 9 shows the circuit configuration for potentiostatic operation.* For example, if the voltage applied to EXT INPUT is +0.5 V, at a time when a potential of +0.5 V is programmed in the instrument, the net potential applied will be +1.0 V, and the working electrode would be controlled at +1.0 V with respect to the reference electrode. (This assumes, of course, that the applied signal is not scaled by selecting the OSC IN mode.) A positive applied potential will make the current tend to be more anodic. A negative applied potential will make the current tend to be more cathodic. In galvanostatic operation, making the applied potential more positive by any means except applying a potential to the EXT INPUT connector will tend to make the cell current more

cathodic. Making the applied potential more negative will tend to make the current more anodic. *This sense is reversed at the EXT INPUT connector. There, making the input more positive will make the cell current more anodic (more negative will make the cell current more cathodic).* Fig. 26 shows the circuit configuration for galvanostatic operation.

In potentiostat operation, the maximum voltage that can be safely applied to the connector is  $\pm 10$  V in the EXT INPUT mode and  $\pm 5$  V in the OSC IN mode. In galvanostat operation, the safe range in either mode is -2 V to +2 V (corresponding to  $\pm 2$  times the full-scale current). The input impedance at the connector is 1 M $\Omega$ .

#### 4.6.3. E MONITOR

This dc-coupled BNC connector can be used to monitor the polarity and amplitude of the working electrode potential versus the reference electrode in the test cell. It can be used to drive the X-axis of a pen recorder or oscilloscope. If positive feedback or current interrupt iR compensation is enabled, the potential at the E MONITOR is corrected for uncompensated resistance ( $R_U$ ). The output impedance is 50  $\Omega$ .

#### 4.6.4. I MONITOR

The potential at this dc-coupled connector represents the ratio of cell current to full-scale current at the current range selected, with 1 volt representing unity or 100% of full-scale current.

For example, with the 10  $\mu$ A full-scale range selected, 0.5 V at the I MONITOR connector indicates that cell current is one half of full scale, or 5.0  $\mu$ A. Or, if the 100  $\mu$ A range is selected, 1.25 V at I MONITOR would indicate that the cell current is 125% of full scale, or 125  $\mu$ A. Although the analog-to-digital conversion is limited to two times full scale, the I MONITOR output is linear to  $\pm 10$  V, allowing large current spikes to be faithfully measured.

The polarity of the potential at the I MONITOR connector is the same as the polarity of the cell current. On the 1 mA current range, for example, a current level of -1 mA will give -1 V at the I MONITOR connector, representing an anodic or reducing current at the working electrode. This connector can be used to drive the Y-axis of a pen recorder or oscilloscope. The output impedance is 50  $\Omega$ .

#### 4.6.5. MUX

When the Model 263A is operated remotely from an external computer, this ac-coupled connector (output impedance 50  $\Omega$ ) can be used to monitor either cell current or cell voltage (as determined by the MIE command). The default is cell current. The MUX connector cannot be controlled from the front panel of the Model 283. Thus, under local control, the connector can monitor current only. This connector is used mainly with PARI electrochemical impedance systems.

When the instrument is monitoring cell current, the potential at this connector is the same as that at the I MONITOR connector, except that any dc component of the signal is blocked by the ac coupling. As with the I MONITOR connector, the potential represents the ratio of test cell current to full-scale current at the current range selected, with 1 volt representing unity or 100% of full-scale current. Again, currents as high as 2 x full scale can be accommodated.

When the instrument is monitoring cell potential, the signal at this connector is the same as that at the E MONITOR connector, except that any dc component of the signal is blocked by the ac coupling. The connector is used to monitor the polarity and amplitude of the working electrode potential versus the reference electrode in the test cell. The output range is  $\pm 10$  V. If positive feedback or current interrupt iR compensation is enabled, the potential at the connector is corrected for uncompensated resistance ( $R_U$ ).

#### 4.6.6. A/D INPUT 1 & A/D INPUT 2

Allows an auxiliary signal applied to either of these connectors to be applied to an A/D converter and acquired during data acquisition. A multiplexer controlled by the AUXSEL 0 & 1 command determines which of the two is selected. Additionally, it is necessary that the SIE parameter be appropriately set in order for the selected auxiliary signal to be acquired during data acquisition. The input impedance at both connectors is 100 k $\Omega$ . *Note: The manner in which signals applied to these inputs are processed cannot be controlled from the front panel.*

#### 4.6.7. OUTPUT

The output of a 12-bit DAC controlled by the SETOUT2 command is provided at this output, making available a precise dc voltage (range  $\pm 2$  V; impedance 300  $\Omega$ ). Possible uses include speed control of the Model 616 or 636 if applied to the **INPUT** connector of either instrument. Note that this output cannot be controlled from the front panel.

#### 4.6.8. D/A OUTPUT

The output of a 12-bit DAC controlled by the SETOUT command is provided at this output, making available a precise dc voltage (range  $\pm 2$  V; impedance 300  $\Omega$ ). Possible uses include speed control of the Model 616 or 636 if applied to the **INPUT** connector of either instrument. Note that this output cannot be controlled from the front panel.

---

### 4.7. Gnd Connector

The GND connector provides a convenient source of ground potential at the front panel. It can be used in a number of ways. Although it is not required for routine potentiostat or galvanostat operation, it is available if needed for a special purpose, such as supplying ground to a shield-screen surrounding a cell.

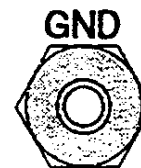


Fig. 15. Ground Connector.

An exception is in making galvanic corrosion measurements, in which the Model 283 is a ZRA and the Ground connector is connected to one of the two metal working electrodes. The Sense Cable connects to the other working electrode and the Working Electrode plugs into the second pin-jack on the Sense Cable pod. The Reference Cable connects to the Reference Electrode in the usual manner.

---

### 4.8. Cell Safety Switch

This switch provides a direct interrupt of the counter electrode lead. It should be in the OFF position whenever the cell cables are being handled or when there is any chance of contact with the cell connections.



Fig. 16. Cell Safety Switch.

---

### 4.9. Dummy Cell Connectors

The internal dummy cells, networks constructed of precision components, are brought out at these pinjacks (Fig. 17). During calibration, the cell cables are connected to these pin jacks, allowing the internal dummy cells to be substituted for an external cell. Schematically, the dummy cells are as shown in Fig. 18. Fig. 19 shows how the connections to a dummy cell are made. *Appendix D shows plots performed on the ac dummy cell using the 398 Impedance Software.*

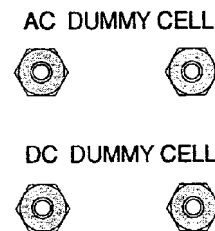


Fig. 17. Dummy Cell Connectors.

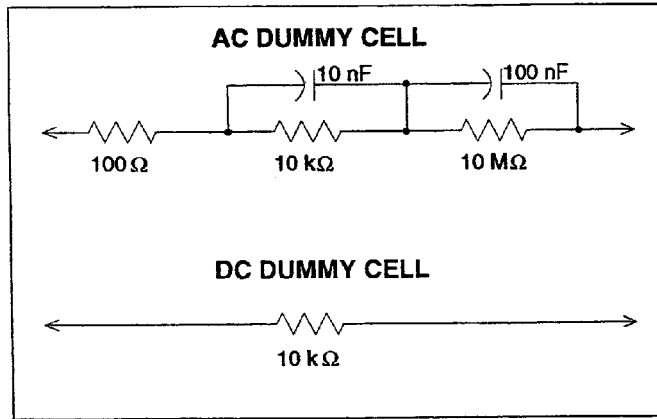


Fig. 18. Dummy Cell Networks.

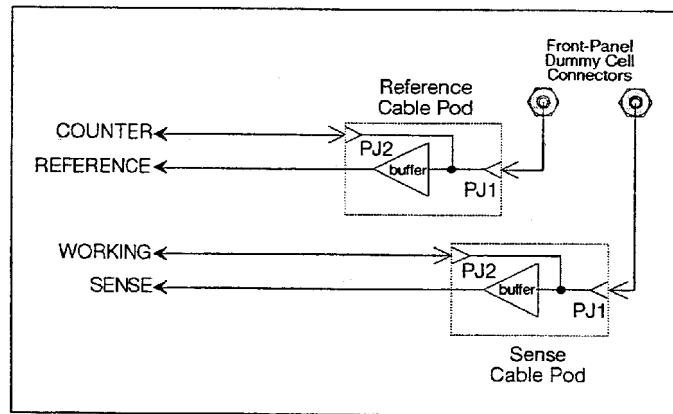


Fig. 19. Dummy Cell Connections.

#### 4.10. Power Switch

The Power switch and its associated indicator are located at the lower left-hand corner of the front panel. As indicated, when the pushbutton is "in" (latched), the instrument is powered. In the "out" position, both sides of the ac line to the instrument are interrupted. The indicator glows whenever the instrument is powered.

POWER



Fig. 20. Power Switch.

# 5. Back Panel

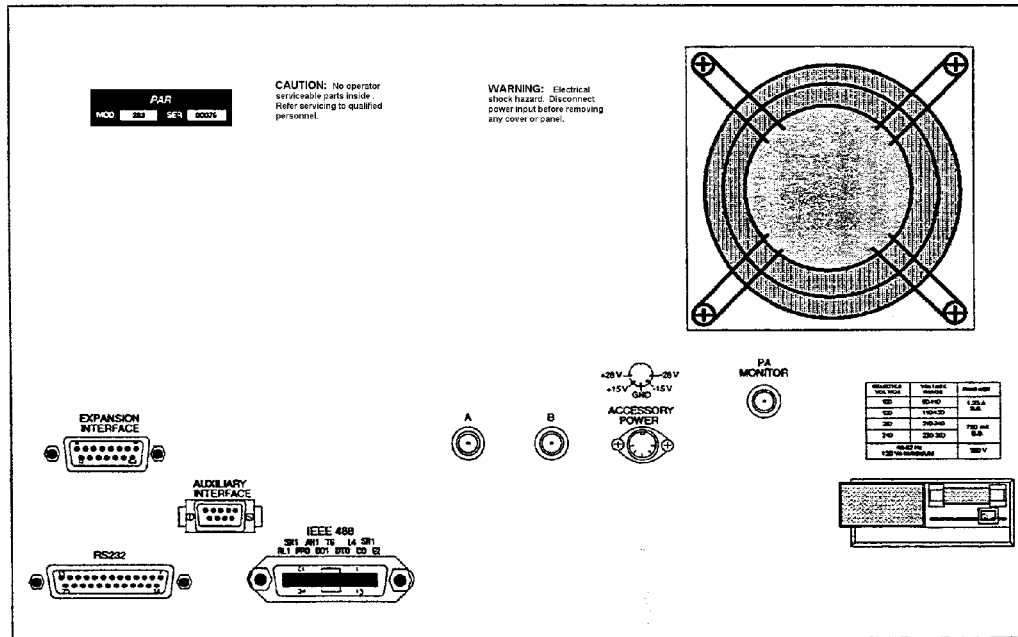


Fig. 21. Model 283 Back Panel.

## 5.1. Introduction

As shown in Fig. 21, there are three BNC connectors, a preamplifier power connector, two communications ports, auxiliary interface connector, and an expansion interface connector on the back panel. The power input assembly is also located there. These items are discussed in the following paragraphs.

## 5.2. Power Input

The Power Input assembly is located at the panel's lower right. The operating and safety considerations germane to this assembly are discussed in *Section 2-3, LINE VOLTAGE*, and are not repeated here.

## 5.3. Accessory Power

Provides  $\pm 28$  V regulated and  $\pm 15$  V regulated power for accessory equipment. Up to about 50 mA may be safely drawn from each of these sources. The voltage-pin assignments are depicted on the back panel directly above the connector as shown in Fig. 21.

## 5.4. Auxiliary Interface

When the Model 283 is controlled from an external computer, this connector, via the Model 507 Interface, can provide control signals for a Model 303A Static Mercury Drop Electrode.

It can send Purge, Stir, and Dispense signals to the Model 303A. But note that the Model 303A is not cabled directly to this connector. It is cabled to the Model 507 Interface unit, which in turn is cabled to the Model 283 AUXILIARY INTERFACE connector.

Motor ON/OFF control of a Model 616 or 636 Rotating Electrode System is also possible using the STIR signal (pin 9).

---

### 5.5. RS-232 Connector

This is a serial port for control of the Model 283 from an external computer via an RS-232 interface cable. The communications parameters are set from the front panel of the Model 283.

*Note: The maximum potential that can be applied to this port is  $\pm 15$  V. The Model 283 Command Set Handbook describes communications protocols and settings. See Appendix C for a pinout listing.*

---

### 5.6. IEEE-488 Connector

This is a parallel port for controlling the Model 283 from an external computer via an IEEE-488 (GPIB) interface cable. The GPIB address, terminator characters, and status of the Test Echo function are set from the front panel of the Model 283. The *Model 283 Command Set Handbook* describes communications protocols and settings. See Appendix C for a pinout listing.

---

### 5.7. PA Monitor

A 10: 1 attenuated analog of the counter-electrode potential is provided at this connector. The output impedance is 10 k $\Omega$ .

---

### 5.8. A & B Connectors

These are BNC connectors provided for future development.

---

### 5.9. Expansion Interface

This connector is provided for future development.

# 6. Getting Started

---

## 6.1. Introduction

Although the Model 283 is a complex and sophisticated instrument, it is easy to use. It can be controlled either directly from its front panel or from a personal computer.

This chapter describes the functions of the controls, LCD display, and indicator lights on the front panel. It then shows you how to set up the basic experiment parameters that are common to both potentiostatic and galvanostatic operation from the front panel. These parameters seldom require changing. It also shows how to set the RS-232 or GPIB (IEEE-488) communications parameters necessary for controlling the instrument from a host computer.

After you have set these parameters, you must also set the parameters that are specific to the kind of experiment you wish to do. To complete your preparation and run your experiment, continue to either

- Chapter 7 to set potentiostatic parameters and run a potentiostatic experiment, or
- Chapter 8 to set galvanostatic parameters and run a galvanostatic experiment.

A battery-powered parameter backup system retains all selections and parameter values when the power is cycled. When the Model 283 is powered up, all selections and parameter values are restored to the values they had at the end of the previous operating session, except for Cell On, which, as one would expect, changes to Cell Off. If you wish to restore all of the default values, hold in any of the keys on the front panel as you power up.

*Note: Many of the parameters set from a remote computer via the GPIB or RS-232 bus are stored in memory locations shared with similar parameters set from the front panel. In some circumstances this can cause unpredictable interactions between remote parameters and front-panel parameters. We recommend that you do not mix front-panel and remote control operations.*

Certain conditions that interfere with normal operation will cause error messages to be displayed on the LCD panel. These messages are explained in Section 6.1 1.

---

## 6.2. Polarity Convention

The Model 283 follows the American polarity convention and the display indications are consistent with that convention. Positive current is cathodic, that is, a current is defined as positive if reduction is taking place at the working electrode. Negative current is anodic, that is, a current is defined as negative if oxidation is taking place at the working electrode.

In potentiostatic operation, making the applied potential more positive will cause the current to become more anodic. Conversely, making the applied potential more negative will cause the current to become more cathodic. This is true for all potential sources at the external input (EXT INPUT) connector.

In galvanostatic operation, making the applied potential more positive by any means except applying a potential to EXT INPUT will tend to make the current more cathodic. Making the

applied potential more negative will tend to make the current more anodic. *This sense is reversed at the EXT INPUT connector. There, making the input more positive will make the cell current more anodic. Making the input more negative will make the cell current more cathodic.*

Bear in mind that EXT INPUT is a high-impedance (1 M $\Omega$ ) input in both potentiostatic and galvanostatic operation. (in galvanostatic operation, 1 V applied results in a full-scale current, assuming EXT INPUT is set to ON and OSC IN is set to OFF.)

## 6.3. Operating Modes

### 6.3.1. Introduction

This instrument can operate in either of two basic operating modes, Potentiostat or Galvanostat. The mode in which it is operating at any time is indicated by an illuminated lamp.

In each of these basic operating modes, the cell potential or current can be held constant to extremely close tolerances, or it can be varied in closely controlled increments. These operating modes are explained below. To switch between modes, simply press the MODE key on the front panel.

### 6.3.2. Potentiostatic

In this mode, the Model 283 controls the potential at the working electrode with respect to the reference electrode. The potential at the counter electrode is driven to the potential required (consistent with the  $\pm 80$  V compliance of the control amplifier) to establish the desired working electrode potential. The range over which the working electrode potential can be controlled is  $\pm 10$  V, with  $\pm 8$  V being available in a single experiment.

### 6.3.3. Galvanostatic

In this mode, the Model 283 controls the current between the counter and working electrodes at the specified fraction of the selected current range (up to the maximum of two times the current range). The counter electrode is driven to the potential required (consistent with the  $\pm 80$  V compliance of the control amplifier) to establish the desired cell current. The reference electrode is not used in the control loop, but can be used to monitor the potential at some point in the electrochemical cell.

### 6.3.4. Scanning and Stepping Transitions

Under front-panel control, the Model 283 can hold the cell potential or current fixed at a single level during the experiment, or it can vary the potential or current between three separate programmable levels. In potentiostatic operation, the separate levels are called E Initial, E Mid, and E Final. In Galvanostatic operation, the levels are called I Initial, I Mid, and I Final.

The transition between the three levels can be in the form of either a gradual ramp or "scan" between levels, or a sudden sharp "step." So there are actually a total of six modes of operation available:

- Potentiostatic, where cell potential is held constant.

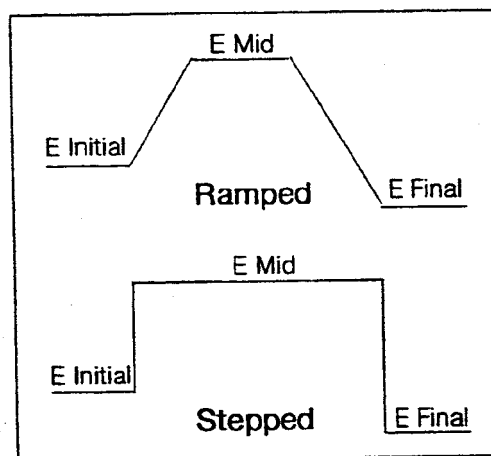


Fig. 22. Transitions.



- Potentiostatic Scan, with a gradual ramp between the three levels of cell potential. You can program the rate of change ("SCANRATE") of the potential between levels.
- Potentiostatic Step, with sharp steps between the three levels of cell potential.
- Galvanostatic, where cell current is held constant.
- Galvanostatic Scan, with a gradual ramp between the three levels of cell current. You can program the rate of change ("SCANRATE") of the current between levels.
- Galvanostatic Step, with sharp steps between the three levels of cell current.

The lengths of time for which each of the three levels of potential or current are held constant during the experiment are called T Init, T Mid, and T Final. Each time can be separately programmed (or omitted entirely) . See **Delays** in Appendix B, the Technical Reference, for a detailed discussion of these parameters.

Note that the Model 283 does not apply a linear scan, but rather a "staircase" scan. However, as long as the individual steps are very small relative to the range scanned, linear scan theory will apply to a close approximation. The nominal step size is the scan rate/250, or 250  $\mu\text{V}$ , whichever is larger. Under remote control via the rear panel GPIB or RS-232 port, steps as small as 25  $\mu\text{V}$  (MR = 1), or 2.5  $\mu\text{V}$  (MR = 0), can be attained as explained in the Model 283 Command Set Handbook).

**Example:** With a scan rate of 1 V/s, the step size will be 4 mV ( $1000/250 = 4$ ).

## 6.4. Controls and Indicators

In local control (when you are not controlling the Model 283 from a separate computer), you communicate with the Model 283 using its front-panel controls and liquid crystal display (LCD). The controls – a large knob and an array of push-button keys – are used to set the test parameters and select the operations to be performed. The LCD panel provides continuous, real-time information on the experiment, including the parameters initially set and the cell potentials and currents measured or applied as the experiment progresses. *Chapter 4, FRONT PANEL*, describes the front-panel controls in detail and that information will not be repeated here. This section focuses on the LCD and menu operations.

## 6.5. Using the LCD Menu Screens

### 6.5.1. Introduction

In local control, the LCD panel and its associated controls provide the means for communication between the researcher and the Model 283. The researcher first sets the required experiment parameters on the appropriate menu screens, using the VALUE knob, and then presses F3 to start the experiment. At any time during the scan the user can reverse the scan direction, suspend its progress and then restart it, or stop it entirely.

The LCD panel can display four lines of alphanumeric characters. The information shown on these lines depends on which menu screen is displayed. Under local control, eight screens are available: the [System interface] and [System Default] screens, three potentiostat screens, and three galvanostat screens. The MODE and SYSTEM keys above the display allow you to cycle through the screens.

When the Model 283 is under control of an external computer, the LCD panel changes to the REMOTE screen. All the front-panel controls except the Cell On key, Cell Safety switch, the Power switch and the F5 function key are disabled, but the indicator lamps continue to function.

Pressing F5 (now called the LOCAL key) will return you to local control and bring up either the [Potentiostat] or [Galvanostat] menu screen. You can use the MODE key from either of these screens to move to any other local-control menu screen.

*Note: We recommend that you do not mix front-panel and remote operations. Please see the note in Section 6.1.*

### 6.5.2. Common Screen Elements

The top line of the LCD panel (Fig.23) shows the name of the current menu screen in brackets ("REMOTE" is displayed when the instrument is under control of an external computer). On the [System Interface] menu, the top line also shows the name of the instrument and the version of the firmware installed.

[Potentiostatic Scan]	—	—	—	—
E = 5.000	I = 50.00 mA	Q = 500.0C		
SCANRATE = 600 mV/s				
offset]	Q -	Reset	Run	Hold Reverse

**Fig. 23. Typical LCD Menu Screen.**

The second line of the display continuously shows, on the left side of the line, the measured and corrected cell potential as the experiment progresses. If a cell potential overload condition occurs (see OVERLOAD Indicators in Section 4.2F), "E = OVERLOAD" will be displayed.

The center of this line continuously shows the actual cell current (I) without I Offset applied. Note: If a current overload condition occurs, "I = OVERLOAD" will be displayed here. This means that the current is too large to be measured. It does not mean that the cell control loop is out of control.

The right side of this line displays either the current with offset applied (i) or the total charge (Q) that has passed through the cell since the beginning of the experiment. To display the value of i or Q, press F1 (see "Bottom Row Functions" below).

### 6.5.3. Setting Parameters

In local control, the third line of the display shows one of several experiment or communications parameters that can be set by the operator. To change the value of the displayed parameter, simply turn the VALUE knob. The PREV and NEXT PARAMETER keys, located under the VALUE knob, allow you to display in turn each of the adjustable parameters. The value of any parameter displayed on the third line can be reset with the VALUE knob.

A useful feature of the Model 283 is that you can change many of the parameters at any time during a scan, as well as before the scan begins. You can change the following parameters while the scan is in progress:

E INIT	E MID	E FINAL
I INIT	I MID	I FINAL
T INIT	T MID	T FINAL
SCANRATE	CYCLES	CELL@END

When the Model 283 is under control of an external computer, the third line of the REMOTE screen may be blank, it may display up to 40 characters of text typed on the computer following the TYPE command, or it may display a communications error message (see Section 6.11).

### 6.5.4. Bottom Row Functions

The fourth (bottom) line of the display shows the function currently assigned to each of the "soft" function keys (F1 through F5). You will note that the functions of some keys vary according to the menu screen displayed. In some menus, not all of the function keys are used.

---

## 6.6. Setting Communications Parameters

### 6.6.1. Introduction

The Model 283 can be controlled remotely from a personal computer running standard PARI electrochemistry software. Instructions for remote operation using the PARI Electrochemical Command Set built into the Model 283 are given in the separately bound *Model 283 Command Set Handbook*.

Either the RS-232 serial port or the IEEE-488 (GPIB) port on the rear panel of the Model 283 can be used for communications with the host computer. If the IEEE-488 interface is used, the host computer must be equipped with a GPIB interface card. For details of hardware requirements, refer to the manual for the software to be run on the host computer. PARI software is designed to interface an IBM or IBM-compatible computer equipped with a National Instruments PC2, PC-2A, PC-AT, or MC-GPIB GPIB card.

Before the Model 283 and a host computer can successfully talk to each other, certain communications parameters have to be set in both. For GPIB communications, the instrument must be set to the address assigned to 4 at the computer, and the terminator character required by the host must be set. For RS-232 communications, the baud rate, parity, number of data and stop bits, and terminator character must match the host settings.

Note that with most software running on an IBM-compatible computer, the terminator must be a CR and both serial and GPIB echo must be off. Further details of communications protocols for GPIB and RS-232 interfacing are given in the *Model 283 Command Set Handbook*.

### 6.6.2. [System Interface] Menu Screen

The [System Interface] menu screen is used to set up certain basic operating parameters for your system. All but one of these parameters (KNOB TIMEOUT) concern communications between the instrument and a host computer, and do not have to be set if you are operating from the front panel of the Model 283.

To set the communications parameters on the Model 283, move to the [System Interface] menu on the LCD panel by pressing the SYSTEM key. Then, press the PREV or NEXT PARAMETER key until a parameter to be set appears on the third line of the display. Turn the VALUE knob to set the parameter. Press the PREV or NEXT PARAMETER key again to display the next communications parameter, and set it in the same fashion. Continue this process until all required parameters have been set.

The SYSTEM key allows you to access the [System Interface] menu screen from any potentiostatic or galvanostatic menu. It also moves you from the [System Interface] menu to the [System Default] menu and from the [System Default] menu to a potentiostatic or galvanostatic menu (see Fig. 11).

The MODE key is used to move directly from the [System Interface] menu screen to one of the potentiostatic or galvanostatic menus, as shown in Fig. 10. (it is also used to move between the potentiostatic and galvanostatic experiment modes).

### 6.6.3. [System Interface] Menu Line 3 Parameters

The operating parameters that can be displayed on line 3 of the [System Interface] menu (and adjusted with the VALUE knob) are listed below. Details of these parameters are given in Appendix B of this manual and in the appendices of the *Model 283 Command Set Handbook*.

Note that when you are controlling the Model 283 from a host computer via the RS-232 bus, the Baud rate, number of data bits, parity, and number of stop bits must be the same for both the Model 283 and the serial port on the host computer.

**GPIB ADDR (1 to 30):** The normal GPIB address setting for use with PARI software is 14. If you are using other software, see the software manual for its requirements.

**TERMINATOR (CR or CRLF):** The terminator required for GPIB communications with IBM PC-compatible computers running PARI software is CR.

**GPIB ECHO (OFF or ON):** During normal operation, GPIB ECHO should be set to OFF. When it is ON, every character transmitted or received via the GPIB port will be echoed to the RS-232 Interface Connector. This feature is particularly useful when developing programs. If a "dumb" CRT terminal is connected to the RS-232 Interface, the programmer will see all communications on the CRT.

**SERIAL BAUD (110/300/600/1200/2400/4800/ 9600/19200):** This sets the Baud rate for RS-232 communications. Hardware handshaking is recommended for the higher settings.

**SERIAL PRY (NONE, EVEN, ODD):** This determines parity checking for RS-232 communications. Parity maintenance provides a direct way of detecting garbled data if the computer is programmed to only accept words having the selected parity. If a word having incorrect parity is read, it is a message to the computer that data loss is occurring.

**SERIAL BITS (7 or 8):** This sets the number of bits in the data word in RS- 232 communications. Eight bits are required for binary data loads and dumps.

**SERIAL STOP (1 or 2):** This sets the number of stop bits in RS-232 communications. Two stop bits give more reliable communications at high baud rates, but slows the data transfer.

**SERIAL ECHO (OFF or ON):** Normally OFF. If ON is selected, each character received via the RS-232 port will be echoed back to the character source. The RS-232 echo is normally used only when the Model 283 is connected to a CRT terminal.

*Note: Do not confuse this function with the GPIB ECHO.*

**KNOB TIMEOUT (DISABLED, 1 to 120 s):** To prevent someone from inadvertently changing an experiment parameter by brushing against the VALUE knob, you can disable the knob after using it. You can specify the period of time it wafts after its last use before becoming inactive (the "timeout" period). At the end of the timeout period the knob will have no effect on parameter settings, and the LCD panel will display "KNOB TIMEOUT HIT ANY KEY." Press any key to reactivate the knob. When DISABLED is selected, the knob remains active and will not time out.

---

## 6.7. Common Experiment Parameters

### 6.7.1. [System Default] Menu Screen

The [System Default] menu screen allows you to view and, if necessary, adjust parameters that normally do not require resetting between experiments. As in the other menus, these parameters can be displayed sequentially on the menu (line 3) by pressing the PREV and NEXT PARAMETER keys. After you select a parameter, you may change its setting with the VALUE knob.

The SYSTEM key allows you to access the [System Default] menu screen from the [System Interface] menu. It also moves you from a system menu to a potentiostatic or galvanostatic menu (see Fig. 11). The MODE key also can be used to move from the [System Default] menu screen to one of the potentiostatic or galvanostatic menus.

### 6.7.2. [System Default] Menu Line 3 Parameters

The experiment parameters that can be displayed on line 3 of the [System Default] menu (and adjusted with the VALUE knob) are listed below. Details of these parameters are given in Appendix B.

- **CELL TYPE: Always** indicates **REAL**

*Note: In the case of the Model 263A Potentiostat/Galvanostat, the alternate selection DUMMY is also provided, which allows the internal dummy cell network to be selected automatically. In the case of the Model 283, there are two internal dummy cells. Either can be accessed via front-panel connectors by using the cell cables as described in Chapter 4. The dummy cell load is useful for determining that the Model 283 is functioning correctly.*

- **EXT INPUT (OFF or ON):** determines whether the front-panel EXT INPUT connector will accept an applied signal without applying a scaling factor to it. Use ON if the applied signal has a suitable amplitude and you do not wish to scale it. OFF is used either when no signal is to be applied, or when an applied signal is too large or too small and you wish to scale it with the OSC GAIN parameter.

Note that both EXT INPUT and OSC IN (see below) cannot be set to ON at the same time. If you are unsuccessful in turning one on, check that the other is off.

- **OSO IN (OFF or ON):** determines whether the front-panel EXT INPUT connector will accept and scale an applied signal. Use ON if the applied signal is too large or too small and you wish to scale it by a factor of 0.02, 0.2, or 2.0. OFF is used either when no signal is to be applied, or when an applied signal is of a useful amplitude with unity gain (in that case, use EXT INPUT = ON).

Note that both EXT INPUT and OSC IN cannot be set to ON at the same time. If you are unsuccessful in turning one on, check that the other is off.

If you set OSC IN = ON, press the NEXT, PARAMETER key once and set OSC GAIN (see below).

- **OSC GAIN (X.02, X.2, or X2):** sets the OSC GAIN factor to one of the three available values: 0.02, 0.2, or 2.
- **LINE SYNC (OFF or ON):** determines whether data acquisition will be synchronized with the power-line frequency. When ON is selected, the sample is taken when the next line-frequency zero crossing occurs. This occurs every 16.6 ms (60 Hz power) or every 20 ms (50 Hz power). If LINE SYNC = OFF, samples are taken at the rate determined by the internal time base of 4 ms. The default state is OFF.
- **I/E FILTER (OFF or ON):** The Model 283 has three filters - an I-Channel low-pass filter, an E-Channel low-pass filter and an I/E Converter low-pass filter that reduces the bandwidth of the I/E converter. The I and E Channel low-pass filters do not affect the output at the I Monitor or E Monitor outputs, but rather affect the E and I signals made available for

monitoring at the display and for digital storage and processing. The I/E Filter on the other hand does affect the signal at the I Monitor connector.

When the I/E Filter is set to OFF, none of these filters are selected. When the I/E Filter is set to ON, *two* filters are selected. The first is the I/E Filter; the second is the I-Channel low-pass filter.

*Note: The E-Channel low-pass filter can not be selected from the front panel. It can, however, be selected via one of the rear-panel interface ports under computer control. See the discussion of the FLT command in the Command Set Handbook for detailed information.*

The effect of the I/E Filter depends on the current range selected. Cut-off frequencies for this filter at each current range are given in Appendix B under **Filters**. This filter is often helpful when making low-current measurements on large electrodes because it reduces the noise at the I MONITOR output. The disadvantage of using the filter is that the I MONITOR output response time is degraded.

It may be advantageous to synchronize data acquisition with the power line frequency when filtering. This can be done by setting LINE SYNC = ON (see LINE SYNC above).

The I/E filters can cause unpredictable effects on your experiment if AUTO current ranging is in use. If I/E FILTER = ON is selected, we recommend manual current ranging.

- **BANDWIDTH (HI STABILITY or HI SPEED):** sets the bandwidth/stability parameter. For the fastest response, choose HI SPEED. For stability, choose HI STABILITY.
- **I AUTO LIMIT:** sets the most sensitive current range to which the Model 283 can automatically range.
- **UPDATE Q W/CELL OFF (NO or YES):** The final current integral (Q), in coulombs, can be displayed, with continuous updating as the measurement progresses. The final current integral is the net charge (including I Offset) that has passed through the cell since the beginning of the experiment while the cell was on.

In a perfect instrument and cell system, Q of course could not change when the cell is disconnected, because no cell current would flow. But in a real system, no matter how precise, some small charge may appear as a result of drift and other circuit variations. Thus, setting UPDATE Q W/CELL OFF = NO prevents charge from accumulating when the cell is off. Choosing YES allows it to accumulate, and might help to estimate drift errors.

---

## 6.8. Resetting Parameters to Default Values

### 6.8.1. Introduction

In certain circumstances it may be desirable to return to the default parameter values, which are stored in battery-backed RAM. There are two ways you can return to the default values of the parameters. One method resets only the experiment parameters - those that appear on the [System Default] menu and on the potentiostatic and galvanostatic menus. It does not alter the parameters on the [System Interface] menu (communications parameters and KNOB TIMEOUT). The second method resets *both groups of* parameters, including those on the [System Interface] menu. Both procedures are described in the following.

### 6.8.2. To reset only the experiment parameters

With the instrument running, press the SYSTEM key to display the [System Interface] menu screen. Then, press "Reset" (F2). The following query will be displayed on the LCD panel:

**RESET SYSTEM?..**

If you press YES (F4), all experiment parameter selections will be cleared and default values will be restored. If you press NO (F5), the parameters will not be reset and the SYSTEM menu screen will reappear.

### 6.8.3. To reset both groups of parameters

With the instrument off, hold down any front-panel key and press the POWER switch. The following message will be displayed on the LCD panel:

**KEY HELD DURING POWER UP  
SYSTEM RESET PERFORMED**

*(third line is blank)*

*(fourth line is blank)*

When the message clears, the following parameters are reset to their default values.

Command Delimiter = 44 (ASCII comma)  
GPIB Address = 14  
Baud Rate = 9600  
Parity = None  
Data Bits = 8  
Stop Bits = 1  
RS232 Echo = OFF  
Knob Timeout = disabled Cell = OFF  
Terminator = CR  
GPIB Echo = OFF  
Front Panel Time Base = 4 ms

Note that the foregoing two reset procedures do not clear the calibration values or recalibrate the instrument. If the battery has been replaced, you will also have to recalibrate. Refer to Section 6.9 below for the calibration procedure.

---

## 6.9. Calibrating the Model 283

In the [System Interface] menu, F1 is assigned the Calib (Calibrate) function. This function is used to recalibrate the Model 283. Calibration values are stored in battery-backed RAM. If the battery has been replaced, use this procedure to recalibrate the instrument. Before recalibrating, allow the instrument to warm up for at least ½ hour. Note that the calibration is done substituting precision resistors for the cell. Both dc and ac precision dummy-cell networks, accessible from the front panel, are built into the Model 283. Section 4.9 describes these networks and the connections required to access them for calibration purposes.

To recalibrate the instrument, press the SYSTEM key to display the [System Interface] menu screen, and then press **CALIB** (F1). The following query will be displayed on line 3 of the LCD panel:

**CALIBRATE SYSTEM?...**

If you press NO (F5), recalibration will not proceed and the [System Interface] menu screen will reappear. If you press YES (F4), the CALIBRATING screen is displayed. As each step in the calibration procedure is performed in sequence, its number and name appear on the second line of the screen. The third line will contain further information during some calibration steps; during others it will be blank. The fourth line shows the constantly changing calibration parameter values.

If calibration fails, for any reason, the second line display (step number and name) will freeze, the third line will now say FAIL, and the fourth line will say HIT ANY KEY TO CONTINUE. Pressing any key will leave the CALIBRATING screen and return to the [System Interface] menu. You may now run experiments, but the results will be suspect because you won't know how far the instrument is out of calibration.

If calibration fails, first check the cable connections to the dummy cell. If they appear to be in order, we recommend that you not take the advice on the fourth line and "hit any key." Instead, leave it in the CALIBRATING screen and call the PARI Service Department to report the number and name of the step that failed. This information will continue to be shown on the second line of the display. The service technician will diagnose the problem and advise you as to what action to take.

---

## 6.10. Determining Installed Options

In the [System Interface] menu, F3 is assigned the Options function. The Model 283 is designed for easy expansion to accommodate future enhancements now under development or envisioned. As these optional features become available, the Options function will allow a user or service technician to determine easily exactly how the system is configured.

To see which options are installed, press the SYSTEM key to display the [System Interface] menu screen, and then press "Options" (F3). A string of numbers separated by spaces will be displayed on the third line of the LCD panel. Each number is in the range 90 to 99 and indicates the presence of an installed option. The number 90 indicates the presence of the basic system PC boards and should always be displayed.

On line 4 of the LCD panel, the prompt

**HIT ANY KEY TO CONTINUE**

will be displayed. After you have read the display of options, press any key to return to the [System Interface] menu.

---

## 6.11. Error Messages

Certain conditions that interfere with normal operation will cause error messages to be displayed on the LCD panel. The message will give a warning statement about the type of error, information about the cause (sometimes in a numeric code), and usually advice about what action to take.

Note that errors indicated on the LCD panel are not related to the software error codes that you can display on the monitor of a host computer with the ERR command.

The following shows the error message screens that may appear on the LCD panel when a problem occurs.





In the foregoing error message screen, the words "**COMM ERROR**" on the fourth line are followed by a two-digit hexadecimal error code.

If this screen is displayed either (a) when you turn on the Model 283 or (b) while you are controlling the Model 283 from a host computer, call the PARI Service Department and report the error code. The service technician will diagnose the problem and advise you as to what action to take. Then, press LOC (F5) to clear the error message.

If the foregoing COMM ERROR message screen is displayed while you are trying to establish communications between a host computer and the Model 283 *via the RS-232 bus*, first press LOC (F5) to clear the error message. Then, check that the following communications parameters are set correctly on the Model 283 to match the settings on the computer:

- Baud rate
- Number of data bits \*
- Number of stop bits \*
- Parity
- Terminator (usually should be CR)

After you have reset any communications parameters that don't match the computer software requirements, send an Action command from the computer to the Model 233. If the command is executed, the problem has cleared. If the error message returns, call the PARI Service Department and report the error code.

The following is not an error message but a cautionary message to warn you that experiment and communications parameters have been reset to their default values:

**KEY HELD DURING POWER UP  
SYSTEM RESET PERFORMED**

*(third line is blank)*

*(fourth line is blank)*

---

## 6.12. Connecting a Pen Recorder or Oscilloscope

The potential of the working electrode with respect to the reference electrode is continuously provided at the E MONITOR connector. This signal can be used to drive the X-axis drive signal line of a pen recorder or oscilloscope.

A meaningful E MONITOR signal is provided as long as there is a reference electrode. If the reference electrode is not connected, as might be the case in galvanostatic operation, the E MONITOR signal is undefined.

In Potentiostatic operation, if positive feedback or current interrupt iR Compensation is on, the compensation corrects the E MONITOR signal level for the iR drop.

The E MONITOR signal is analog inverted with respect to the applied potential. For example, if the applied potential is +1 V, the potential at the E MONITOR connector will be -1 V.

The output impedance at the E MONITOR and I MONITOR connectors is 50  $\Omega$ . We suggest using either a PAR RE0150 X-Y recorder or an RE0151 X-Y-T recorder, as both instruments are designed for use with the Model 283. Simply connect the X-axis drive signal line of the recorder to the E MONITOR connector, and the Y-axis drive signal line to the I MONITOR connector.

---

### 6.13. Adding an External Signal

The EXT IN connector on the front panel provides a means for summing external control potentials with those generated in the instrument or transmitted to it from an external computer. This gives you a way to add any customized waveform function you wish. The control signals could be generated by, for example, a PARI Model 175 Universal Programmer to provide rapid scanning and true analog cyclic voltammetry. Other waveform generators, a lock-in amplifier, or a frequency response analyzer could be used. The applied signal can be scaled up or down, if desired, by a factor of 2, 0.2, or 0.02.

To control the EXT IN connector from the front panel, press the SYSTEM key until the [System Default] menu appears on the LCD panel. If the applied signal has a suitable amplitude and you do not wish to scale it, press the PREV or NEXT PARAMETER key until "EXT INPUT =" appears on the third line of the menu. Then, turn the VALUE knob until "EXT INPUT = ON" is displayed. To disconnect, turn the knob until "EXT INPUT = OFF."

If the applied signal is too large or too small and you wish to scale it, press the NEXT PARAMETER key until "OSC IN =" is displayed on the third line of the menu. Turn the VALUE knob to "OSC IN = ON." Then, press the NEXT PARAMETER key again until "OSC GAIN =" appears on the third line of the [System Default] menu. Turn the VALUE knob to set the OSC GAIN factor to one of the three available values: 0.02, 0.2, or 2. To disconnect, set "OSC IN = OFF."

Note that both EXT IN and OSC IN cannot be set to ON at the same time. If you are unsuccessful in turning one on, check that the other is off.

When the connector is ON (connected), the EXT IN indicator lights and the instrument becomes responsive to potentials applied to the connector. When it is OFF (disconnected), the indicator goes out, indicating that potentials applied to this input will be ignored.

---

### 6.14. Connecting a Model 303A SMDE

When the Model 283 is controlled from an external computer, it can send PURGE, STIR, and DISPENSE signals to a PARI Model 303A Static Mercury Drop Electrode. Instructions for sending these commands are given in the *Model 283 Command Set Handbook*.

Also required is a PARI Model 507 Interface, which must be purchased separately. To control the Model 303A, connect it to the Model 507 Interface and the Interface unit to the AUXILIARY INTERFACE connector on the back of the Model 283. The required Gables are provided with the Model 507 Interface. Refer to the *Model 507 Interface Installation Guide*, PARI Part Number 222556, if you need more detailed installation instructions.

---

### 6.15. Connecting a Model 616 or 636 Rotating Electrode

In both the 616 and the 636 there is provision for stopping the motor with a TTL level signal applied to a Motor Stop (616) or Motor Control (636) jack. In both instruments an internal jumper determines whether the motor-stop function is enabled by a TTL 1 or TTL 0. The TTL 1 STIR signal provided on pin 9 of the 283's rear panel AUXILIARY INTERFACE connector can be used as a motor on/off control signal to the 616 or 636. The level on pin 9 of the AUXILIARY INTERFACE connector in turn is controlled from an external computer via the STIR command.

The front-panel D/A OUTPUT level, controlled by the SETOUT command, is suitable for controlling the speed of a 616 or 636. *Alternatively, the dc level at the OUTPUT connector, controlled by the SETOUT2 command, could be used.* In both the 616 and the 636 the dc level applied to the INPUT jack sets the motor speed. A BNC to double-banana adaptor cable should be used.

---

## 6.16. Supplying Accessory Power

The ACCESSORY POWER connector on the rear panel can provide  $\pm 28$  V regulated and  $\pm 15$  V regulated power for accessory equipment. Up to about 50 mA may be safely drawn from each of these sources. The voltage available at each connector pin is defined in Appendix C.

# 7. Running Potentiostatic Experiments

---

## 7.1. Introduction

This chapter shows you how to set the experiment parameters for a potentiostatic experiment and explains how to run your potentiostatic experiments. In the course of following these discussions, you will come across many technical terms specific the Model 283 as well as to potentiostats and galvanostats in general. Should you encounter an unfamiliar term, or find that the discussion provided in this chapter isn't sufficiently detailed, please see the Technical Reference in Appendix B. In the interest of streamlining the procedures chapters, detailed discussions of the parameters and other technical terms have been placed in a separate appendix (Appendix B), which is alphabetically arranged and quite thorough.

---

## 7.2. Potentiostatic Modes

Under front-panel control, the Model 283 can hold the working electrode potential fixed at a single level during the experiment, or it can vary the potential between three separate programmable levels, called E Init, E Mid, and E Final.

The transition between the three levels can be in the form of either a gradual ramp or "scan" between levels, or a sudden sharp "step." So there are actually three modes of potentiostatic operation available:

- **Potentiostatic with a fixed potential [Potentiostat]**, where the potential at the working electrode is held constant.
- **Potentiostatic Scan [potentiostatic Scan]**, with a gradual ramp between the three levels of working electrode potential. You can program the rate of change ("SCANRATE") of the potential between levels.
- **Potentiostatic Step [Potentiostatic Step]**, with sharp steps between the three levels of working electrode potential.

The lengths of time for which each of the three levels of potential are held constant during the experiment are called **T Init, T Mid, and T Final**. Each time can be separately programmed (or omitted entirely).

To run a potentiostatic experiment from the front panel, first set up the basic parameters as described in Chapter 6. Then, press the MODE key as many times as necessary to display the menu screen for the potentiostatic mode you wish to use: [Potentiostat], [Potentiostatic Scan], or [Potentiostatic Step].

After you select the appropriate menu screen, use the PREV and NEXT PARAMETER keys to display each experiment parameter in turn. The parameters used in each potentiostatic mode are described in the following sections. More detailed explanations are given in Appendix B. If the default value of any parameter is not satisfactory for your experiment, use the VALUE knob to change it.

---

### 7.3. Setting Fixed-Potential Experiment Parameters

The [Potentiostat] menu allows you to set the following experiment parameters used in steady-state potentiostatic operation, where the potential at the working electrode is held constant with respect to the reference electrode.

- **POTENTIAL** at the working electrode.
- **IR MODE (OFF or ON)** and, if **ON**, whether Positive Feedback (**PFIR**) or Current Interrupt (**IRUPI**) iR compensation is to be used).
- **PFIR COMP.** When Positive Feedback iR compensation is selected, you specify the amount of resistance here (in ohms).
- **IRUPT T1** sets the increment of time between the interruption of current to the cell at the start of a periodic Current Interrupt iR Compensation cycle and the first voltage sampling. This voltage sampling, in conjunction with the second sampling at IRUPT T2, is used to extrapolate back to the interrupt potential in determining the Current Interrupt iR Compensation correction factor. The range is 10  $\mu$ s to 2000 - (IRUPT T2)  $\mu$ s. The default value is 10  $\mu$ s on the 100 mA range and 75  $\mu$ s on all other ranges. Note that IRUPT T1 + IRUPT T2 may not exceed 2000  $\mu$ s. Note that IRUPT T1 and IRUPT T2 are independently set for all ranges, and must be separately set for each one,
- **IRUPT T2** sets the increment of time between the first voltage sampling during a periodic Current Interrupt iR Compensation cycle and the second voltage sampling. The voltage samplings are used to extrapolate back to the interrupt potential in determining the Current Interrupt iR Compensation correction factor. The range is 10  $\mu$ s to 2000 - (IRUPT T1)  $\mu$ s. The default value is 10  $\mu$ s on the 100 mA range and 75  $\mu$ s on all other ranges. Note that IRUPT T1 + IRUPT T2 may not exceed 2000  $\mu$ s. Note that IRUPT T1 and IRUPT T2 are independently set for all ranges, and must be separately set for each one.
- **IRUPT** (Intermittent Current Interrupt) sets the number of points between current interrupts in Current Interrupt iR Compensation. The range is 1 to 32,767 points, with a default of 5 points. As the time base used in local operation is 4 ms, 5 points is equal to 20 ms.
- **IRPC** (Current Interrupt Percent Correction) is the percent of correction applied in Current Interrupt iR Compensation. The range is 0% to 200%. The default value is 100%.
- **I OFFSET** (current offset) allows you to specify a current value to be mathematically subtracted from the cell current before it is displayed. The result of this subtraction is displayed as "i" and accumulated over time as "Q". That is,  $i = I - (I \text{ OFFSET})$ , where I OFFSET can have a positive or negative value.

Note that there is no actual current subtraction, only a numerical calculation. Thus current offset does not affect the potential at the I MONITOR connector.

The offset is specified in units of current. The offset range is  $\pm 2$  times the full-scale current range in effect at the time I OFFSET is set.

These parameters are explained in greater detail in Appendix B. After you have set them as required for your experiment, follow the directions in Section 7.6 for running your experiment.

---

## 7.4. Setting Scanned-Potential Experiment Parameters

The [Potentiostatic Scan] menu is used to set the experiment parameters for the Potentiostat Scan mode. In this mode, the Model 283 varies the potential of the working electrode in a gradual sweep or ramp between steady-state levels. Many parameters are the same as for fixed-potential experiments and the discussions in Section 7.3 apply fully. However, there are some that are unique to scanned-potential experiments, as follows.

- **E INIT**, the potential at the working electrode during the first steady-state stage of a scan or step sequence.
- **E MID**, the potential at the working electrode during the second steady-state stage (sometimes called the "vertex") of a scan or step sequence.
- **E FINAL**, the potential at the working electrode during the third steady-state stage of a scan or step sequence.
- **T INIT**, the length of time that E INIT is maintained at the working electrode.
- **T MID**, the length of time that E MID is maintained at the working electrode.
- **T FINAL**, the length of time that E FINAL is maintained at the working electrode.
  
- **SCANRATE**, the rate of change of the potential at the working electrode between E INIT and E MID, and between E MID and E FINAL.
  
- **CYCLES** allows selection of three different scan or step sequences: HALF CYCLE, FULL CYCLE, and CONTINUOUS. The cycle setting determines the number of separate steady-state potential levels that will be used at the working electrode during your experiment.
  
- **CELL@END** determines the working electrode potential at the end of the scan or step sequence. If you select OFF, the cell will be turned off (counter electrode connection interrupted) at the end of the programmed cycle. If you select E INIT, the working electrode potential will be returned (stepped sharply) to E INIT.

If you select E FINAL, the working electrode potential remains at its last value in the sequence. In the FULL CYCLE mode, this is E FINAL. But note that in HALF CYCLE operation, the last potential level reached in the sequence actually is E MID.

Also note that in the CONTINUOUS cycle mode, the experiment doesn't end until the STOP key (F3) is pressed. At that point, the working electrode potential returns to E INIT.

These parameters are explained in greater detail in Appendix B. After you have set them as required, follow the directions in Section 7.6 to run your experiment.

---

## 7.5. Setting Stepped-Potential Experiment Parameters

In the Potentiostat Step mode, the Model 283 varies the potential of the working electrode in sharp steps between steady-state levels. The experiment parameters that can be set from the [Potentiostatic Step] menu are the same as those set from the [Potentiostatic Scan] menu, except that there is no **SCANRATE** setting. After you have set the parameters as required, follow the directions in Section 7.6 to run your experiment.

---

## 7.6. Running Your Experiment

### 7.6.1. Introduction

After you have connected your equipment and set all required parameters, you are ready to begin your experiment. After activating the cell connections (**Cell Safety** switch and **Cell On** key), you will start the experiment and control its progress with the *soft function keys*, **F1** through **F5**, below the LCD panel.

The functions assigned to these keys in each of the potentiostatic modes are displayed on the bottom line of the menu screen. These functions are described below. If something goes wrong and an error message is displayed.

### 7.6.2. F1 (Coulombs or offset I)

This key selects the parameter to be displayed on the right side of the second line of the menu screen.

By pressing the F1 key, you can display either of two parameters on this line: net current with I OFFSET applied (i) or the final current integral (Q). The final current integral is the net charge, after the algebraic addition of I OFFSET, that has passed through the cell since the beginning of the experiment while the cell was on (or since the coulometer was reset). It is expressed in coulombs.

### 7.6.3. F2 (Q-Reset)

The F2 key has the Q Reset (Q-Reset) function. When F2 is pressed, the following query is displayed on line 3 of the LCD panel:

**RESET COULOMBS?.**

If you press YES (F4), it resets the coulometer to zero and reestablishes the initial scaling factor, as set by the selected current range. If F1 has been used to display Q, you will see the final current integral (in coulombs) on the second line of the display reset to zero and then begin to increment as charge accumulation resumes.

If you press NO (F5), the coulometer is not reset and the previous menu screen reappears.

### 7.6.4. F3 (Start or Stop)

The F3 key is used to start a scan. When it is pressed, the scan progresses as programmed. After the scan begins, the function assigned to F3 changes to 'Stop', which continues to be displayed even after the scan goes to completion. Pressing F3 during a scan ends the scan sequence and immediately reestablishes E INIT. Pressing it after the scan ends also restores E INIT.

### 7.6.5. F4 (Hold or Resume)

Pressing the F4 key during a scan causes the scan to temporarily halt. When the key is pressed again (it will now be labeled "Resume"), the scan resumes.

If a "Hold" occurs when a potential is applied, it will continue to be applied (assuming that the CELL ON key is ON). This is true if the hold takes place at any time during the scan sequence. The scan simply halts and the potential in effect at the moment of the halt continues to be applied. Time is not counted for the duration of the hold.



If F2 (**Q-Reset**) is pressed to reset the coulomb count, a prompt appears asking whether you want to proceed. To provide a way to respond to the query, F4 is temporarily reassigned the YES function.

#### **7.6.6. F5 (Reverse or Bypass)**

In the Potentiostat Scan mode, the F5 key is assigned the "Reverse" function. Pressing F5 during a scan reverses the direction of the scan.

In the Potentiostat Step mode, the F5 key has a different function: Bypass. Pressing Bypass before or during the programmed T INIT, T MID, or T FINAL delay in the scanning sequence temporarily overrides that delay and sets it to a minimum (actually 4 ms). The scanning sequence then immediately advances to the next step. For example, if F5 is pressed during the T INIT interval, the sequence would immediately advance to the first scan. In half-cycle or single-cycle scanning, if the next step would advance the sequence to the end of the scan, the scan would halt.

If F2 (Q-Reset) is pressed to reset the coulomb count, a prompt appears asking whether you want to proceed. To provide a way to respond to the query, F5 is temporarily assigned the function NO.

---

### **7.7. Error Messages**

Certain conditions that interfere with normal operation will cause error messages to be displayed on the LCD panel. The message will give a warning statement about the type of error, information about the cause (sometimes in a numeric code), and usually advice about what action to take. Chapter 6, Section 6.11 shows the error messages that could be displayed, explains their meanings, and describes the actions you should take in response to each.

Another class of error messages can occur in remote-control operation as a result of problems in setting up or running software on the host computer. These error messages appear on the computer monitor screen, not the LCD panel. For a discussion of these messages, refer to the ERR command in the *Model 283 Command Set Handbook*. Please note that errors indicated on the LCD panel are hardware errors and are not related to the software error messages that you can display on the computer monitor with the ERR command.



# 8. Running Galvanostatic Experiments

---

## 8.1. Introduction

This chapter shows you how to set the experiment parameters for a galvanostatic experiment and explains how to run the experiment. In the course of discussion that follows, you will come across many technical terms specific to the Model 283 as well as to potentiostats and galvanostats in general. Should you encounter an unfamiliar term, or find that the discussion provided in this chapter isn't sufficiently detailed, please see the Technical Reference in Appendix B. In the interest of streamlining the procedures chapters, detailed discussions of the parameters and other technical terms have been grouped into Appendix B, which is alphabetically arranged and quite thorough.

---

## 8.2. Galvanostatic Modes

Under front-panel control, the Model 283 can hold the cell current fixed at a single level during the experiment, or it can vary the current between three separate programmable levels, called **I Init**, **I Mid**, and **I Final**.

The transition between the three levels can be in the form of either a gradual ramp or "scan" between levels, or a sudden sharp "step." So there are actually a total of three modes of galvanostatic operation available:

- Galvanostatic with constant, non-varying cell current [Galvanostat].
- Galvanostatic Scan [Galvanostatic Scan], with a gradual ramp between the three levels of cell current. You can program the rate of change ("SCANRATE") of the current between levels.
- Galvanostatic Step [Galvanostatic Step], with sharp steps between the three levels of cell current.

The lengths of time for which each of the three levels of current are held constant during the experiment are called **T Init**, **T Mid**, and **T Final**. Each time can be separately programmed (or omitted entirely).

To run a galvanostatic experiment from the front panel, first set up the basic parameters as described in Chapter 6. Then, press the **MODE** key as many times as necessary to display the menu screen for the galvanostatic mode you wish to use: [Galvanostat], [Galvanostatic Scan], or [Galvanostatic Step].

After you select the appropriate menu screen, use the **PREV** and **NEXT PARAMETER** keys to display each experiment parameter in turn. The parameters used in each galvanostatic mode are described in the following sections. More detailed explanations are given in Appendix B. If the default value of any parameter is not satisfactory for your experiment, use the **VALUE** knob to change it.

---

### 8.3. Setting Cell Current: Special Considerations

It is important to understand that if you change the full-scale current range, the instrument will automatically reset the cell current to maintain the same ratio of current to full-scale current range. For example, let's say the full-scale current range is 10 mA and cell current is set to 8.00 mA. Then cell current will be 80% of the full-scale current range. If you decrease the full-scale current range to 1 mA, this ratio will be maintained automatically and cell current will be reset to 0.800 mA. This is true for any current parameter - **CURRENT**, **I INIT**, **I MID**, and **I FINAL**.

Note that the value specified for any cell current parameter can be no greater than two times the full-scale current range selected.

---

### 8.4. Setting Cell Current in a Fixed-Current Experiment

The [Galvanostat] menu allows you to set the amount of cell current used in steady-state galvanostatic operation, where the cell current is held constant. The value for the **CURRENT** parameter is that in effect at the time the instrument was last powered down, or the last value set if changed since power-up. After you have set it as required for your experiment, follow the directions in Section 8.7 for running your experiment.

---

### 8.5. Setting Scanned-Current Experiment Parameters

The [Galvanostatic Scan] menu allows you to set the following experiment parameters for the Galvanostat Scan mode. In this mode, the Model 283 varies the cell current in a gradual sweep or ramp between steady-state levels.

- **I INIT**, the cell current during the first steady-state stage of a scan or step sequence.
- **I MID**, the cell current during the second steady-state stage (sometimes called the "vertex") of a scan or step sequence.
- **I FINAL**, the cell current during the third steady-state stage of a scan or step sequence.
- **T INIT**, the length of time that **I INIT** is maintained in the cell.
- **T MID**, the length of time that **I MID** is maintained in the cell.
- **T FINAL** the length of time that **I FINAL** is maintained in the cell.
- **SCANRATE**, the rate of change of the cell current between **I INIT** and **I MID**, and between **I MID** and **I FINAL**.
- **CYCLES** allows selection of three different scan or step sequences: **HALF CYCLE**, **FULL CYCLE**, and **CONTINUOUS**. The cycle setting determines the number of separate steady-state cell current levels that will be used during your experiment.
- **CELL@END** determines the cell current at the end of a scan or step cycle. If you select **OFF**, the cell will be turned off (counter electrode connection interrupted) at the end of the programmed cycle. If you select **I INIT**, the cell current will be returned (stepped sharply) to **I INIT**.

If you select **I FINAL**, the cell current remains at its last value in the sequence. In the **FULL CYCLE** mode, this is **I FINAL**. But note that in **HALF CYCLE** operation, the last current level reached in the sequence actually is **I MID**.

Also note that in the CONTINUOUS cycle mode, the experiment doesn't end until the "Stop" key (F3) is pressed. At that point, the cell current returns to I INIT.

These parameters are explained in greater detail in Appendix B. After you have set them as required for your experiment, follow the directions in Section 8.7 for running your experiment.

---

## 8.6. Setting Stepped-Current Experiment Parameters

In the Galvanostat Step mode, the Model 283 varies the cell current in sharp steps between steady-state levels. The experiment parameters that can be set from the [Galvanostatic Step] menu are the same as those set from the (Galvanostatic Scan] menu (see above), except that there is no SCANRATE setting. After you have set the parameters as required for your experiment, follow the directions in Section 8.7 for running your experiment.

### 8.6.1. Introduction

After you have connected your equipment and set all required parameters, you are ready to begin your experiment. After activating the cell connections (**Cell Safety** switch and **Cell On** key), you will start the experiment and control its progress with the **soft function keys, F1** through **F5**, below the LCD panel.

The functions assigned to these keys in each of the galvanostatic modes are displayed on the bottom line of the menu screen. These functions are described below. If something goes wrong and an error message is displayed.

### 8.6.2. F1 (Coulomb or offset I)

This key selects the parameter to be displayed on the right side of the second line of the menu screen.

By pressing the F1 key, you can display either of two other parameters on this line: net current with current offset applied (i) or the final current integral (Q).

Current offset ("I OFFSET") is a feature that can be used in potentiostatic experiments but is not useful in galvanostatic operation. Thus there is no provision for setting it from the galvanostatic menus. But be aware that if you have set a value for I OFFSET in one of the potentiostatic menus and then switch to galvanostatic operation, the offset will remain in effect when "i" is displayed.

I OFFSET is a current value that is mathematically subtracted from the cell current before it is displayed. The result of this subtraction is displayed as "i" and accumulated over time as "Q". That is,  $i = I - (I \text{ OFFSET})$ , where I OFFSET can have a positive or negative value.

Note that there is no actual current subtraction, only a numerical calculation. Thus current offset does not affect the potential at the I MONITOR connector.

The final current integral (Q) is the net charge, after the algebraic addition of I OFFSET, that has passed through the cell since the beginning of the experiment while the cell was on (or since the coulometer was reset). It is expressed in coulombs.

### 8.6.3. F2 (Q-Reset)

When F2 is pressed, the following quill is displayed on line 3 of the LCD panel:

RESET COULOMBS?...

When F2 is pressed, in order to provide a way to respond to the query, F4 is temporarily reassigned the YES function and F5 the NO function. If you press YES (F4), it resets the coulometer to zero and reestablishes the initial scaling factor, as set by the selected current range. If F1 has been used to display 0, you will see the final current integral (in coulombs) on the second line of the display reset to zero and then begin to increment as charge accumulation resumes.

If you press NO (F5), the coulometer is not reset and the previous menu screen reappears.

#### **8.6.4. F3 (Start or Stop)**

The F3 key is used to start a scan. When it is pressed, the scan progresses as programmed. After the scan begins, the function assigned to F3 changes to "Stop". Pressing F3 ends the scan sequence and immediately reestablishes I INIT.

#### **8.6.5. F4 (Hold or Resume)**

Pressing the F4 key during a scan causes the scan to temporarily halt. When the key is pressed again (it will now be labeled "Resume"), the scan resumes.

If a "Hold" occurs when a current is applied to the working electrode, it will continue to be applied (assuming that the CELL ON key is ON). This is true if the hold takes place at any time during the scan sequence. The scan simply halts and the current in effect at the moment of the halt continues to be applied. Time is not counted for the duration of the hold.

If F2 (Q-Reset) is pressed to reset the coulomb count, a prompt appears asking whether you want to proceed. To provide a way to respond to the query, F4 is temporarily reassigned the YES function.

#### **8.6.6. F5 (Reverse or Bypass)**

In the Galvanostat Scan mode, the F5 key has the "Reverse" function. Pressing F5 during a scan reverses the direction of the scan.

In the Galvanostat Step mode, the F5 key has a different function: Bypass. Pressing F5 before or during the programmed T INIT, T MID, or T FINAL delay in the scanning sequence temporarily overrides that delay and sets it to a minimum (actually 4 ms). The scanning sequence then immediately advances to the next step. For example, if F5 is pressed during the T INIT interval, the sequence would immediately advance to the first scan. In half-cycle or single-cycle scanning, if the next step would advance the sequence to the end of the scan, the scan would halt. For an explanation of the T INIT, T MID, and T FINAL delays, see Appendix B.

---

## **8.7. Error Messages**

Certain conditions that interfere with normal operation will cause error messages to be displayed on the LCD panel. The message will give a warning statement about the type of error, information about the cause (sometimes in a numeric code), and usually advice about what action to take.

Please note that errors indicated on the LCD panel are hardware errors and are not related to the software error codes that you can display on the computer monitor with the ERR command.

# 9. Circuit Description

---

## 9.1. Introduction

In essence, the Model 283 Potentiostat/Galvanostat is a high-current feedback amplifier. This chapter contains basic circuit descriptions keyed to the simplified block diagrams in Figs. 25, 26, and 27. Fig. 25 is a simplified block diagram of the 283 operating in the potentiostat mode. Fig. 26 shows the instrument operating in the galvanostat mode. Fig. 27 shows the signal conditioning circuits that processes the basic analog E and I signals to make possible the ancillary, control, display, and computer interface functions. These figures also list some of the commands that affect the indicated circuits. Although there are instances where it may prove helpful to have this information, keep in mind that only a few commands are listed, and that they may well have effects far beyond what can be indicated in these simple diagrams.

The microprocessor incorporated in the instrument allows cell voltage and/or current readings to be transmitted to a host computer via a GPIB or RS-232 interface, and allows for control of the system either from the front panel or from a host computer. The program control and data-taking processes are coordinated so that the resulting data sets can be plotted or otherwise processed as a function of the applied control program.

---

## 9.2. Potentiostat Operation

Fig. 25 illustrates potentiostatic operation. Referring to the figure, first note the Power Amplifier, which drives the cell's Counter Electrode. *The switch between the output of the Power Amplifier and the Counter Electrode symbolizes the Cell On key and Cell Safety switch.* The key to understanding how the 283 works as a potentiostat is to recognize that it is basically a feedback amplifier. Several signals drive the summing junction (inverting input) of the Power Amplifier. Most important of these is the negative feedback from the Reference Electrode to the Power Amplifier's input. As indicated, there is an electrometer circuit interposed between the Reference Electrode and the Power Amplifier, necessary because of the Reference Electrode's high input impedance. Note that there is provision for operating the electrometer differentially or single-ended. In single-ended (Hi Stab) operation, the potential at the Reference Electrode is measured with respect to the ground as supplied to the inverting input of the E Feedback amplifier via contacts of the indicated ground switch. In differential (Hi Speed) operation, the potential at the Reference Electrode is measured with respect to the true sensed potential at the Working Electrode as supplied to the E Feedback amplifier via the Sense cable.

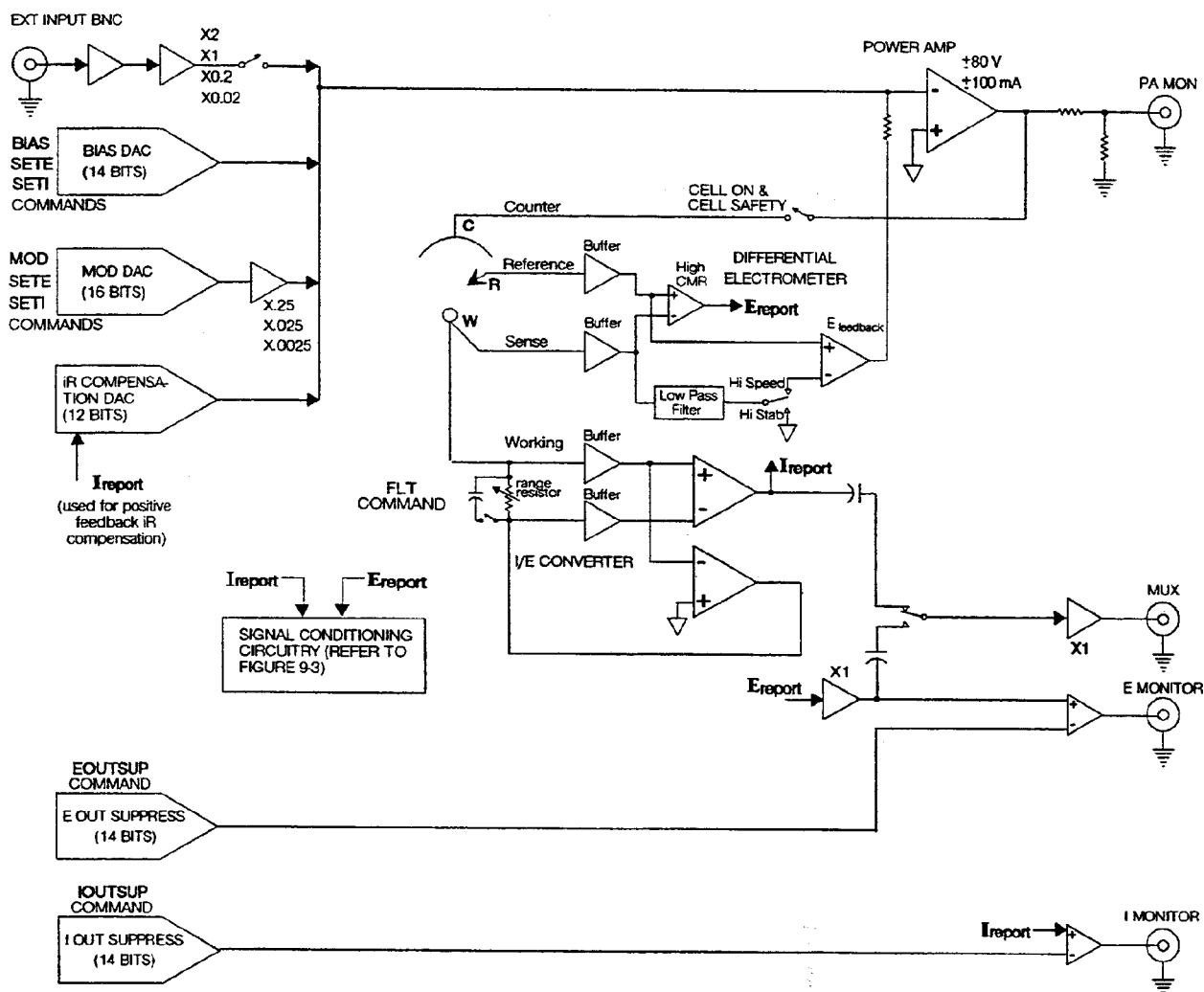


Fig. 25. Simplified Block Diagram of Model 283 in Potentiostatic Mode.

When an input is applied to the Power Amplifier (External Input or DACs), the Power Amplifier's output applied to the Counter Electrode moves in the opposite direction. For example, applying +1 V to the input would cause the Counter Electrode to become increasingly negative. As it becomes more negative, the potential at the Reference Electrode with respect to the Working Electrode (virtual ground) becomes more negative as well. This Reference Electrode potential is sensed by the Electrometer and fed back to the summing junction of the Power Amplifier, countering the effect of the applied input. Because of this negative feedback, the voltage applied to the Counter Electrode will always assume the level required (within the limitations of the Power Amplifier's voltage and current capabilities) to maintain zero volts at the summing junction of the Power Amplifier. This condition is satisfied when the detected Working Electrode potential equals the net control potential. Thus the Working Electrode potential is controlled at the set or programmed level. In other words, in potentiostat operation, the potential is controlled and the cell current at any time is simply determined by the potential of the Counter Electrode and the analyte characteristics.



As shown, the net control potential (External Input, when applied, and DACs) is summed with the Working Electrode potential detected by the Reference Electrode and buffered by the Electrometer. The Bias DAC sets the background level. The Modulation DAC allows complex time-varying control programs to be applied.

Provision is made for monitoring the cell current. Another feedback amplifier, the I/E Converter, which is connected to the cell's Working Electrode, provides this function. A resistance determined by the selected current range is connected between the output of the I/E Converter amplifier and its inverting input (buffered). The amplifier output assumes whatever potential it must to force the inverting input potential to that of the noninverting input (ground). This requirement is satisfied when the output voltage is  $I \times R$  volts, where  $I$  is the working-electrode current in amperes and  $R$  is the feedback resistance in ohms determined by the current range. Thus current equal to the selected current range gives full-scale (1 V) output. The I/E Filter capacitor is also shown.

The output of the I/E Converter is applied to a differential gain-of-one amplifier that provides the *Ireport* signal at its output. As shown, this signal is made available at the I MONITOR connector, and is applied to the Signal Conditioning circuits. Note that the Differential Amplifier looks at the potential difference across the current-range resistor. Producing the *Ireport* signal in this manner accommodates any potential movement that occurs at the Working Electrode at higher frequencies where the gain/bandwidth limitations of the I/E Converter come into play.

The *Ereport* signal is similarly derived. A high common-mode rejection (CMR) amplifier senses the potential at the Reference Electrode with respect to the Working Electrode to develop the *Ereport* signal. This signal is always derived differentially to maintain the highest accuracy at higher frequencies where the virtual ground at the Working Electrode will "move" as the gain-bandwidth limitations of the I/E Converter become a factor.

Also shown in Fig. 25 are the MUX Output circuit, which provides either the E Monitor or I Monitor signal, ac coupled. Indicated also are the E OUT and I OUT suppression DACs, which allow the E Monitor and I Monitor signals to be suppressed to zero.

---

### 9.3. Galvanostat Operation

In Galvanostat operation (Fig. 26) the basic feedback configuration is changed to make current the controlled parameter rather than potential. As in potentiostat operation, all of the control inputs are summed at the input of the Power Amplifier and its output drives the Counter Electrode of the cell. The significant difference is that it is the *Ireport* signal at the output of the I/E Converter that is fed back to the summing junction of the Power Amplifier. As a result, the system stability conditions are satisfied when the cell current is equal to the selected current range. The other inputs (Ext Input and DACs) simply shift the cell current with respect to that established by the selected Current Range.

Note that the electrometer and high CMR amplifier are still available so that the potential of the working electrode with respect to the reference electrode can still be measured to produce the *Ereport* signal, the same as in potentiostat operation. Except that it is optional and is not fed back to the summing junction of the Power Amplifier, *Ereport* is distributed the same as in potentiostat operation.

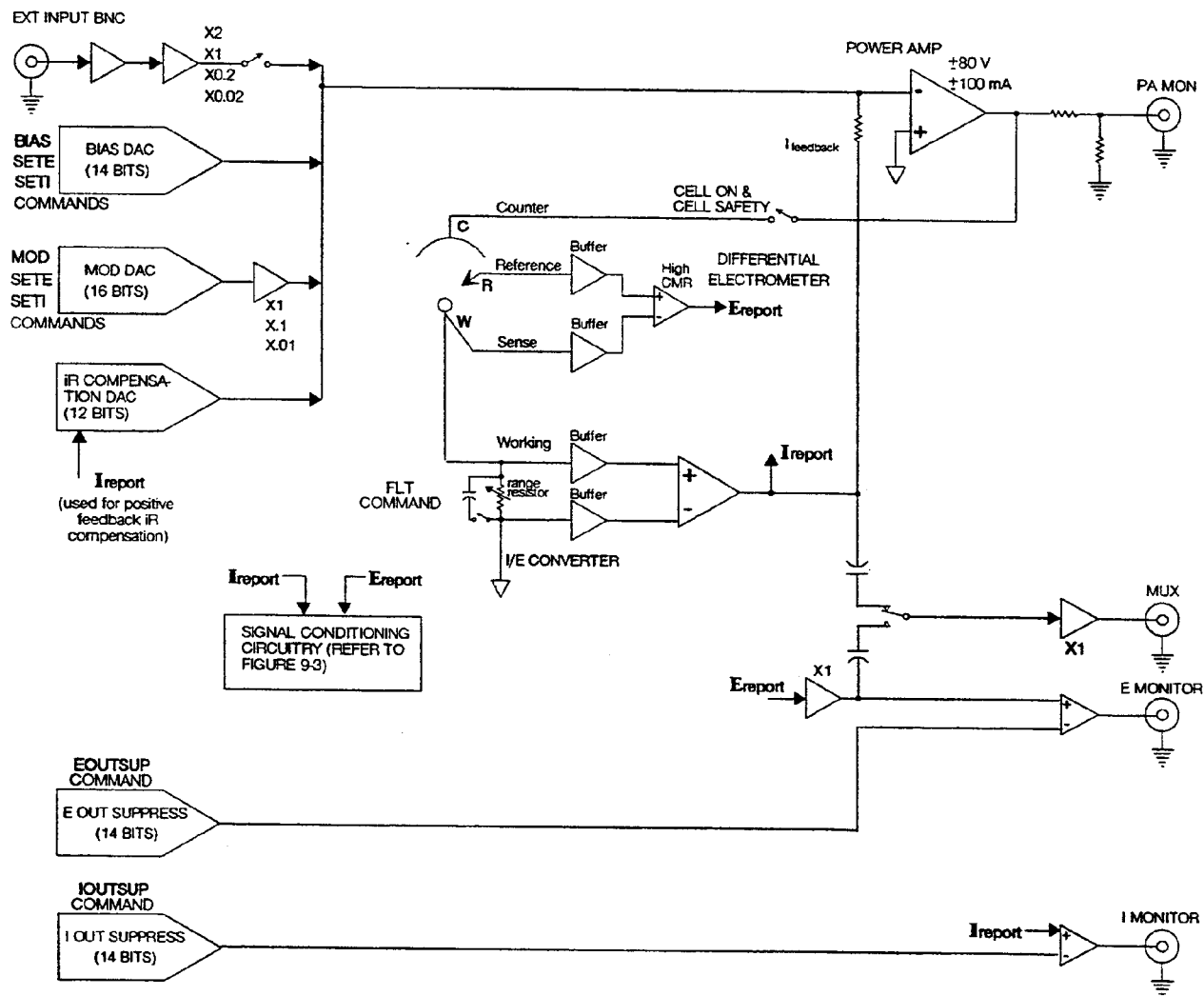


Fig. 26. Simplified Block Diagram of Model 283 in Galvanostatic Mode.

---

## 9.4. Signal Conditioning

The signal conditioning circuitry is denoted by a block in Figs. 25 and 26 and in greater detail in Fig. 27. The heart of this circuitry is the multi-line Multiplexer controlled by the SIE command. This multiplexer makes the selected signal, *Ereport or Ireport* (both filtered or unfiltered), or selected A/D Input, available for further processing. As shown, the output of the Multiplexer is routed through some amplifiers to the Gain Calibration DAC, and from there through some Sample/Hold circuits to the input of the Analog-to-Digital Converter (ADC). The output of the ADC is a 12 bit representation of the multiplexed signal. This 12 bit code is made available to the display and to the computer interface circuitry. Note that there is provision for doing suppression at the output of the Multiplexer.

---

## 9.5. Ancillary Functions

### 9.5.1. E & I Suppression

Figs. 25 and 26 both show the E Out Suppress and I Out Suppress DACS, which generate a dc suppression voltage in response to the EOOTSUP and IOOTSUP commands and sum it with the E Monitor and I Monitor outputs.

### 9.5.2. Auxiliary Inputs

There are two auxiliary inputs on the front panel, called A/D Input 1 and A/D Input 2. Under control of the AUXSEL command, one of these is selected for and made available to the Multiplexer as one of the many signals that can be selected by via the SIE command for acquisition.

### 9.5.3. Output DACs

There are two Output DACs shown in Fig. 27. One of them drives the OUTPUT connector; the other the D/A OUTPUT connector. The voltages supplied to these connectors are developed by the Output DACs in response to the SETOUT and SETOUT2 commands as discussed in the *Command Set Handbook*. These dc outputs can be used to control the speed of a Model 616 or 636 Rotating Electrode or put to other use.

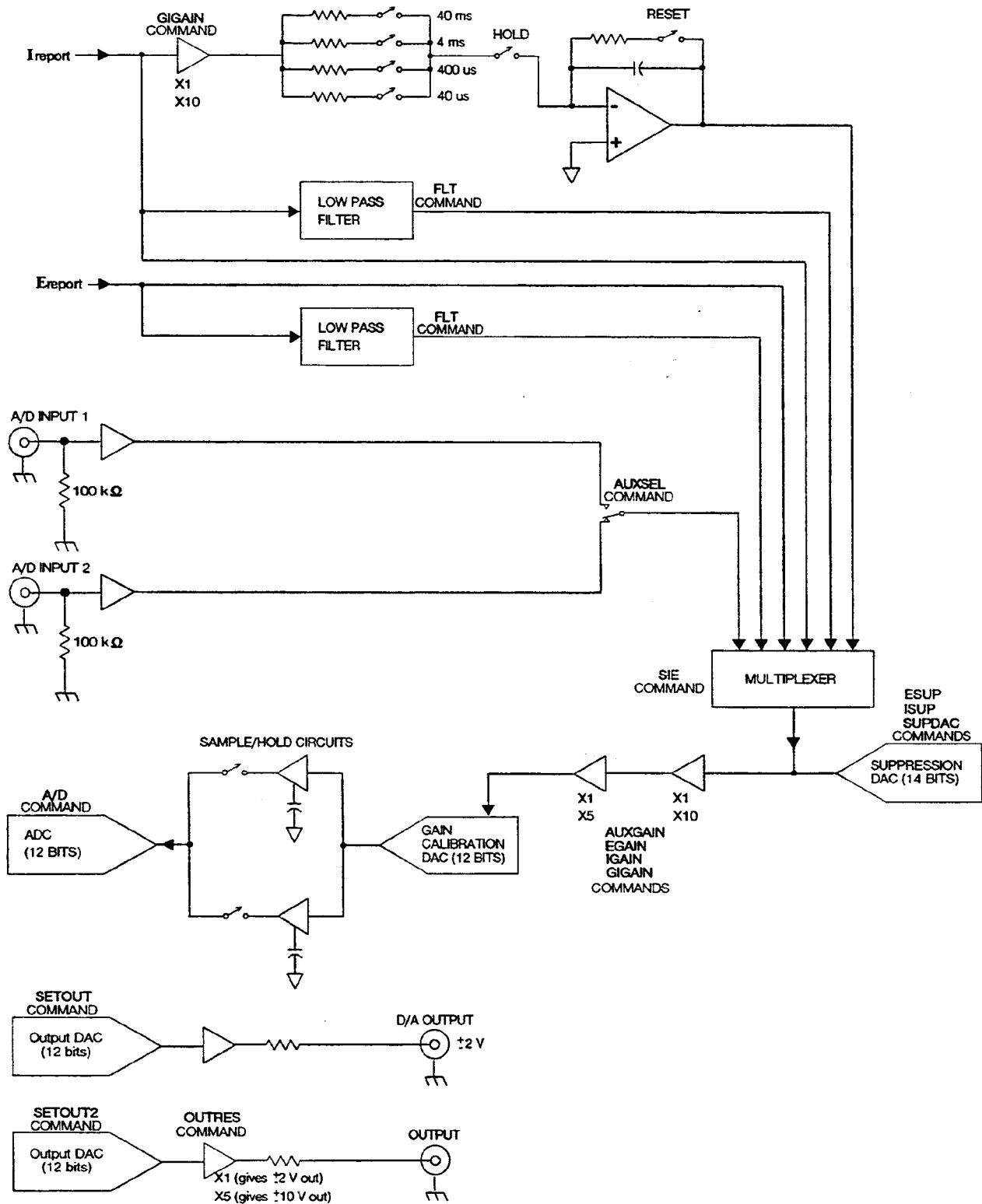


Fig. 27. Simplified Block Diagram of Signal Conditioning Circuitry.

# 10. Maintenance and Service

---

## 10.1. Introduction

The Model 283 Potentiostat/Galvanostat has been designed for optimum reliability, and requires no periodic maintenance except for battery replacement.

---

## 10.2. Battery Replacement

After several years of use, the internal battery may require replacement. The Model 283 is equipped with a long-life lithium battery to retain the calibration settings in memory. The battery has a life of approximately two to five years, depending on how much you use the instrument. You cannot replace the battery yourself; you must send the instrument to an authorized PARI repair facility for battery replacement.

When the battery needs replacement, the instrument will alert you with a message on the front-panel LCD display. Note that you can use the instrument without the battery, but if you do, you will have to recalibrate the instrument every time you power up.

---

## 10.3. Service

This manual contains no service information, as there are no operator-serviceable parts inside the Model 283. The instrument is very difficult to service in the field; special fixtures and services are required that are not readily obtainable except at the factory or at certain affiliate facilities. Contact the factory service department or the affiliate in your area if service is required.



# APPENDIX A. Specifications

## Power Amplifier

Compliance Voltage: >  $\pm 80$  V  
Maximum Output Current: >  $\pm 100$  mA  
Rise Time: < 300 ns  
(1 V, unity gain, no load, 10% - 90%)  
Slew Rate: 10 V/ $\mu$ s  
Bandwidth (Unity Gain, 1 k $\Omega$  load): >1.5 MHz  
Voltage Temperature Stability: < 50  $\mu$ V/deg C

## Differential Electrometer

Input Impedance: >  $10^{13}$   $\Omega$  ( $10^{14}$   $\Omega$  typ) in parallel  
with 5 pF (1 pF typ)  
Input Bias Current: <10 pA at 25°C  
Maximum Input Voltage  
Differential:  $\pm 12$  V no damage, either input  
Common Mode Rejection  
>80 dB at 100 Hz  
>60 dB at 1 MHz  
Bandwidth (1 k $\Omega$  source resistance, -3 dB,  
small signal): >9 MHz  
Offset Voltage: <100  $\mu$ V  
Offset Temperature Stability: <50  $\mu$ V/deg C

## iR Compensation

Positive Feedback  
Range: 2 G $\Omega$  to 20  $\Omega$  depending on current range  
Resolution: 0.05% of current range  
Current Interrupt  
Digital Potential Error Correction: 12 bit DAC  
Total Interruption Time: 10  $\mu$ s to 2000  $\mu$ s

## Current Measurement

Ranges: 9 decades, 100 mA to 1 nA  
Accuracy @ I MONITOR connector  
100 nA to 100 mA Ranges: 0.2% of full scale  
1 nA and 10 nA Ranges: 2% of full scale

## Frequency Response (Small Signal)

1 mA Range: -3 dB at >2 MHz, 1 k $\Omega$   
1  $\mu$ A Range: -3 dB at >200 kHz, 1 M $\Omega$

## Potential/Current Control

Bias Digital/Analog Converter (DAC)  
Resolution: 14 bits  
Range (Potentiostat):  $\pm 8$  V  
Modulation Digital/Analog Converter (DAC)  
Resolution: 16 bits  
Range (Potentiostat):  $\pm 8$  V,  $\pm 0.8$  V, and  $\pm 0.08$  V  
Range (Galvanostat):  $\pm 200\%$ ,  $\pm 20.00\%$ , and  
 $\pm 2.000\%$  of Full-Scale current

## Accuracy

Applied Potential: 0.2% of reading  $\pm 2$  mV  
Applied Current: 0.2% of Full-Scale current

## System

Applied Voltage Noise (0.1 Hz to 100 kHz): 25  $\mu$ V rms  
Drift:  
vs temp: < $\mu$ V 50 /°C  
vs time: <200  $\mu$ V/week

## Computer Interfaces

RS-232C  
IEEE 488.1-1987 with the following interface functions  
implemented: SH1, AH1, T6, L4, SR1 RL1, PP0, DC1,  
DT0, C0, E2

## Weight

18.2 kg (40 lb)

## Size

17.0" W x 10.3" H x 20.0" D

## Power Requirements

90-130 VAC or 210-260 VAC, 50-60 Hz

## Ambient Temperature Range

Specifications apply from 20°C to 30°C  
Instrument will operate from 10°C to 40°C





# APPENDIX B. Technical Reference

---

## B.1. Introduction

This reference comprises an alphabetical list of all the experiment setup parameters and commands that can be programmed from the front panel of the Model 283, with detailed explanations of each. Although you may wish to read through it in its entirety to become more familiar with the Model 283 and its operation, this material is particularly well suited to use as a convenient reference.

---

## B.2. Front-Panel Parameters and Commands

### **Address**

See *GPIB Address*.

### **Automatic Current Ranging**

See *Current Auto-Ranging*; *Current Range*.

### **Bandwidth (Stability versus Speed)**

Bandwidth is set from the FUNCTION menu screen. One of the two bandwidth modes, HI SPEED or HI STABILITY, will always be in effect. The default setting is HI STABILITY. The speed vs stability tradeoff is achieved by operating with the electrometer configured single-ended (HI SPEED) or differentially (HI STABILITY) as discussed in Chapter 9.

The HI SPEED mode gives the fastest response in Potentiostat or Galvanostat operation, but without guaranteed stability in all experiments. Under the proper conditions with certain cells, ringing almost always occurs and oscillations may occur. Cells having large capacitance and low resistance are most likely to prove troublesome.

The HI STABILITY mode provides extreme stability at somewhat reduced speed. In this mode, stable operation is assured with virtually any cell. However, the possibility always exists that with an unfamiliar cell configuration, or under extremely unusual operating conditions, stability problems might occur. If oscillation does occur in the HI STABILITY mode, the cause may be too much resistance in the reference electrode. Even a well-designed, low-impedance reference electrode can develop a high resistance if salts precipitate in the junction.

### **Baud Rate**

See *Serial Baud Rate*.

### **Cell (Condition) at End**

This parameter, set from the scan or step experiment menu screens, determines the working electrode potential (in potentiostatic operation) or cell current (galvanostatic operation) at the end of a scan or step cycle. If you select OFF (the default setting), the cell will be turned off (counter electrode connection interrupted) at the end of the programmed cycle. If you select E INIT (I INIT in galvanostatic operation), the working electrode potential (or cell current) will be returned to E INIT (or I INIT).

If you select E FINAL (or I FINAL), the working electrode potential (or cell current) remains at its last value in the programmed scan sequence. In the FULL CYCLE mode, this is E FINAL (or I FINAL). But note that in HALF CYCLE operation, the last level reached in the sequence actually is E MID (or I MID).

Also note that in the CONTINUOUS cycle mode, the experiment doesn't end until the "Stop" key (F3) is pressed. At that point, the cell status returns to E INIT (I INIT in galvanostatic operation).

## Cell Current

Cell current is the controlled parameter in galvanostatic operation. In steady-state galvanostatic operation, where the cell current is held constant, the CURRENT parameter is set from the [Galvanostat] menu screen. The value for CURRENT is that in effect at the time the instrument was last powered down, or the last value set if changed since power-up. The units and resolution are indicated by the display.

Current parameters I INIT, I MID, and I FINAL, set from the [Galvanostatic Scan] and [Galvanostatic Step] menu screens, specify the cell current at each of three stages in a scan or pulse sequence. I INIT specifies the current at the start of the scan. I MID specifies the current at end of the scan's first leg. In Half Cycle mode operation, the scan ends at I MID, and I MID continues to flow in the cell.

In Full Cycle operation, I MID is a vertex and I FINAL specifies the final current which continues to flow after the scan is over. In Continuous Cycle operation, there is repetitive cycling between I MID and I FINAL until the STOP key (F3) is pressed. Delays T INIT and T MID may be used to determine the length of time I INFT and I MID are in effect (PASS = 4 ms). The Delay at I INIT and I MID may be carried out with the cell either on or off. See **Delays** for details.

It is important to understand that if you change the full-scale current range, the instrument will automatically change the cell current to maintain the same ratio of current to full-scale current range. For example, let's say the full-scale current range is 10 mA and cell current is set to 8.00 mA. Then cell current will be 80% of the full-scale current range. If you decrease the full-scale current range to 1 mA, this ratio will be maintained automatically and cell current will be reset to 0.800 mA. This is true for any current parameter – CURRENT, I INIT, I MID, and I FINAL.

Keep in mind that the value specified for any cell current parameter can be no greater than two times the full-scale current range selected.

## Cell Potential

E INIT, E MID, and E FINAL specify the potential applied at each of three stages in a scan or pulse sequence. Potential is the controlled parameter in Potentiostat mode operation. E INIT specifies the potential applied at the start of the scan. E MID specifies the potential applied at end of the scan's first leg. In Half Cycle mode operation, the scan ends at E MID, and E MID continues to be applied.

In Full Cycle operation, E MID is a vertex and E FINAL specifies the final potential, which continues to be applied after the scan is over. In Continuous Cycle operation, there is repetitive cycling between E MID and E FINAL until the "Stop" key (F3) is pressed. Delays T INIT and T MID may be used to determine the length of time E INIT and E MID are applied (PASS = 4 ms). The Delay at E INIT and E MID may be carried out with the cell either on or off. See **Delays** for details.

In steady-state potentiostatic operation, where the potential at the working electrode is held constant with respect to the reference electrode, the Potential parameter is set from the [Potentiostat] menu screen. In steady-state operation, the value for the Potential parameter is that in effect at the time the instrument was last powered down, or the last value set if changed since power-up.

The units and resolution are indicated by the display. Potential can be specified to the nearest mV. Potentials can be set over a range of -10 V to +10 V. However, the absolute potential range, that is, the difference between the highest potential in an experiment and the lowest potential in that same experiment, cannot exceed 8 V.

## Current Cell

See **Cell Current**.

## Current Auto-Ranging

In potentiostatic operation, you can allow the Model 283 to automatically set the appropriate full-scale current range. In the Auto-Ranging mode, selected by pressing the AUTO key, the Model 283 automatically seeks the full-scale current range that causes the I MONITOR potential to be between 15% and 190% of full scale; that is, between 150 mV and 1.9 V. If cell current is less than 150 nA,

the 100 nA range will be selected. If the instrument is on the 10 mA range and cell current is greater than 19 mA, the 100 mA range will be selected. This process occurs after each point is acquired, with the constraint that it can only change one range at a time. Data could be lost if the data amplitude changed faster than it could be tracked by the auto-ranging function. For an explanation of the full-scale current range, see **Current Range, Full Scale**.

You can set a limit to the automatic current ranging by adjusting the I AUTO LIMIT parameter on the [System Default] menu (see Chapter 6, Section 6.7B). The full-scale current range will not go below the I AUTO LIMIT you set. The default range is 100 nA.

Note that automatic current ranging is restricted to operation in the Potentiostat mode. It cannot be selected in the Galvanostat mode.

### **Current Integral (Coulombs) Display**

In the potentiostatic and galvanostatic experiment menu screens, the FI key selects the parameter to be displayed on the right side of the second line of the menu screen.

By pressing FI, you can display either of two other parameters on this line: net current with I OFFSET applied (i) or the final current integral (Q).

I OFFSET is a current value that is mathematically subtracted from the cell current before it is displayed. The result of this subtraction is displayed as "i" and accumulated over time as "Q". That is,  $i = I - (\text{I OFFSET})$ , where I OFFSET can have a positive or negative value.

Note that there is no actual current subtraction, only a numerical calculation. Thus current offset does not affect the potential at the I MONITOR connector.

Current offset is a feature that can be used in potentiostatic experiments but is not useful in galvanostatic operation. Thus there is no provision for setting it from the galvanostatic menus. But be aware that if you have set a value for I OFFSET in one of the potentiostatic menus and then switch to galvanostatic operation, the offset will remain in effect when "i" is displayed.

The final current integral (Q) is the net charge, after the algebraic addition of I OFFSET, that has passed through the cell since the beginning of the experiment while the cell was on (or since the coulometer was reset). Q is expressed in coulombs. In the FULL FRILLS acquisition mode (see the *Command Set Handbook* for a discussion of the acquisition modes), the displayed charge accumulation will be updated every timebase. Q normally is not selected if speed of data acquisition is the main concern, such as might be the case when the Model 283 is being controlled from an external computer via the RS-232 or GPIB interface.

When you press the F2 key (Q Reset), the following query is displayed on line 3 of the LCD panel:

RESET COULOMBS?...

If you press YES (F4), it resets the coulometer to zero and reestablishes the initial scaling factor, as set by the selected current range. If FI has been used to display Q, you will see the final current integral (in coulombs) on the second line of the display reset to zero and then begin to increment as charge accumulation resumes.

If you press NO (F5), the coulometer is not reset and the previous menu screen reappears.

In a perfect instrument and cell system, Q of course could not change when the cell is disconnected, because no cell current would flow. But in a real system, no matter how precise, some small charge may appear as a result of drift and other circuit variations. Thus, setting UPDATE Q W/CELL OFF = NO (from the [System Default] menu) prevents charge from accumulating when the cell is off. Choosing YES allows it to accumulate, and might help to estimate drift errors.

### Current Interrupt iR Compensation

Current Interrupt is one of two available iR Compensation techniques (see **iR Compensation**). iR Compensation can be selected from any of the three potentiostatic menu screens (IR MODE). The default setting is OFF.

iR Compensation is used to eliminate the error caused by the iR drop across the uncompensated resistance in the electrochemical cell. The Current Interrupt technique does this by rapidly shutting off the cell current, estimating the drop in reference potential before the cell double-layer capacitance discharges through  $R_p$  (the polarization resistance), and then adding that iR drop back into the counter electrode control voltage.

When the current in the cell is interrupted, a drop in the E MONITOR potential equal to  $iR_u$  occurs. As this potential drop cannot be measured directly, it is estimated by extrapolation from two other potential levels measured at specified intervals after current interruption.

Four parameters, all available from the potentiostatic menu screens, can be adjusted to estimate and fine-tune the amount of iR compensation to be applied. IRUPT (Intermittent Current Interrupt) sets the interval between current interrupts. The range is 1 to 32767 data points, with a default setting of 5 points. In local operation from the front panel, 5 points is equivalent to 20 ms if LINE SYNC is not enabled. (In remote control from a host computer, the interrupt timing is controlled by the computer.)

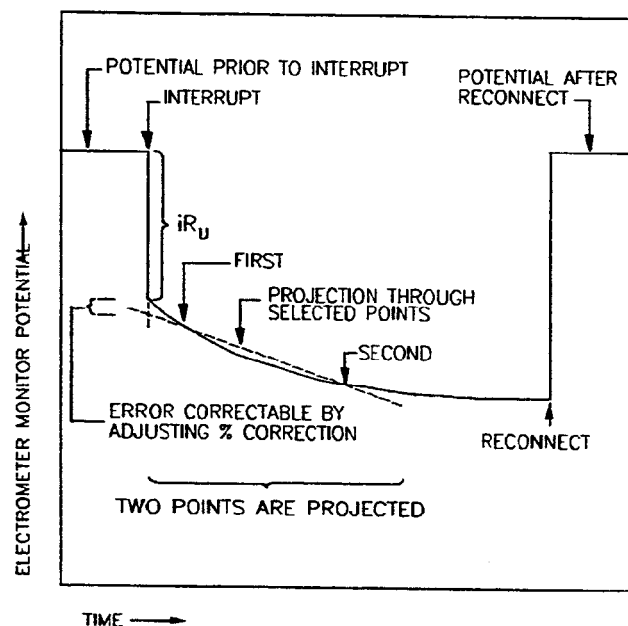
IRUPT T1 sets the increment of time between the interruption of current to the cell and the first sampling of potential during the no-current condition. IRUPT T2 sets the time increment from IRUPT T1 to the second sampling of potential. These two potential levels, at IRUPT T1 and IRUPT T2, are used to extrapolate the value of the iR drop across the uncompensated resistance in the cell.

The IRUPT T1 and IRUPT T2 settings can range from 10  $\mu$ s to 2000  $\mu$ s, but the sum of the values of IRUPT T1 and IRUPT T2 may not exceed 2000  $\mu$ s. The default values for both are 10  $\mu$ s on the 100 mA current range and 75  $\mu$ s on all other current ranges. Note that IRUPT T1 and IRUPT T2 *can be set independently for each current range*.

IRPC (Current Interrupt Percent Correction) sets the percentage of correction, adjustable from 0% to 200%, with a default of 100%. This function is used to fine-tune the extrapolation procedure.

Note: The default values of these parameters give good results in many applications. Do not change them unless you are well versed in current-interrupt iR compensation theory. This is particularly true of IRUPT T1, IRUPT T2, and IRPC.

A prerequisite to evaluating these parameter selections is that an oscilloscope be connected to the E MONITOR BNC connector to observe the current-interrupt waveform, as discussed in the following paragraphs. Even with the oscilloscope, it is not easy to make optimum determinations. The position of the selected points, as well as the path of the projection through the points, must be estimated.



**Fig. 28. Current Interrupt Waveform At E Monitor Connector.**

Fig. 28 illustrates the E MONITOR waveform for a typical Current Interrupt cycle. Referring to the figure, note that a fast potential drop equal to  $iR_U$  occurs at the moment of interrupt. The purpose of the current interrupt procedure is to estimate this potential drop so that a correction factor can be developed. As the drop cannot be measured directly, it is estimated by extrapolation from two potential levels measured later at different points on the curve of potential decay after current interruption.

Just before current interruption, the potential level is sampled. After interrupt, two more potential samples (at IRUPT T1 and T2) are taken. The operator specifies the time intervals between the current interruption and the second sample (IRUPT T1), and between IRUPT T1 and the third sample (IRUPT T2). Each time interval must be at least 10  $\mu$ s.

The potential levels at IRUPT T1 and T2 are used to define a projection that is extrapolated back to the instant just after current interruption. By comparing the linearly extrapolated potential at that instant with that before the interruption (the first sample), a correction function is developed that corrects for the uncompensated  $iR$  drop in the cell.

The goal is to select two points for IRUPT T1 and T2 that will provide a projection that intersects the lower end of the  $iR_U$  drop. If the intersection occurs at a higher point, the correction factor will be too small. If it occurs at a lower point, as is the case for the example depicted in the figure, the correction factor will be too large.

Two general guidelines can be used for setting IRUPT T1 and IRUPT T2:

1. T1 should be greater than cell cable capacitance (about 20 pf)  $\times R_U$  (often on the order of 1000  $\Omega$ ). Assuming these values, IRUPT T1 should be greater than 20 ns. But  $R_U$  may be considerably higher than 1000  $\Omega$  when you are working with low-conductivity media, such as concrete or nonaqueous solvents.
2. T2 should be less than cell capacitance (generally around 25  $\mu$ F/cm<sup>2</sup>)  $\times R^U$  (as determined from a polarization resistance experiment).

Fortunately, IRPC, by allowing user control of the percentage of correction, eases the point selection task. For example, if the extrapolated line were to intersect exactly halfway down the drop, the correction factor would be 50% of the required value. The resulting correction factor could be easily adjusted to its proper value by using IRPC to set the percentage of correction to 200%. Similarly, if the intersection occurred below the drop, as in the depicted example, IRPC would be used to set a percentage of correction of less than 100% (90% would be about right for the example).

Once Current Interrupt iR Compensation is established by setting IR MODE = IRUPT, and IRUPT T1, IRUPT T2, IRUPT, and IRPC are set, no other operator intervention is required during the measurement.

Current Interrupt iR Compensation has several advantages as compared to Positive Feedback iR Compensation:

1. This technique corrects for essentially the entire potential error caused by the uncompensated resistance.
2. This technique corrects for any changes in the uncompensated resistance as the scan progresses.
3. No adjustment is required on the part of the user. The only action required is the simple selection of IR MODE = IRUPT. (The default values of IRUPT T1, IRUPT T2, IRUPT, and IRPC will give good results in many applications.)

Disadvantages of the technique include:

1. The correction occurs at finite times. Thus the technique is not suitable for scan rates greater than 500 mV/s and may, in fact, not work properly at scan rates greater than 100 mV/s.
2. If the correction isn't updated frequently enough, the applied correction can be in error.
3. In some cases, this technique can cause the entire system to oscillate.

Note that Current Interrupt is a positive feedback technique which reduces the margin of stability in the control of the cell. Slow scan rates reduce this problem by allowing the potentiostat loop to fully settle before the next interruption.

**Note:** *If the cell is turned OFF while current interrupt is selected, the current interrupt routine is skipped and no correction occurs. When the cell is turned back on, the current-interrupt routine resumes.*

Once Current Interrupt Compensation is running, the user may wish to monitor the waveform at the E MONITOR connector with an oscilloscope to optimize the Current Interrupt parameters as established by IRUPT T1, IRUPT T2, IRUPT, and IRPC. The selection of the extrapolation points (T1 and T2) and the Percent Correction (IRPC) setting determine the accuracy of the applied correction. Note that the waveform depicted in Fig. 28 is idealized; actually encountered waveforms may not be so easy to analyze.

### **Current Offset (I Offset)**

Available at the three potentiostatic operation menus, I OFFSET allows you to specify a current value to be mathematically subtracted from the cell current before it is displayed. The result of this subtraction is displayed as "i" and accumulated over time as "Q". That is,  $i = I - (I \text{ OFFSET})$ , where I OFFSET can have a positive or negative value.

Note that there is no actual current subtraction, only a numerical calculation. Thus current offset does not affect the potential at the I MONITOR connector.

The offset range is  $\pm 2$  times the selected full-scale current range. If you change the current range, the instrument will automatically reset I OFFSET to maintain the same ratio of current offset to full-scale current range.

### **Current Overload**

The I OVERLOAD indicator lights if the cell current exceeds two times the selected full-scale current range. This does not mean that the cell control loop is out of control. It means only that the cell current monitoring circuits are being driven to the limit.

### **Current Range, Full Scale**

The full-scale current range selection is used to scale the output potential at the I MONITOR connector to a useful value for any cell current. A cell current equal to the selected current range gives 1 V at the I MONITOR connector. Note that a current that exceeds two times the current range generates an I OVERLOAD condition.

The polarity of the voltage at the I MONITOR connector is that of the current. For example, a current level of -1 mA will give -1 V at the I MONITOR connector (1 mA Current Range), representing an anodic or reducing current.

The full-scale current range can be set either manually by the operator or automatically by the Model 283 ("Auto-Ranging"). But note that Auto-Ranging is restricted to potentiostatic operation. Should the user attempt to select Auto-Ranging in galvanostatic operation under remote control, an error message will be generated. In local control, no error message will be generated but the AUTO key will be ignored.

In the Manual ranging mode, selected by toggling the AUTO key to turn the AUTO indicator off, the current range is selected with the arrow keys below the current range indicators. The  $\uparrow\uparrow$  key moves the selection upwards through the available ranges. The  $\downarrow\downarrow$  key moves it downwards.

In the AUTO mode, selected by pressing the AUTO key, the Model 283 automatically seeks the full-scale current range that causes the I MONITOR potential to be between 15% and 190% of full scale; that is, between 150 mV and 1.9 V. If cell current is less than 150 nA, the 100 nA range will be selected. If the instrument is on the 10 mA range and cell current is greater than 19 mA, the 100 mA range will be selected. This process occurs after each point is acquired, with the constraint that it can only change one range at a time. Data could be lost if the data amplitude changed faster than it could be tracked by the auto-ranging function.

You can set a limit to the automatic current ranging by adjusting the I AUTO LIMIT parameter on the [System Default] menu (see Chapter 6, Section 6.7B). The full-scale current range will not go below the I AUTO LIMIT you set. The default range is 100 nA.

The I/E Filter (if selected) can cause unpredictable effects on your experiment if AUTO current ranging is in use. If I/E FILTER = ON is selected (from the [System Default] menu screen), you generally should use manual current ranging.

Current Ranging, Automatic  
See *Current Auto-Ranging*.

### **Cycle Control**

The CYCLES parameter, set from the [Potentiostatic Scan], [Potentiostatic Step], [Galvanostatic Scan], or [Galvanostatic Step] menu, determines the number of separate steady-state potential levels that will be used at the working electrode (or steady-state cell current levels in galvanostatic operation), during your experiment. Three different cycle sequences are available: HALF CYCLE, FULL CYCLE, or CONTINUOUS. A brief description of each setting follows.

1. HALF CYCLE: This is the simplest cycle, involving only two potential or current settings. A half-cycle sequence proceeds as follows.
  - a. Delay T INIT at E/I INIT.
  - b. Scan (or step) from E/I INIT to E/I MID.
  - c. Scan remains at E/I MID for T MID, then stops.

At the end of the scan or step sequence, the setting of CELL@END on the menu will determine whether cell potential or current will remain at its last value (CELL@END = E FINAL or I FINAL), will step to E INIT or I INIT, or will step to OFF (counter electrode connection interrupted).

Note that the setting of CELL@END = E FINAL or I FINAL will cause cell potential or current to remain at the last level it reached in the experiment sequence, which in half-cycle operation actually is E MID or I MID.

2. FULL CYCLE: A Full Cycle is more complex and involves all three programmed potential or current levels. The sequence is:
  - a. Delay T INIT at E/I INIT.
  - b. Scan (or step) from E/I INIT to E/I MID.
  - c. Delay T MID at E/I MID.
  - d. Scan (or step) from E/I MID to E/I FINAL.
  - e. Scan remains at E/I FINAL for T FINAL, then stops.

At the end of the scan or step sequence, the setting of CELL@END on the menu will determine whether cell potential or current will remain at E/I FINAL, will step to E/I INIT, or will step to OFF (counter electrode connection interrupted).

3. CONTINUOUS: Continuous is the most complex of the three cycles. The sequence is as follows.
  - a. Delay T INIT at E/I INIT.
  - b. Scan (or step) from E/I INIT to E/I MID.
  - c. Delay T MID at E/I MID.
  - d. Scan (or step) from E/I MID to E/I FINAL.
  - e. Delay T FINAL at E/I FINAL.
  - f. Scan (or step) from E/I FINAL to E/I MID.
  - g. Steps 3 through 6 repeat until "Stop" key is pressed.

Automatic cycling of the scan back and forth between E/I MID and E/I FINAL will continue until you press the "Stop" key (F3). When it is halted, the cell potential or current will step sharply to E/I INRT, ending the cycling.

Data Bits  
See *Serial Data Bits*.



### **Delays T Init, T Mid, T Final**

A delay is a time interval between rampwise or stepwise changes in cell potential or current. The cell potential or current does not change during a delay. Delays are programmed from a "Scan" or "Step" menu, and can be set at three different points (T INIT, T MID, and T FINAL) in the scan or step sequence. Each delay can range from 4 ms to 500 s.

Scans typically, but not necessarily, begin with a delay. The first delay interval, T INIT, precedes the first leg of the scan or step. It begins when you press "Run" (F3). The cell potential or current during T INIT is determined by the setting of E/I INIT. If E/I INIT is not zero, the cell potential or current steps sharply to the specified level. Once the delay interval ends, the scan begins and the potential or current begins to increment as programmed.

In full-cycle or continuous operation, a second delay, T MID, can be interposed between the first and second legs of the scan. The cell potential or current is determined by the setting of E/I MID.

In continuous operation only, a third delay, T FINAL, can be interposed between the second and third legs of the scan. The cell potential or current is determined by the setting of E/I FINAL.

In [Potentiostatic Step] or [Galvanostatic Step] operation, you may temporarily override a programmed T INIT, T MID, or T FINAL delay by pressing "Bypass" (F5). Pressing F5 before or during the delay temporarily overrides that delay and sets it to a minimum (actually 4 ms). The scanning sequence then immediately advances to the next step.

For example, if "Bypass" F5 is pressed during the T INIT interval, the sequence would immediately advance to the first scan. In half-cycle or single-cycle scanning, if the next step would advance the sequence to the end of the scan, the scan would halt.

### **Dummy Cell**

See **Cell Type**.

### **E Initial, E Mid, E Final**

See **Cell Potential**.

### **E Overload**

The E OVERLOAD indicator lights if the control amplifier output is at its limit ( $E_{\text{control}} > 80 \text{ V}$ ) and the control loop is not controlling the cell potential. This can happen in either Potentiostatic or Galvanostatic operation and normally indicates either a cell-setup problem or an extremely high resistance solution.

Whenever E OVERLOAD lights, the problem *must* be located and corrected before valid measurements can be made. A common cause in potentiostatic operation is a disconnected reference electrode. Note that this can cause damage to the working electrode if it occurs.

### **Echo**

See **GPIB Echo; Serial Echo**.

### **External Input**

The EXT INPUT connector has two separate but similar functions: External Input and Oscillator Input. The main difference between these functions is that in the OSC IN mode the gain of the applied signal can be scaled up or down, while the EXT INPUT mode always applies unity gain to the input signal.

This connector can be made active (turned on) or inactive either with the front panel controls or by software commands from an external computer. From the front panel, it can be controlled with either the EXT INPUT or the OSC IN setting on the [System Default] menu (see "Adding an External Signal", Section 6.13). Remote control from an attached computer is described in the

Model 283 *Command Set Handbook*. Note that both EXT INPUT and OSC IN cannot be set to ON at the same time.

When the EXT INPUT connector is active ("ON"), an analog control voltage applied to it will be summed with the output of the digital-to-analog converters (DACs), which are set at the front panel or from an attached PC. The control signals could be generated by, for example, a PARI Model 175 Universal Programmer to provide rapid scanning and true analog cyclic voltammetry. Other waveform generators, a lock-in amplifier, or a frequency response analyzer could be used.

In potentiostatic operation, all of the control potentials add algebraically. For example, if the voltage applied to EXT INPUT is +0.5 V, at a time when a potential of +0.5 V is programmed in the instrument, the net potential applied will be +1.0 V, and the working electrode would be controlled at +1.0 V with respect to the reference electrode. (This assumes, of course, that the applied signal is not scaled by selecting the OSC IN mode.) A positive applied potential will make the current tend to be more anodic. A negative applied potential will make the current tend to be more cathodic.

In galvanostatic operation, making the applied potential more positive by any means except applying a potential to the EXT INPUT connector will tend to make the cell current more cathodic. Making the applied potential more negative will tend to make the current more anodic. *This sense is reversed at the EXT INPUT connector. There, making the input more positive will make the cell current more anodic. Making the input more negative will make the cell current more cathodic.*

Extrapolation Points

See **Current Interrupt *iR* Compensation**.

### Filters

You can switch in two low-pass filters by setting I/E FILTER = ON from the [System Default] menu screen. Note that you cannot select only one filter at a time; both must be either selected at the same time or bypassed. Both filter the signal input to the A/D converter. One of these filters has a sharp cutoff at 5.3 Hz. (In remote operation, a 590 Hz low-pass filter is also available under software control.)

The second low-pass filter selected by setting I/E FILTER = ON consists of a roll-off capacitor that reduces the bandwidth of the I/E converter. The effect of this capacitor on bandwidth depends on the current range selected.

Unlike the 5.3 Hz filter, the roll-off capacitor filters the signal at the I MONITOR connector. This capacitor is often helpful when making low-current measurements on large electrodes because it reduces the noise at I MONITOR. The disadvantage of using the filter is that the I MONITOR response time is degraded.

As the effect of the roll-off capacitor on the I/E converter bandwidth varies with the current range, filtering can cause unpredictable effects if AUTO current ranging is in use. If I/E FILTER = ON is selected, we recommend manual current ranging.

It may be advantageous to synchronize data acquisition with the power line frequency when filtering. This can be done by setting LINE SYNC = ON (see "Line Sync").

### Full-Scale Current Range

See **Current Range, Full Scale**.

### GPIB Address

The IEEE 488-1978 Instrument Bus Standard defines a bit-parallel, byte-serial bus structure designed to allow communications between intelligent instruments. Using this standard, many instruments may be interconnected and remotely controlled or programmed. Data can be taken from, sent to, or transferred between instruments via one connector or port.

Each device on a shared GPIB bus is assigned a listen address and a talk address for identification. These addresses are set at the device. When the controller (the PC) wishes to communicate with a specific device (the Model 283) on the bus, it places the listen address of the device on the bus. Only the device having the corresponding address will respond to the subsequent message. Similarly, if the controller wants a device to talk, it sends the talk address of the device in question. The addressed device will transmit until a different talker is designated.

When the controller communicates with a device on the bus, it begins by placing the address of that device on the bus with ATN asserted. Naturally, each device must "know" its own TALK and LISTEN address. In the case of the Model 283, these addresses are set from the [System Interface] menu on the front panel with the VALUE knob.

The Model 283 can be set for any address from 1 to 30. The normal address setting for use with PARI software is 14. See your software manual for its individual requirements.

Further details of GPIB addressing are given in the appendixes of the *Model 283 Command Set Handbook*.

### **GPIB Terminator Character**

In GPIB communications, the terminator is the character that marks the end of each transmission from the Model 283 to the host computer or from the host computer to the Model 283. It must be selected on the Model 283 according to the requirements of the host computer, sometimes in conjunction with the software it is running. Failure to satisfy this requirement is one of the most common causes of problems in establishing communications via the GPIB.

You set the terminator from the [System Interface] menu on the Model 283 for *GPIB transmissions* to the host computer. When the terminator is set to "CR", it is a Carriage Return. When the terminator is set to "CRLF", it is a Carriage Return followed by a Line Feed. The terminator required for GPIB communications with IBM PC-compatible computers running PARI software is CR.

Note that you cannot configure the Model 283 to receive transmissions ended by the CRLF terminator. The Model 283 always expects the OR terminator in data it is receiving via the GPIB bus.

### **GPIB Test Echo**

A special GPIB TEST ECHO mode can be established by switching to the [System Interface] menu and setting GPIB ECHO = ON. When the Test Echo function is ON, every character transmitted or received via the GPIB port will be echoed to the RS-232 interface connector. The RS-232 baud rate should be high to prevent slowing down the GPIB.

This feature is particularly useful when developing programs. If a "dumb" CRT terminal is connected to the RS-232 interface, the programmer will see all communications on the CRT. Such a terminal will allow direct interaction, thereby facilitating the programmer's understanding of the commands and responses. In addition, the programmer will be able to monitor the program data and intervene if necessary.

During normal operation, GPIB ECHO should be set to OFF.

### **High-Speed Mode**

See *Bandwidth*.

### **High-Stability Mode**

See *Bandwidth*.

### **I Initial, I Mid, I Final**

See *Cell Current*.

## I Offset

See **Current Offset**

## I Overload

See **Current Overload**.

## iR Compensation

In an electrochemical experiment, the voltage across the double layer of the specimen surface must be closely controlled. If you don't have confidence that the potential you're applying is the potential felt at the specimen, you can't be sure that your measurement is valid.

But there are factors which make it difficult to control this potential. In all electrochemical cells there is some resistance between the tip of the reference electrode and the outside of the double layer of the specimen surface. This resistance is referred to as the "uncompensated resistance."

As current flows through the electrochemical cell, a potential is developed across the uncompensated resistance. When the uncompensated resistance gets high (as it does in pure water or organic solvents, for example) or the current becomes large, a significant potential error may occur.

Obviously, it is desirable to eliminate this error. The Model 283 provides two techniques for this: Positive Feedback iR Compensation (PFIR) and Current Interrupt iR Compensation (IRUPT). The voltage at the E MONITOR connector is corrected when either technique is employed.

Both iR Compensation techniques can be set from any of the three potentiostatic menu screens. Only one iR Compensation mode can be active at a time. If one of the two is active and the other is selected, the one previously active will be turned off and the newly selected mode will become active.

The two iR Compensation techniques are performed in entirely different ways. Because each of the techniques has strengths and weaknesses, some situations will call for one technique and some for the other. Fig. 29 briefly lists the relative strengths of the two techniques.

For details of the two techniques, see **Current Interrupt iR Compensation; Positive Feedback iR Compensation**. A more complete discussion of iR Compensation can be found in "Technical Note 101," available on request from PARI.

Parameter	-----iR Compensation-----	
	Pos. Feedback	Current Interrupt
Speed	Fast	Slow
Ease of Use	More Difficult	Very Simple
$R_u$ Tracking	Does Not Track	Tracks
Stability	Critical	Very Stable
Artifacts	None	Minor

**Fig. 29. Comparison of Positive Feedback and Current Interrupt iR Compensation.**

### **iR Mode**

See ***iR Compensation; Current Interrupt iR Compensation; Positive Feedback in iR Compensation***

### **IRUPT**

See ***Current Interrupt iR Compensation***.

### **Knob Timeout**

To prevent someone from changing an experiment parameter by inadvertently moving the VALUE knob, you can disable the knob after you have finished using it. You can specify the period of time R waits after its last use before becoming inactive (the "timeout" period). At the end of the timeout period, the knob will have no effect on parameter settings, and the LCD panel will display "KNOB TIMEOUT HIT ANY KEY." Press any key to reactivate the knob. The KNOB TIMEOUT parameter is set from the [System Interface] menu screen.

### **Line Sync**

The LINE SYNC parameter, set from the [System Default] menu screen, determines whether data acquisition will be synchronized with the power line frequency. If you set it to YES, samples are taken every 16.6 ms (60 Hz power) or every 20 ms (50 Hz power), If you set it to NO, samples are taken at the rate determined by the internal time base. The default state of this parameter is NO.

If the LINE SYNC setting is changed while a scan is in progress, the scan will proceed at the new rate.

**Note:** In P-Scan, if the **scan rate** is >250 mV/s, Line Sync **cannot** be enabled. Conversely, if Line Sync is enabled, the **scan rate** will not increase beyond 250 mV/s. A similar interaction applies to G-Scan, where Line Sync is incompatible with scans faster than 25% of f.s. range per second. For example, on the 100  $\mu$ A range, the fastest scan rate possible with Line Sync enabled would be 25  $\mu$ A per second.

### **Osc In**

Set from the [System Default] menu screen, the OSC IN parameter setting determines whether the front-panel EXT INPUT connector will accept and scale an applied signal. Use ON if the applied signal is too large or too small and you wish to scale it by a factor of 0.02, 0.2, or 2.0. OFF is used either when no signal is to be applied, or when an applied signal is of a useful amplitude with unity gain (in that case, use EXT INPUT = ON).

Note that both EXT INPUT and OSC IN cannot be set to ON at the same time. If you are unsuccessful in turning one on, check that the other is off.

If you set OSC IN = ON, press the NEXT PARAMETER key once and set OSC GAIN (see below).

### **Osc Gain**

When the OSC IN parameter is set to ON, an external signal applied to the EXT INPUT connector will be scaled by a factor specified by the OSC GAIN parameter. Both parameters are set from the [System Default] menu screen. The provided scaling factors are: 0.02, 0.2, and 2.

### **Parity**

See ***Serial Parity***.

### **Positive Feedback iR Compensation (PFIR)**

Positive Feedback is one of two available iR Compensation techniques (see **iR Compensation**). iR Compensation can be selected from any of the three potentiostatic menu screens (IR MODE). The default setting is OFF.

In the Positive Feedback technique, an analog positive feedback loop is established from the output of the current measurement circuit to the Control Amplifier input. The user sets the loop gain to approximately the value required to compensate for  $R_U$ .

The principal advantage of Positive Feedback is that the correction is continuous. As a result, correction remains effective even at the fastest scans possible with the Model 283. While this technique is the only one possible for rapid scans (scans of 100 mV/s or faster), there are several significant disadvantages.

1. Adjusting the feedback is a tedious and subjective process.
2. The feedback reduces the stability of the potentiostat and can lead to severe ringing or oscillation.
3. Because of the effect on system stability, it is generally not possible to achieve 100% compensation. Instead, the user normally has to be satisfied with a correction in the range of 75% to 90%.
4. The feedback assumes that the uncompensated resistance is constant. Should it vary, the applied correction will be incorrect.  $R_U$  is frequently not stable; it can change with the applied potential, time, changes in cell geometry, and other factors.

Before the Positive Feedback Mode can be activated, it is necessary to set and enter the correct value for  $R_U$ , the value to be compensated. If the entered value is too low,  $R_U$  will not be adequately compensated. If it is too high, the system will be unstable and may even oscillate. Once  $R_U$  is entered, Positive Feedback iR Compensation can be activated. The resistance resolution limit and maximum compensation as a function of Current Range is:

<b>Current Range</b>	<b>Maximum Compensation</b>	<b>Resolution Limit</b>
1 nA	2 G $\Omega$	1 M $\Omega$
10 nA	200 G $\Omega$	100 k $\Omega$
100 nA	20 M $\Omega$	10 k $\Omega$
1 $\mu$ A	2 M $\Omega$	1 k $\Omega$
10 $\mu$ A	200 k $\Omega$	100 k $\Omega$
100 $\mu$ A	20 k $\Omega$	10 k $\Omega$
1 mA	2 k $\Omega$	1 $\Omega$
10 mA	200 $\Omega$	100 m $\Omega$
100 mA	20 $\Omega$	10 m $\Omega$

Resistance values have a resolution limited to 0.05% of the current-measuring resistor associated with the Current Range. Thus, the accuracy of the value that is actually programmed can vary with the Current Range. Moreover, as a result of this resolution limit, the value in effect can change during the experiment if the Current Range changes either manually or automatically. For this reason, care should be taken when using Positive Feedback iR Compensation with auto-ranging.

Consider how the resolution limit affects the accuracy of the programmed value. For example, assume a resistance of 1.234 k $\Omega$  is entered on the 100  $\mu$ A range. On that range, the resistance resolution is 10  $\Omega$ , giving an actual programmed resistance of 1230  $\Omega$ . In other words, the programmed resistance differs from that entered (front or rear panels) by 4  $\Omega$ .

Let us continue with this example to see how error due to the resolution limit can occur when the current range changes. If, during the experiment, the current range changes to 1 mA, where the resistance resolution is 1  $\Omega$ , the actual programmed resistance will change to 1234  $\Omega$ . The improved resolution allows the actual programmed value to be identically that originally entered. Although this change could be a problem in some situations, it will usually be relatively minor.

The real problem occurs when shifting to a more sensitive range. For instance, if, in the example, the current range were to shift to 10  $\mu\text{A}$ , where the resolution limit is 100  $\Omega$ , the actual programmed resistance will become 1200  $\Omega$  because the value can only be represented to the nearest 100  $\Omega$ . In other words, the error will now total 34  $\Omega$ . Similarly, a further shift to 1  $\mu\text{A}$  would give a resistance of 1000  $\Omega$  (234  $\Omega$  error) and a shift to 100 nA would give a resistance of 0  $\Omega$  (1234  $\Omega$  error). Although this is a fairly large error, it is generally not significant because the current is small.

*Note: Should one later shift to less sensitive ranges, the error will be successively reduced with each current range step.*

Clearly, operators need to be mindful of the resolution limit for the "setup" current range and should set a resistance appropriate to that limit. Also, if more sensitive ranges are used during the experiment, users will have to be mindful of the impact the changing resolution will have on the programmed resistance and of the possible consequences of large resistance errors.

Two procedures for establishing positive feedback compensation are provided. The first procedure applies when the value of  $R_U$  is known. The second applies when  $R_U$  is not known.

***If  $R_U$  is known:***

1. Set IR MODE = PFIR.
2. Press the NEXT PARAMETER key to display the PFIR COMP parameter. The current value of assumed  $R_U$  will be displayed.
3. Use the VALUE knob to set the value of  $R_U$  to be compensated.

***If  $R_U$  is not known:***

1. Set IR MODE = PFIR.
2. Press the NEXT PARAMETER key to display the PFIR COMP parameter. The current value of assumed  $R_U$  will be displayed.
3. Use the VALUE knob to set the value of  $R_U$  to 0.00 ohms.

It is always advisable to start with zero iR compensation. With a higher starting value, there is a definite risk factor in that the system may oscillate when the Positive Feedback Mode is activated. High power, high amplitude oscillations can be destructive and definitely should be avoided.

4. Program the Model 283 to apply a 62.5 Hz,  $\pm 50$  mV square wave to the cell. (The  $\pm 50$  mV figure is not critical. Smaller or larger amplitudes if more appropriate to the chemistry, can be used.) The following parameter values can be used.

*Note: If LINE SYNC is set to ON, the frequency will be 15 Hz (60 Hz power) or 12.5 Hz (50 Hz power). The procedure will generally be easier to perform with the LINE SYNC set to OFF (less flicker on the oscilloscope display).*

MODE = POTENTIOSTATIC STEP

E INIT = -0.05 V with respect to the potential of interest

T INIT = PASS (see Note below)

E MID = +0.05 V with respect to the potential of interest

T MID = PASS (see Note below)

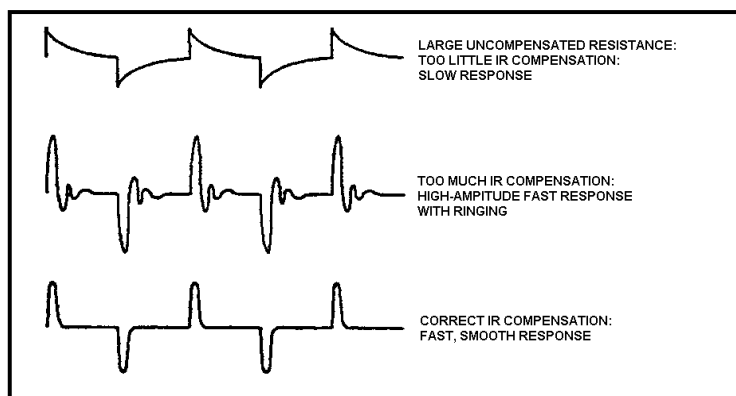
E FINAL = -0.05 V with respect to the potential of interest

CYCLES = CONTINUOUS

**Note:** 62.5 Hz rate results from setting both delays to PASS.

5. Set up the cell for the measurements to be made. (Any change at the cell will probably change  $R_U$ .)
6. Set the full-scale current range to the range that will be used in the measurement. If the current range setting is changed, the actual value of iR compensation can change as previously discussed.
7. Press the CELL ON key to establish the Cell ON state. Then press "Run" (F3) to apply the square wave to the cell.
8. Monitor the I MONITOR connector with an oscilloscope. At the oscilloscope, use internal triggering and display the waveform so As rise time can be readily observed. A horizontal deflection factor of 2 ms per division will generally give good results.
9. Make sure the PFIR COMP parameter is shown on the LCD panel. Then, while observing the displayed waveform on the oscilloscope, turn the VALUE knob slowly clockwise. The  $R_U$  compensation will increase, causing the decay intervals in the displayed waveform to become shorter. You can see the actual value of R. compensation changing on the Model 283 display.





**Fig. 30. I Output Waveforms as a Function of  $R_u$  Compensation (Square Wave Applied).**

Fig. 30 illustrates the effect of the compensation. For optimum stability, the rise time should be as fast as possible without ringing. When the uncompensated resistance is about 90% to 95% compensated, the waveform will show a smooth decay with perhaps just a bit of undershoot. This is optimum for fast measurements.

As the compensation is increased to the 95% to 100% range, increasing ringing appears as the system becomes more unstable. This level of compensation is not suitable for fast measurements. Any data taken during the ring-down will be of doubtful validity. Also, even a slight increase in compensation from this point (or a real decrease in the actual  $R_u$ ) could cause the potentiostat to oscillate.

Compensation in the 95% to 100% range is best suited to slow experiments (such as for corrosion). Since Current Interrupt Compensation is ideal for slow measurements, there will normally be relatively few instances where Positive Feedback Compensation in the 95% to 100% range would be used.

When you are satisfied with the compensation level, turn off the cell and set up the other parameters you need for the intended measurement. Unless changed, the compensation level you set will remain in memory, ready to be applied whenever Positive Feedback iR Compensation is activated.

### **Potential, Working Electrode**

See **Cell Potential**.

### **Remote Operation**

The Model 283 can be controlled from an IBM-compatible personal computer via either its GPIB (IEEE-488) interface or its RS-232 interface. When it is under remote control, its LCD panel displays the REMOTE screen and its front-panel controls, except for the Cell On key, Cell Safety switch, and POWER switch, are inactive.

You can return it to local operation simply by pressing the LOCAL key (F5). But in remote operation via GPIB, pressing F5 is effective only if the LOCAL LOCKOUT message has not been sent from the host computer. This GPIB message would be sent only under special circumstances, and in any case is not supported by PARI software. See Appendixes A and B of the *Model 283 Command Set Handbook* for a discussion of GPIB communications considerations.

Other ways of returning to local include applying the GO TO LOCAL message, deasserting REN, or cycling the power. GO TO LOCAL is another GPIB message defined by IEEE-488 and explained in the *Model 283 Command Set Handbook*.

## Reset

In the [System Interface] menu screen, F2 is assigned the "Reset" (Reset) function. This function resets all *experiment* (not communications) parameters to their default values. When you press F2, the message RESET SYSTEM? is displayed. If you want to reset the experiment parameters, press the YES key (F4). All experiment parameter selections will be cleared and default values restored. Note that this will not reset the parameters on the [System Interface] menu (communications parameters and KNOB TIMEOUT).

This effect is not the same as that which occurs when the power is cycled. When the Model 283 powers down, all parameter values and selections are retained. When it is powered up, these values are restored, except for **Cell On**, which becomes **Cell Off**.

If you wish to reset the parameters, including those on the [System Interface] menu, hold down any front-panel key when you power up. Refer to Chapter 6, Section 6.8 for a more detailed explanation of resetting methods.

## Reverse Scan

In the Potentiostat Scan and Galvanostat Scan modes, the F5 key is assigned the "Reverse" function. Pressing F5 during a scan reverses the direction of the scan.

## Scan Rate

The scan rate is the rate of change of cell potential or current with respect to time. It is set from the [Potentiostatic Scan] or [Galvanostatic Scan] menu screen.

Scan rates from 1  $\mu\text{V/s}$  to 1  $\text{V/s}$  can be specified in the [Potentiostatic Scan] mode. In the [Galvanostatic Scan] mode, the range is 1  $\mu\text{X/s}$  to  $\text{X/s}$ , where X is the selected current range.

Note that the Model 233 does not apply a linear scan, but rather a *staircase* scan. However, as long as the individual steps are very small relative to the range scanned, linear scan theory will apply to a close approximation. When LINE SYNC is not enabled, the nominal step size is the Scan Rate/250, or 250  $\mu\text{V}$ , whichever is larger. LINE SYNC causes larger steps.

**Note:** Under remote control via the rear panel GPIB or RS-232 port, steps as small as 25  $\mu\text{V}$  ( $MR = 1$ ), or 2.5  $\mu\text{V}$  ( $MR = 0$ ), can be attained as explained in the Model 283 Command Set Handbook). For example, with a scan rate of 1  $\text{V/s}$ , the step size will be 4  $\text{mV}$ , because  $1000/250 = 4$ .

## Serial Baud Rate

A baud is a unit of signaling speed. In serial RS-232 communications, it refers to the number of times the state or condition of a line changes per second. Baud rates from 110 to 19,200 can be selected from the [System Interface] menu screen. The default setting is 9,600 baud.

## Serial Data Bits

Serial communications between the Model 283 and a host computer normally are in ASCII code. You can also select a binary load or dump. From the [System Interface] menu screen, you can select a character length of either seven or eight data bits. Eight data bits are required for binary loads and dumps. If "8" is selected, the Model 283 will always send a "0" as the eighth (MSB) bit when transmitting ASCII codes.

## Serial Echo

From the [System Interface] menu screen, you can select either SER. ECHO = OFF or SER. ECHO = ON. If you select ON, each character received via the RS-232 port will be echoed back to the character source. The Serial Echo is normally used only when the Model 283 is connected to a CRT terminal.

**Note:** Do not confuse this function with the GPIB ECHO.

### **Serial Parity**

In serial RS-232 communications, parity checking is an optional method of error detection. It provides a direct way of detecting garbled data if the computer is programmed to only accept words having the selected parity.

Parity checking traps errors in the serial data stream in the following manner. When the Model 283 frames each character, it counts either the number of 0's or the number of 1's in the data bits. It then appends a parity bit that corresponds to whether the count was even or odd. The host computer also counts the 0's or 1's in the data bits as they arrive, and compares this count with the arriving parity bit. If an error is detected, a flag can be set and retransmission can be requested.

From the [System Interface] menu screen, you can select either SERIAL PARITY = ODD, SERIAL PARITY = EVEN, or SERIAL PARITY = NONE. The parity setting on the Model 283 must match that on the host. If ODD or EVEN parity is selected, the Model 283 will generate the parity bit when transmitting and detect it when receiving.

### **Serial Stop Bits**

This sets the number of stop bits in RS-232 communications. The stop bit or bits signal the end of a binary bit frame, and return the line to the idle state. Stop bits follow the parity bit; either one or two may be used. Two stop bits give more reliable communications at high baud rates.

### **Step Mode, Potentiostatic or Galvanostatic**

The step mode [Potentiostatic Step] or [Galvanostatic Step] substitutes a sharp step between two potential or current levels instead of a gradual scan. The cell potential or current will step as quickly as possible between the two levels. The time between steps can be as long as 4 ms, during which time no other operation can be started.

The step feature is useful for applying pulse waveforms. For example, it allows the Model 283 to perform double-potential step chronoamperometry, in which the applied potential starts at E INIT, remains there long enough to let the sample come to equilibrium with the solution, steps to E MID for T MID (perhaps 2 seconds or so), and then steps to E FINAL, which continues to be applied.

### **Stop Bits**

See **Serial Stop Bits**.

### **T Init T Mid, T Final**

See **Delays**.

### **Terminator Character**

See **GPIB Terminator Character**.

### **Test Echo**

See **GPIB Test Echo**.

### **Update Q With Call Off**

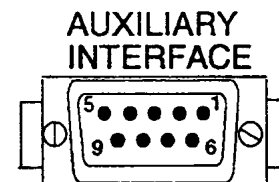
In a perfect instrument and cell system, the accumulated charge Q could not change when the cell is disconnected, because no cell current would flow. But in a real system, no matter how precise, some small charge may appear as a result of drift and other circuit variations. Thus, setting UPDATE Q W/CELL OFF = NO (from the [System Default] menu) prevents charge from accumulating when the cell is off. Choosing YES allows it to accumulate, and might help to estimate drift errors.



# APPENDIX C. Connector Pinouts

## C.1. Auxiliary Interface (Mating Connector DB9S)

This connector provides several functions only available when the Model 283 is being controlled from an external computer via the RS-232 or GPIB (IEEE-488) port. Included are the signals required to drive a Model 303A Static Mercury Drop Electrode. If this electrode is used, connections between the Auxiliary Interface and the Model 303A are made via the Model 507 Interface.



The Model 507 Interface is a universal power supply and control interface for the Model 303A SMDE. It can relay DISPENSE, PURGE, and STIR signals from the Model 283 AUXILIARY INTERFACE connector to the Model 303A. The Model 507 is provided with all cables required to make the necessary connections. Refer to the *Model 507 Interface Installation Guide*, Part Number 222556, for installation instructions.

Pinouts for the AUXILIARY INTERFACE connector are listed below.

Pin	Signal	Function
1	ground	
2	EXT TRIG	This input allows an operation in progress to be halted via the WFT command from an external computer. If the command WFT 0 is applied, operation will resume when a TTL logic 0 is applied to the EXT TRIG line. If the command WFT 1 is applied, operation will resume when a TTL logic 1 is applied to the EXT TRIG line.
3	$\overline{\text{DISPENSE}}$	In applications where the Model 283 is being used with a Model 303A via a Model 507 Interface, this signal causes the Model 303A to do a Dislodge/Dispense operation on command from an external computer. The computer initiates the dispense operation by applying a DISP command (see description in the <i>Model 283 Command Set Handbook</i> ).
4	TRIG OUT	A TTL trigger output is provided on this line on application of the TRIG command. The Trig Out baseline is either a logic 0 or a logic 1 (default is logic 0), according to the operand of the last applied TRIG command. TRIG 0 establishes a logic 1 baseline. TRIG 1 establishes a logic 0 baseline. Once a logic 0 baseline is established, subsequent TRIG 1's will cause a 10 to 20 ms wide logic 1 pulse to be generated. Similarly, once a logic 1 baseline is established, TRIG 0's will cause a 10 to 20 ms wide logic 0 pulse to be generated.
5	BIT 0 IN	The level on this line will be read and reported to the host computer if the command BIT 0 is applied.
6	+5V	+5 V at up to 100 mA is available for external use.
7	BIT 0 OUT	If Current Interrupt iR Compensation is <i>not</i> active, the level on this line will be set to a logic 0 if the command BIT 0 0 is applied. It will be set to a logic 1 if the command BIT 0 1 is applied.

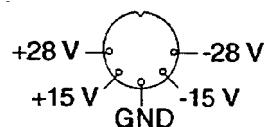
If Current Interrupt iR Compensation is active, this line will go high about 3  $\mu$ s before the start of the current interruption and will go low about 7  $\mu$ s after the end of the current interruption. This pulse can be used to trigger an oscilloscope so that the iR Current Interrupt waveform can be easily monitored at the E MONITOR connector.

8	<u>PURGE</u>	When operating a Model 283 with a Model 303A SMDE via a Model 507 Interface, this signal controls the Model 303A's purge function in response to commands from the external computer. The computer initiates a purge by applying a PURGE command (see discussion of this command in the <i>Model 283 Command Set Handbook</i> ).
9	STIR	This signal controls the Model 303A's Stir function in response to commands from an external computer. The assumption is that the Model 303A is being used with a Model 305 Stirrer. It can also be used to control the motor ON/OFF status of a Model 616 or 636 Rotating Electrode. In the Model 616 the motor-control jack is called MOTOR STOP. In the Model 636 the motor-control jack is called MOTOR CONTROL. In both the 616 and the 636, an internal jumper determines whether a TTL 0 or TTL 1 applied to the motor-control input will halt the motor.

## C.2. Accessory Power Connector

Note that the pins on this DIN connector are not numbered consecutively. They are numbered in the following sequence, looking into the connector from the rear of the instrument and counting clockwise from the keyway at the top.

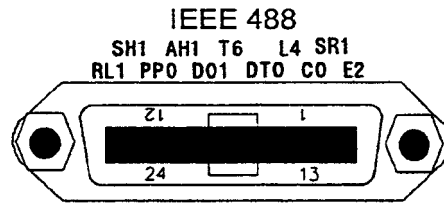
Pin	Function
1	-28 V DC Regulated
4	-15 V DC Regulated
2	Power Ground
5	+15 V DC Regulated
3	+28 V DC Regulated



**ACCESSORY  
POWER**

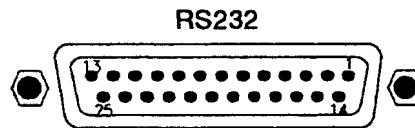


### C.3. IEEE-488 GPIB Interface



Pin	Function
1	DIO1
2	DIO2
3	DIO3
4	DIO4
5	EOI
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	SHIELD
13	DIO5
14	DIO6
15	DIO7
16	DIO8
17	REN
18	GND 6
19	GND 7
20	GND 8
21	GND 9
22	GND 10
23	GND 11
24	LOGIC GROUND

### C.4. RS-232C Interface



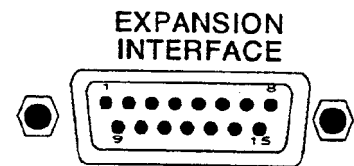
Pin	Function	Comment
1	Chassis Ground	Ties the chassis of the Model 283 to that of the computer.
2	Transmit Data	The Model 283 transmits on this line. It must connect to the computer connector pin that receives serial data.
3	Receive Data	The Model 283 receives data on this line. It must connect to the computer connector pin that transmits serial data.
4	Request to Send	This line is permanently asserted in the Model 283, that is, R is always at a positive logic level (+ 12 V). As a result, the computer continuously receives the message that the Model 283 is ready to receive a character.

5	Clear to Send	The computer controls the Model 283 via this line. To enable the Model 283 to transmit, the line is placed at the positive logic level (+3 V to +12 V). To hold off transmission by the Model 283, the line must be at the negative logic level (-3 V to -12 V). Once this line goes positive, data transfer, if initiated by an appropriate command, will proceed rapidly. This line is pulled up to +12 volts so that, if it is left unconnected, the Model 283 is allowed unimpeded transmission.
6	Unused	
7	Logic Ground	Data signal levels should be with reference to logic ground. The logic ground line of the Model 283 should inter-connect with the logic ground line of the computer.
8-25	Unused	

Note that the Model 283 RS-232 port is configured as a female DTE port (Data Terminal Equipment) rather than as a DCE (Data Communications Equipment). Thus, cabling to most microcomputers can be accomplished with a standard reversed or switched RS-232 cable, also known as a null modem cable.

### C.5. Expansion Interface

This connector is provided to allow for future expansion and enhancements.





# APPENDIX D. Model 398 Impedance Plots

## D.1. Introduction

This appendix contains a series of plots generated by the Model 398 AC Impedance application software on a theoretical model having the same configuration and values as the Model 283 internal ac dummy cell. To a close approximation, impedance plots performed on an actual dummy cell should yield the same results.

## D.2. Plots

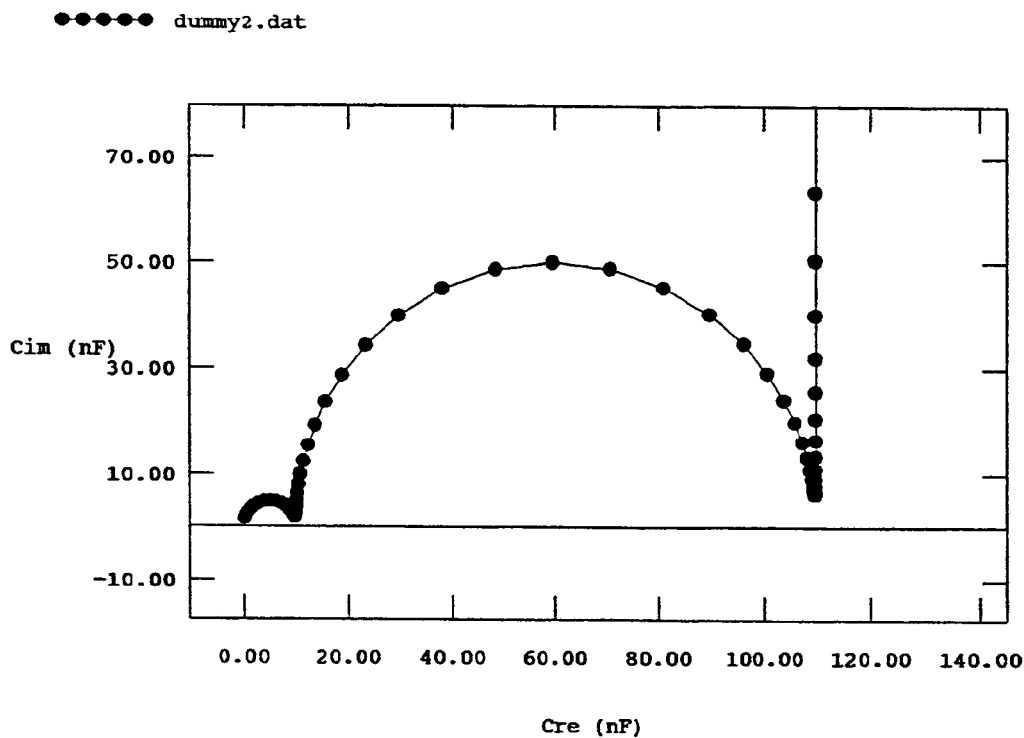


Fig. 36. Imaginary Vs. Real Capacitance.

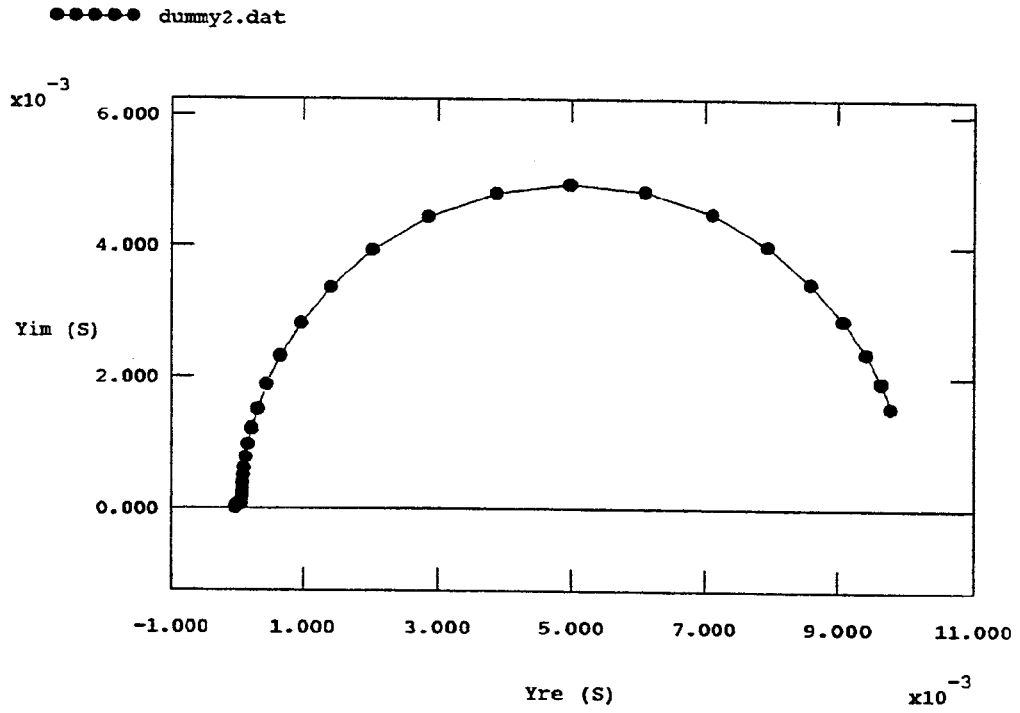


Fig. 37. Imaginary Vs. Real Admittance.

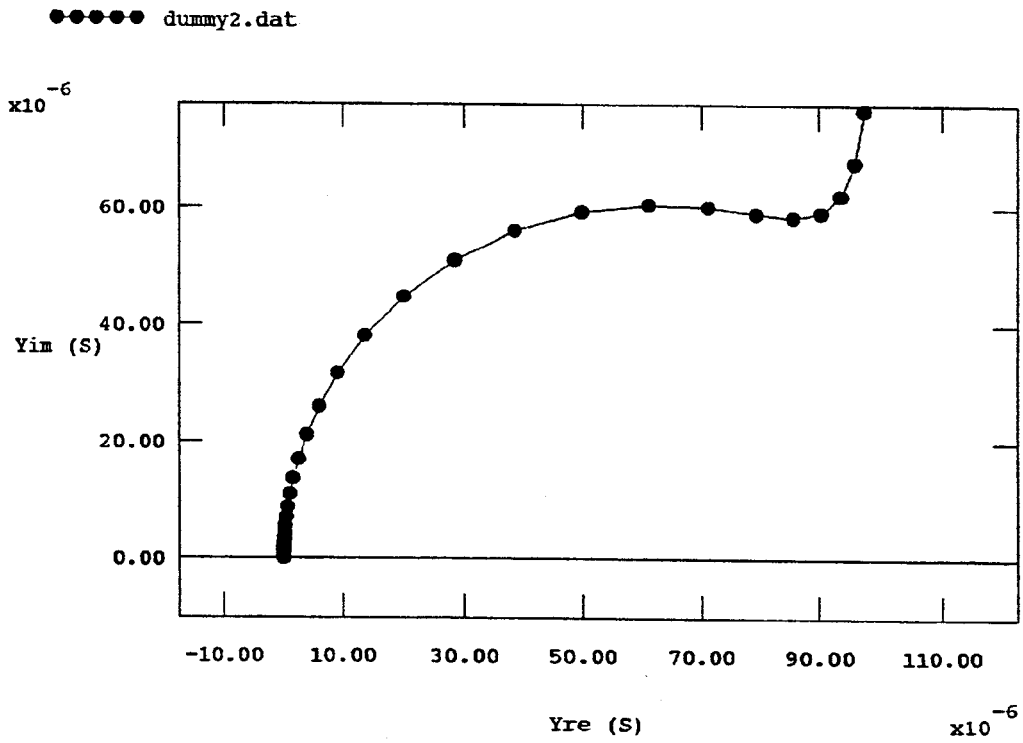


Fig. 38. Imaginary Vs. Real Admittance Zoomed.

●●●●● dummy2.dat

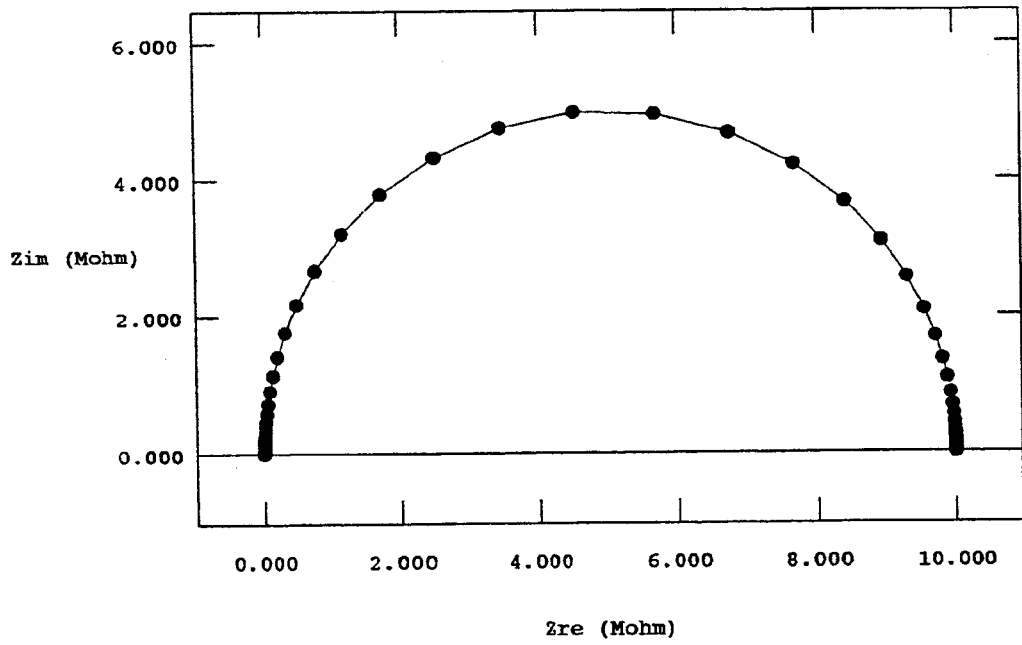


Fig. 39. Nyquist Plot.

●●●●● dummy2.dat

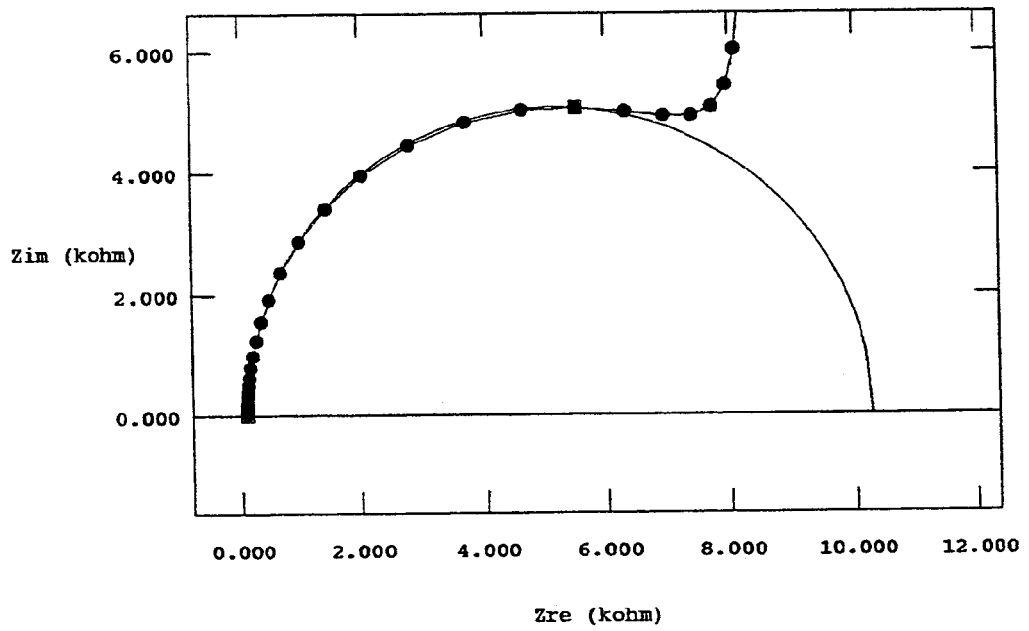


Fig. 40. Nyquist Plot Zoomed and Fitted.

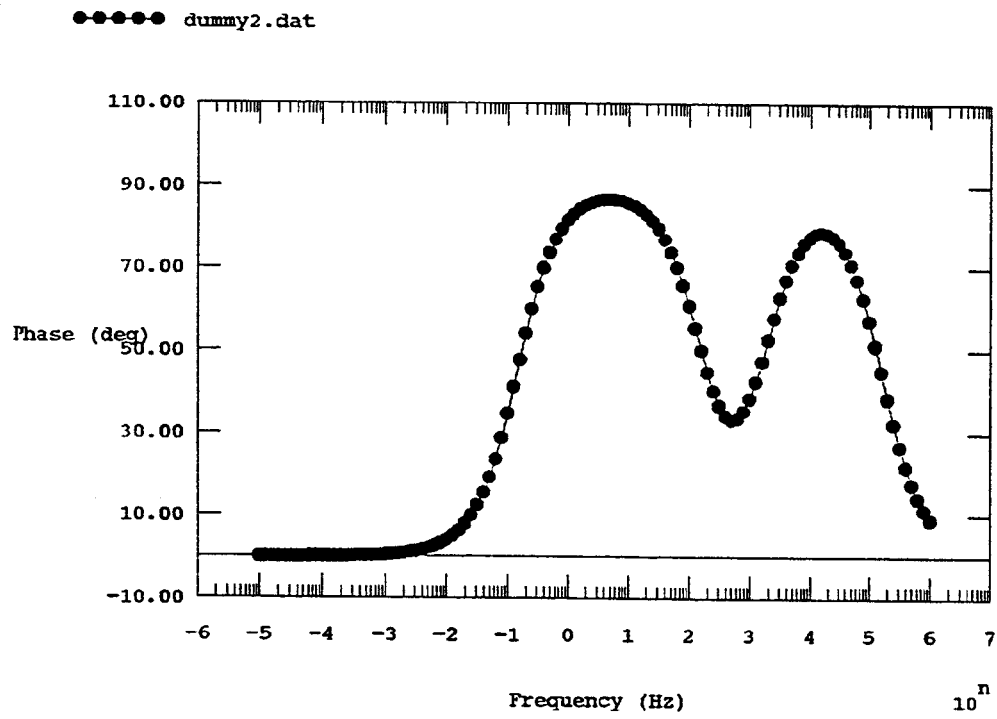


Fig. 41. BODE Phase Plot.

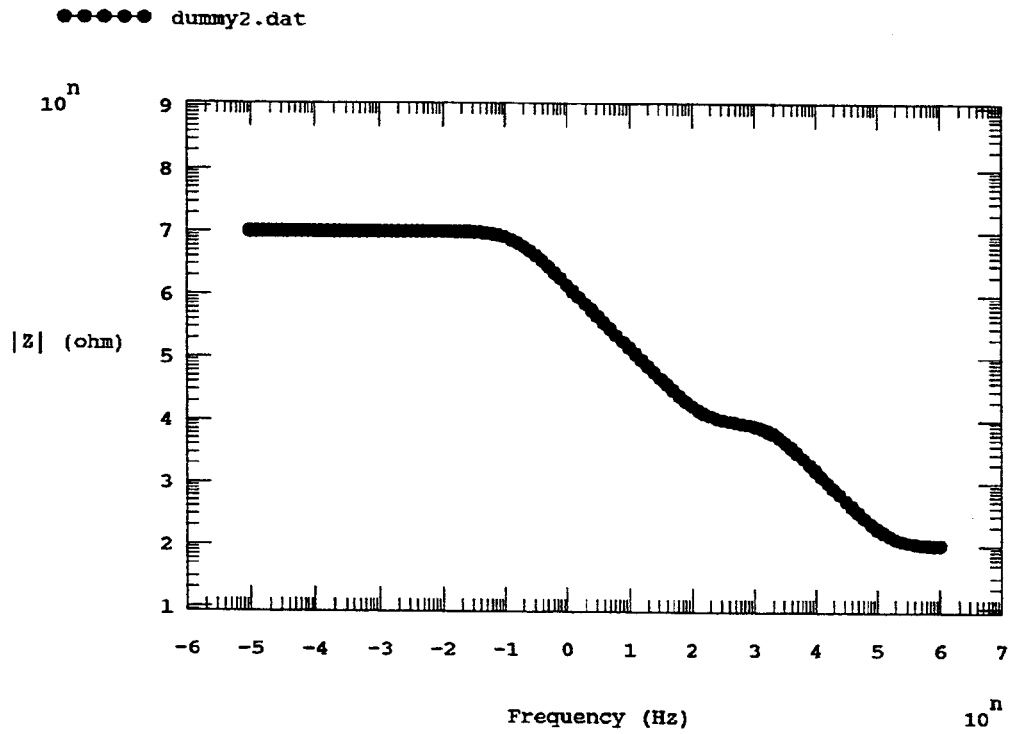


Fig. 42. BODE Absolute Magnitude Plot.

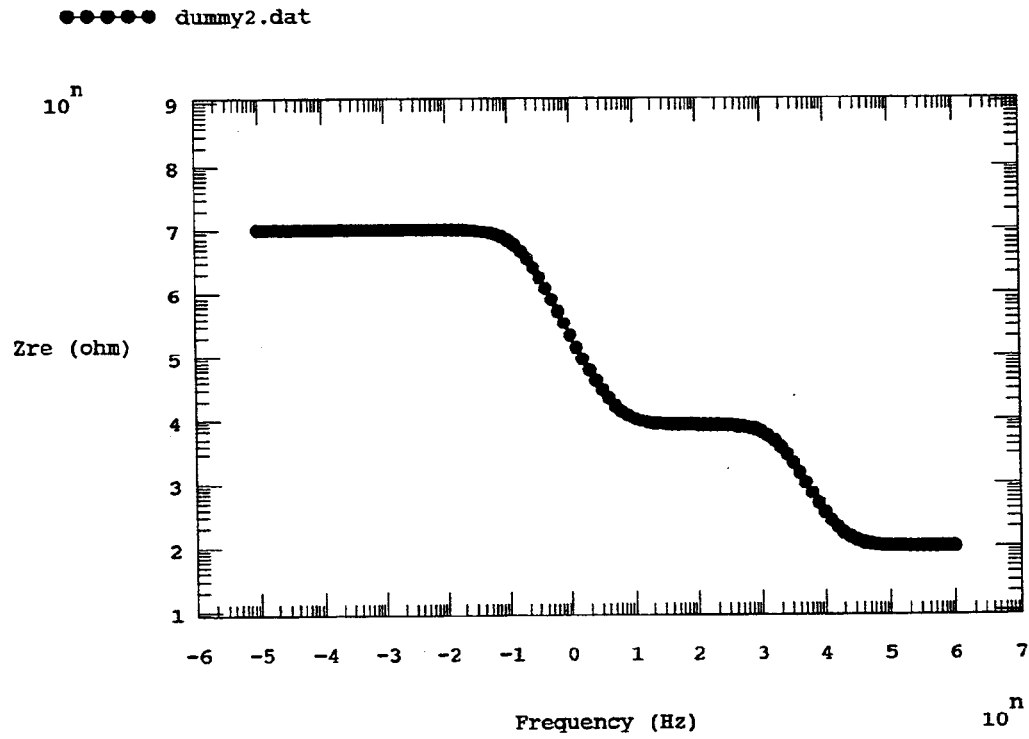


Fig. 43. BODE Real Magnitude Plot.

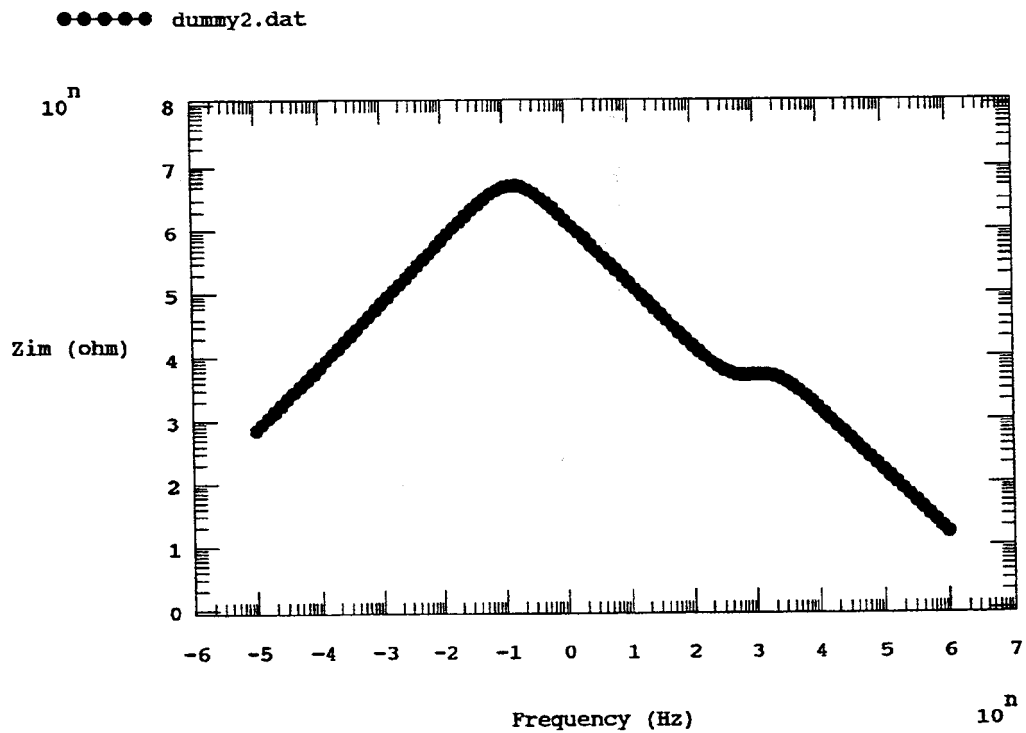


Fig. 44. BODE Imaginary Magnitude Plot.



# INDEX

175 Universal Programmer	25, 43, 74	Connecting a Pen Recorder	42
270/250 Software	2	Connecting an Oscilloscope	42
303A	2	Connector	
352	2	D/A OUTPUT	27
507 Interface	29, 43	OUTPUT	27
616 or 636 Rotating Electrode	2	Connector Diagrams	
A & B Connectors	30	Accessory Power	29
A/D Input 1	10	Auxiliary Interface	29
A/D INPUT 2	27	Expansion Interface	30
ac power	5	IEEE-488	30
Accessory Power	29, 44	Connector Pinouts	85
Accessory Power Connector	86	RS-232C	87
Address	30	Connectors	
Air circulation	7	A & B	30
Ambient Temperature Range	63	A/D INPUT 2	27
American polarity convention	31	A/D INPUT I	27
Ancillary Functions	59	Accessory Power	29
AUTO current range mode	24	Auxiliary Interface	29
AUTO switch indicator	24	BNC	25
Automatic current ranging	24	D/A OUTPUT	27
Auxiliary Inputs	59	Dummy Cell	27
Auxiliary interface	29, 85	E MONITOR	26
AUXSEL	17, 27, 59	Expansion Interface	30
Back Panel	29	EXT IN	25
BANDWIDTH	38, 65	Gnd	27
Bandwidth (Stability versus Speed)	65	I MONITOR	26
Battery replacement	61	IEEE-488 Connector	30
Baud Rate	65, 83	MUX	26
BNC Connectors	25	OUTPUT	27
Bottom Row Functions	34	PA Monitor	30
Calibrating the Model 283	39	RS-232 Connector	30
Cell (Condition) at End	65	CONTINUOUS	47
CELL command	20	CONTINUOUS cycle	47
Cell connectors	15	Controls and Indicators	33
Cell Current	52	Convention	
Cell Group	15	Polarity	31
CELL Indicator	20	cooling	7
CELL ON Key	20	COUNTER connector	16
Cell Potential	66	Counter Electrode cable	10
Cell Safety	6, 11	Current Auto-Ranging	66
CELL SAFETY switch	6	Current Integral (Coulombs) Display	67
CELL TYPE	37	Current Interrupt iR Compensation	68
CELL@END	47, 52	Current Measurement	63
character length	82	Current Offset (I Offset)	70
circuit description	55	Current Overload	71
Galvanostat	57	Current Range, Full Scale	71
signal conditioning	59	Current Range, Full Scale	71
Ancillary Functions	59	Cycle Control	71
Potentiostatic operation	55	Delays T Init, T Mid, T Final	73
COMM ERROR message	42	Differential Electrometer	63
Command Set Handbook	2, 3	DIN connector	86
Communications Parameters	35, 38	Display/Control Group	20
Computer Interfaces	63	E & I Suppression	59
Connecting a Model 303A SMDE	43	E Overload	73

ERROR	23	Potentiostatic Modes	45
Error Messages	40, 49	Power Cord	5
Expansion Interface	88	Power Cord Plug	9
External Input	73	Power Requirements	63
External Signal		Power-Up	11
Adding	43	Reference Electrode cable	10
F1 (Coulombs or offset I)	48	Remote Computer Control	1
F1 Through F5 Function keys	23	Remote Operation	81
F2 (Q-Reset)	48	Reset	82
F3 (Start or Stop)	48	Resetting Parameters	38
F4 (Hold or Resume)	48	Reverse Scan	82
F5 (Reverse or Bypass)	49	RS-232C Interface	87
Filters	74	Running Your Experiment	48
Frequency Response	63	Scan Rate	82
Fuse		Sense cable	10
Changing	6	Sense connector	19
Galvanostat Operation	57	SERIAL BAUD	36
Galvanostatic Experiments	51	Serial Baud Rate	82
Galvanostatic Modes	51	SERIAL BITS	36
GPIB ADDR	36	Serial Data Bits	82
GPIB Address	74	SERIAL ECHO	36, 82
GPIB ECHO	36	Serial Parity	83
GPIB Terminator Character	75	SERIAL PRTY	36
GPIB Test Echo	75	SERIAL STOP	36
I AUTO LIMIT	38	Serial Stop Bits	83
I/E FILTER	37	Service	61
IEEE-488 GPIB Interface	87	Setting Cell Current	52
Impedance Plots		Signal Conditioning	59
Model 398	89	Specifications	63
Inspection	9	Step Mode	
Installation	9	Galvanostatic	83
Interface Group	23	Potentiostatic	83
iR Compensation	63, 76	System key	21
KNOB TIMEOUT	36, 77	TALK	23
LCD Display	22	TERMINATOR	36
LCD Menu Screens	33	UPDATE Q W/CELL OFF	38
Line Fuses	9	Value knob	23
LINE SYNC	37, 77	Ventilation	7
Line Voltage	5	Working Electrode cable	10
Line Voltage Selection	6	↑↑ key	24
Line Voltage Setting	5	↓↓ key	24
LISTEN	23		
Maintenance	61		
Mode key	21		
Model 303A SMDE	43		
Model 616 or 636	43		
Operating Modes	2		
Galvanostatic	2, 32		
Potentiostatic	2, 32		
OSC GAIN	37, 77		
Osc In	77		
Output DACs	59		
OVERLOAD Indicators	20		
Parameter keys	23		
Positive Feedback iR Compensation	77		
Potential/Current Control	63		
Potentiostat Operation	55		
Potentiostatic Experiments	45		



