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Princeton Applied Research

PARSTAT 4000

Hardware Manual

AMETEK

AMETEK® Part No. 224187
Manual Revision C

082021
Printed in USA

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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:

Safety Keywords:

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.

Safety Symbols:



Indicates **Warning** or **Caution**



Indicates **Danger** due to Electric Shock Hazard

Please read all safety instructions carefully and make sure they are understood fully 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.

1. INTRODUCTION

The PARSTAT 4000 (Figure 1), teamed with the VersaStudio software package, comprises a simple-to-use, flexible, and extremely powerful system for performing a wide range of electrochemical testing. The PARSTAT 4000 is a potentiostat/galvanostat with frequency response analyzer (FRA) contained in a single unit. It is controlled from any suitably equipped PC by a Universal Serial Bus (USB) interface using the VersaStudio electrochemistry software package.



Figure 1. PARSTAT 4000

1.1. General

The host computer provides memory, data processing, input-output, and interface capabilities. The PARSTAT 4000 electronically controls the measurement under the direction of the software and parameter values entered from the host computer. The computer must be equipped with a USB port, and the operating system must support the USB interface.

> **NOTE** The PARSTAT 4000 requires 20 seconds between power-off and power-on. If the main power switch is cycled off-on shorter than this 20 second duration, the main voltages to the electronics will not be applied, and the system will not power up properly. This delay enhances the overall reliability of the internal power supply and the system as a whole.

1.2. Hardware Circuitry

The PARSTAT 4000 circuitry includes:

- Two 16-bit digital-to-analog converters (DACs) for versatile waveform generation.
- Three 18-bit analog-to-digital converters (ADCs) to measure current (I), potential (E), SYNC ADC INPUT.
- An onboard microprocessor to perform the experiment defined by the operating software.
- Onboard memory to store the programmed parameters and data point values.

The PARSTAT 4000 operates with VersaStudio in either the potentiostatic or galvanostatic mode, described below.

1.2.1. Potentiostatic Mode

In this mode, the PARSTAT 4000 controls the potential at the working-sense electrode with respect to the reference electrode (see Figure 2). The counter electrode is driven to the potential required (consistent with the ±48V compliance of the control amplifier) to establish the desired working potential. The range over which the working electrode potential can be controlled is ±10V.

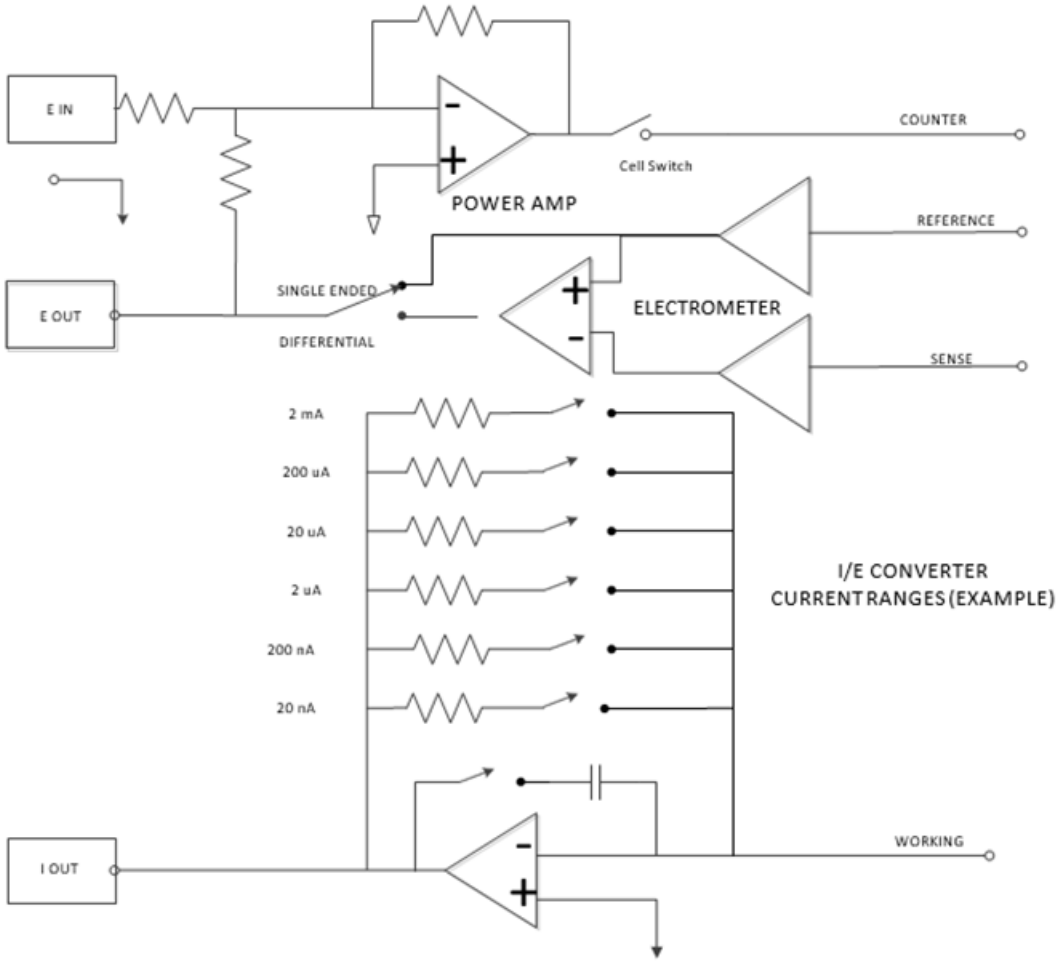


Figure 2. Potentiostat-Mode Block Diagram

1.2.2. Galvanostatic Mode

In galvanostatic operation, the PARSTAT 4000 controls the current between the counter and working electrodes at the specified fraction of the selected current range (up to the maximum of the current range; see Figure 2). The counter electrode is driven to the potential required (consistent with the ±48V 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 relative to the working-sense connection point.

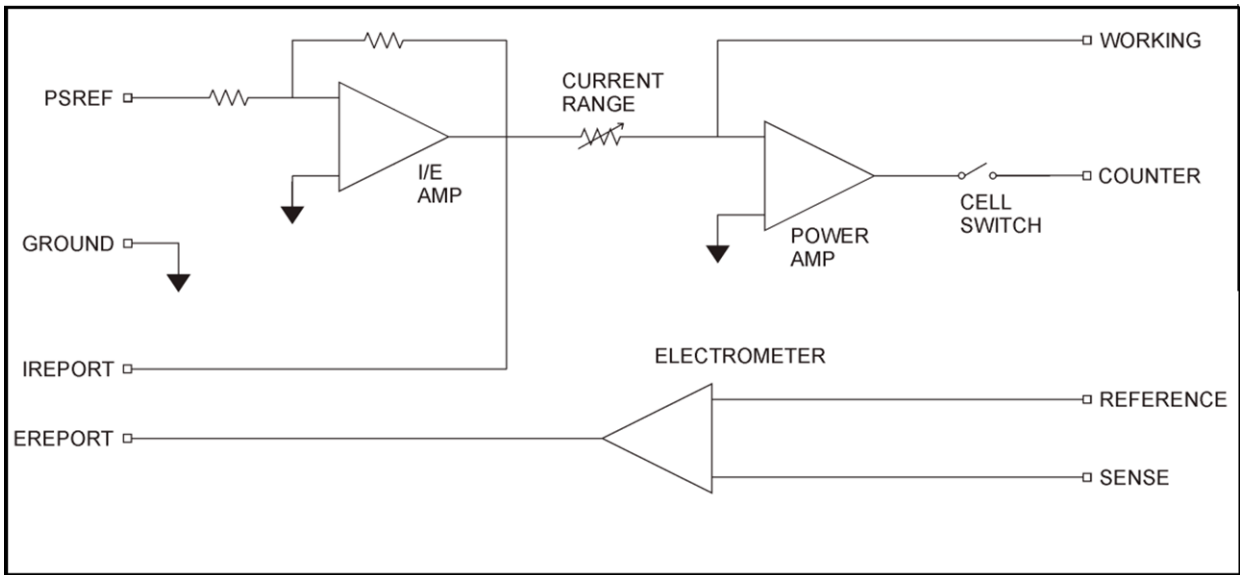


Figure 3. Galvanostat-Mode Block Diagram

1.3. Software

The PARSTAT 4000 is fully compatible with the VersaStudio software *only*. The PARSTAT 4000 will not operate with any other software other than that specified in this manual or the most recent documentation available on the website (http://www.ameteksi.com). Likewise, the PARSTAT 4000 does not have an open command set to allow user programming outside of the VersaStudio software. The software is designed specifically to work with Windows 8 and Windows 10.

1.4. Inspecting the New Instrument

As soon as the new PARSTAT 4000 is received, inspect it for shipping damage. If any damage is noted, immediately notify Princeton Applied Research and file a claim with the carrier. Save the shipping container for possible inspection by the carrier.

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

1.5. Maintenance, Service, and Support

The PARSTAT 4000 has been designed for optimum reliability and requires no periodic maintenance. **There are no user-serviceable parts in this instrument. Breaking the seal by opening the cover will void the warranty!** Contact the factory service department if the unit needs service (see the Warranty in Section 6 for more information).

Remember that Ametek's worldwide staff continues to provide support after the instrument has been purchased. Ametek provides top quality service, applications support, and a variety of helpful information in the form of application notes, technical notes, and training materials. For more information, visit the website at http://www.ameteksi.com.

1.6. About this Manual

Chapter 2 describes recommended safety precautions for operating this instrument, including the provision of adequate ventilation. It also tells how to deal with transients on the power line and discusses the unlikely possibility of the instrument causing radio frequency (RF) interference.

Chapter 3 shows how to set up the hardware. It describes the functions of the connections and indicator lights and shows how to connect the PARSTAT 4000 to the host computer and test cell.

Chapter 4 gives the physical and electrical specifications of the PARSTAT 4000 including the AUXILIARY INTERFACE connector pinouts.

2. SAFETY AND COMPONENT PLACEMENT

This chapter lists safety precautions for use when operating the PARSTAT 4000; please read them. There are suggestions for system component placement and information on possible RF interference and transient sensitivity.

2.1. Safety Considerations

2.1.1. Line Voltage Settings and Fuses

The PARSTAT 4000 has a Corcom™ Power Entry Module on the left side of the rear panel. The Corcom module (pictured below) contains the power connector and two line fuses. The PARSTAT 4000 automatically detects the correct line voltage and frequency, so there are no line voltage changes required in the Corcom.

The PARSTAT 4000 is supplied with the line voltage fuses in place, as well as extra fuses supplied with each unit. For fuse replacement:

- For 100 – 120 Vac line voltages, use an 8.0 A T (slow-blow) fuse (Littlefuse® type 213, 5 x 20 mm or equivalent).
- For 220 - 240 Vac line voltages, use a 4.0 A T (slow-blow) fuse (Littlefuse® type 213, 5 x 20 mm or equivalent).

CAUTION **Do not use makeshift fuses or short-circuit the fuse holders.**

NOTE The PARSTAT 4000 requires 20 seconds between power-off and power-on. If the main power switch is cycled off-on shorter than this 20 second duration, the main voltages to the electronics will not be applied, and the system will not power up properly. This delay enhances the overall reliability of the internal power supply and the system as a whole.

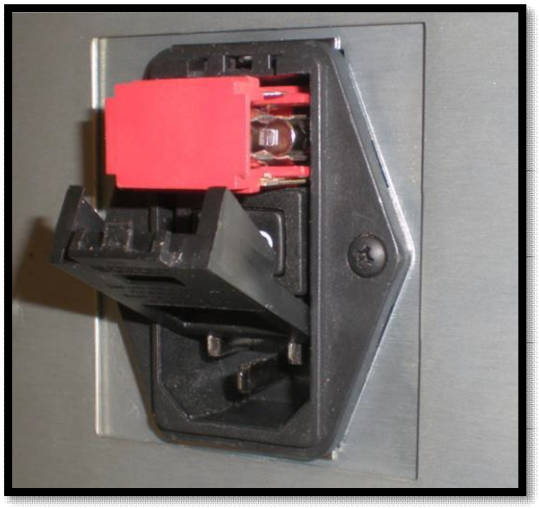


Figure 4. PARSTAT 4000 Corcom Module

To replace a fuse:

1) Disconnect the instrument from the ac power source.
2) Use a small flat-blade screwdriver or similar tool to pop open the module door (as shown in the picture above).
3) The line fuse is in a plastic removable fuse holder “drawer.” Gently pull the fuse holder out, remove the old fuse, and press in the replacement.
4) Slide the fuse holder back into the module and close the module door. Reconnect the instrument to the ac power source.

2.1.2. Defects and Abnormal Stresses

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

The PARSTAT 4000’s 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, or
- has been subjected to severe transport stresses.

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

2.2. Component Placement

Before assembling the system, give some thought to component placement. Users will of course need convenient access to the computer keyboard and, if applicable, the printer. Depending on the application, users might also need to connect and disconnect the cell leads regularly.

When users are satisfied that the system is ready to install, connect the units according to the instructions in Chapter 3.

NOTE The standard system does not include an electrochemical cell. Users must supply a suitable cell and electrodes.

2.2.1. Ventilation

PARSTAT 4000 specifications apply at the nominal line voltage ± and at a temperature of 25°C (77°F) unless otherwise noted. Ambient temperature must not exceed 50°C (122°F). See Section 4.3 for more detailed environmental specifications.

To maintain a safe operating temperature, allow some free space (minimum 10 cm) at either side and at the rear of the PARSTAT 4000 for adequate air circulation. There must be adequate circulation between the spaces at the sides and rear of the instrument and the ambient laboratory air. In a typical bench top installation, these requirements are satisfied with a large safety margin.

CAUTION **Because some of the ventilation for the PARSTAT 4000 is on the side panels, rack mounting in an enclosed cabinet is not recommended.**

The PARSTAT 4000 is equipped with onboard temperature sensors and ventilation fans with variable speed control such that the fan speed will increase as the temperature inside the system increases. Fan speeds will increase and can be audibly detected when temperatures rise above 44°C inside the unit. Likewise, the control software (VersaStudio) monitors the onboard temperature and fans and will halt experiments and disengage critical voltage inputs if either a critical thermal limit inside the unit is detected (>84°C) or any of the onboard ventilation fans stops working.

2.2.2. Radio Frequency Interference

In a typical application, it is unlikely that the PARSTAT 4000 will act as a source of noticeable RF interference. However, when operated near particularly sensitive equipment, interference from the PARSTAT 4000 could be a problem.

Below is a discussion of steps users can take to minimize that interference.

Interference below about 10 MHz is most likely to be caused by RF currents flowing in the input and output cables or in the power line cord.

If excessive noise pickup is present, try decoupling the power line with an external filter. At frequencies below 100 kHz, an external isolation transformer could be helpful.



WARNING **To reduce the risk of potentially dangerous electrical shock, only a qualified service technician should perform this work, and then only with the instrument disconnected from all sources of power.**

At frequencies above 10 MHz, these measures might not suffice to prevent radiation from being a problem, particularly at VHF frequencies. Additional measures will then be required. Shielding is generally effective. A suitable shield can be constructed using metal foil, wire screening, or similar materials.

Once the instrument is completely surrounded by the shield (taking care not to unduly restrict ventilation), the only additional requirement is to install low-pass filters where lines pass through the shield (all openings through the shield should be as small as possible). A capacitor between a line and the shield can function as a suitable low-pass filter. The leads of the capacitor should be as short as possible. We suggest using coaxial feed through capacitors.

In the case of a signal lead, it is essential that the capacitor's value be such as to attenuate the interference frequencies without unduly attenuating critical frequency components of the signal itself.

NOTE	Keep the filter capacitor leads short! Long leads establish sizable ground loops and could additionally act as radiating antennae.

Coaxial cables are a special case in that the cable shield acts as an extension of the enclosure shield. Thus, the filter can be counted in a shielded box fitted with coaxial connectors without undue concern for keeping the box extremely close to the enclosure. If more convenient, it can be located at some distance from the enclosure as long as the integrity of the coaxial shield is maintained.

The preceding techniques are extraordinary measures that should be required only in unusual

cases. If they are applied with care, RF interference should be reduced to an acceptably low level in all but the most critical applications. Contact the Customer Service Department for advice in the case of a problem that does not yield to these measures.

2.2.3. Transient Sensitivity

Princeton Applied Research instruments are designed and constructed to ensure normal operation in the presence of moderate transient levels. Although these provisions are sufficient for operation in most places where the equipment is used, it is certainly possible for transient levels in particular environments to be so severe that they make reliable operation uncertain. There are three general types of high-level transients:

1. **Static discharge**
   Transients from this source generally affect input or output circuits, input circuits that include MOS field-effect transistors to achieve high input impedance are particularly susceptible to damage from this source. Damage typically occurs when the charge built up on a user's body discharges into an input or output connector as a connection is being made. Among the factors determining the tendency for charges to build are the kind of clothing fabrics worn, shoe materials, and the materials in the floor or floor covering.

2. **High-level transients generated internal to the place of use**
   Such transients almost always enter the instrument via the line cord. Possible sources include heavy-duty electric motors, RF equipment, diathermy machines, arc welder, spark chambers, and others.

3. **Lightning**
   Transients caused by lightning almost always enter the instrument via the line cord.

Static discharge problems can sometimes be avoided by judiciously selecting the floor covering in the work area. The simplest approach to the problem is to self-discharge by touching a grounded metal object just before touching the instrument, particularly when making connections to the cell. External line-transient filters can generally suppress transients that enter the instrument via the line cord. A suitable transient suppressor is available from Princeton Applied Research. Various kinds of power-line conditioners are also commercially available.

3. INSTALLATION

This chapter describes the PARSTAT 4000 connectors and indicators and details how to connect it to the host PC, electrochemical cell, and other equipment users might wish to use with it. The pinouts for AUXILIARY INTERFACE connector and cell cable connector are listed in Section 4.

3.1. Enabling the USB port on the PC

Some PC manufacturers ship their PCs with the USB port disabled. Check for this before trying to use the PARSTAT 4000. If the port is disabled, follow the manufacturer's instructions for enabling it.

3.2. Connectors and Indicators

3.2.1. Rear Panel

The PARSTAT 4000 rear panel is shown in Figure 5**.**



Figure 5. PARSTAT 4000 Rear Panel

3.2.1.1. Input Power

120-240-V; the supplied AC power cord can be connected to 120- 240V AC. See Section 2.1.1 for more details.

3.2.1.2. USB

Attach the supplied USB cable to this connector and to the USB connector on the PC. Users can connect to and disconnect from the PC without shutting down or restarting Windows or VersaStudio.

3.2.1.3. Sync ADC Input

This BNC allows users to monitor an auxiliary signal in the ±10V range with 16-bit resolution. This signal is monitored synchronously with the E and I channels.

3.2.1.4. DAC Output

Rear-panel BNC delivers a precise DC voltage in the ±10V range. This output can be used to control the rotation speed of rotating disk electrodes (RDEs).

CAUTION **The voltage at this connection will be uncontrolled at power-on until the system fully boots (~1 min after power-on). As a result, no connection should be made until the system has completely booted, or in the case of an RDE (i.e., the 616/636 systems), leave the power off on the RDE until the system is completely booted.**

3.2.1.5. Auxiliary Interface

This DB9 female connector provides several functions including the signals required to drive a Model 303A Static Mercury Drop Electrode. If using a Model 303A, users must connect the electrode to the AUXILIARY INTERFACE connector via the Model 507 Interface. AUXILIARY INTERFACE can also turn the Model 616 Rotating Disk Electrode on and off with the STIR signal issued with the VersaStudio software. See Section 4.4. for the pin assignments. PMC AUX01 cable is now available to convert these pins to convenient BNCs.

3.2.1.6. E MON

This rear panel BNC connector outputs the analog of the reference voltage (±10V range, 50Ω output impedance), however, the polarity at E MON is opposite that at the cell.

3.2.1.7. I MON

This rear panel BNC connector outputs the analog of the current with ±2V corresponding to +/- full scale current range, 50Ω output impedance.

NOTE If the PARSTAT 4000 is operating in “float” mode, then all connections to the rear panel must be floating (isolated from ground) as well. If a grounded connection is made to any rear panel connectors (any non-isolated connection), then the PARSTAT 4000 system will no longer be isolated itself, and ground loops will result in excessively noisy data.

3.2.2. Front Panel

The PARSTAT 4000 front panel is shown in Figure 6.



Figure 6. PARSTAT 4000 Front Panel

3.2.2.1 Cell Cable Connector

The cell cable connector provides a means of connecting a cell cable to the instrument. The cell cable is described in more detail below.

3.3. Connecting to the PC and Cell

This section gives instructions on connecting the PARSTAT 4000 to the host PC and to an electrochemical cell and other equipment.

WARNING **For operator and equipment safety, power to all instruments should be off when connecting or disconnecting cables.**

3.3.1. Connecting to the PC

The PARSTAT 4000 is shipped with a standard USB cable. Connect it between the rear- panel USB connector and a USB port on the PC. As noted above, it is not necessary to shut down and restart Windows or VersaStudio.

Installing the USB Driver

The first time the PARSTAT 4000 is connected to the host PC and powered on, Windows® should display a “Found New Hardware” message, and request driver installation. Upon this request, insert the VersaStudio CD into the CD-ROM drive, and select “Automatic” to install the driver. This driver should be located in the C:\Program Files\Princeton Applied Research\VersaStudio\ folder.

3.3.2. Connecting to the Cell

To connect the cell cable (part no. 223945) to the PARSTAT 4000:

1) Make sure the POWER switch is off.
2) Match and attach the D connector side of the Cell cable to the front of the PARSTAT 4000 and secure the screws on either side.
3) After cell cable is connected to front panel, power the unit on and let it boot fully (approximately 1 min to boot up) before connecting a cell to the leads of the cell cable.

CAUTION **Having a cell connected at power-on or at power-off should be avoided to prevent any voltage or current spikes from reaching the cell, or in the case of energy storage devices (such as batteries, capacitors, or fuel cells), preventing spikes from discharging back into the PARSTAT 4000 and causing damage to the instrument.**

The opposite end of cell cable is color-coded at the tip as follows:

Green – Working (WE) electrode lead. This lead connects to the electrode of interest at which the desired reactions will occur. The current (I) is measured through the WE.

Red – Counter (CE) electrode lead. This lead connects to the electrode opposite the WE and controls the power output of the PARSTAT 4000.

Gray – Sense (SE) electrode lead. This usually connects to the working electrode (the combination often referred to as the working-sense) and is a component of the differential amplifier that measures/controls the voltage between itself and the reference electrode.

White – Reference (RE) electrode lead. This connects to the reference electrode, a component of the differential amplifier that measures/controls the voltage between itself and the sense electrode.

Black – Ground lead. The use of the ground lead depends on the application, but it is not ordinarily used in most experiments. It can be used to supply a ground point to a Faraday shield for the experimental cell and is used in some open circuit experiments to form a zero-resistance ammeter (ZRA).

The following descriptions and figures explain how to connect a two-, three-, or four-terminal electrochemical cell to the terminals of the PARSTAT 4000 cell cable.

a) Batteries, capacitors, resistors, fuel cells, and some sensors are generally connected using a two-terminal connection (Figure 7). The connectors for the cable leads are designed to allow easy interconnection of the working/sense and reference/counter leads.

NOTE If the cell has low impedance (battery) and/or the experiment generates currents more than 100mA, do not connect the leads into one another for a two-terminal connection. Instead, connect the leads independent of one another to their proper terminal at the cell to prevent voltage offsets that can result from milliohms of contact resistance in a “piggy-back” connection as shown below.

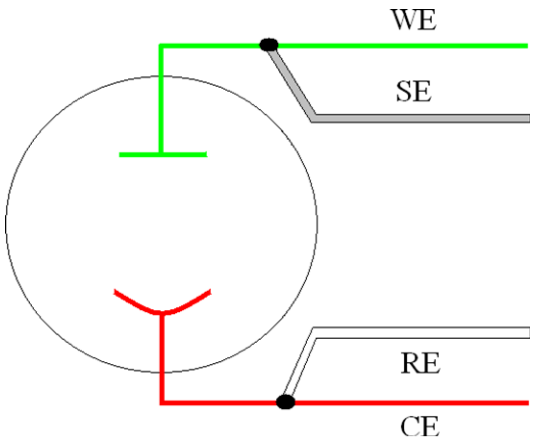


Figure 7. Two-Electrode Connection

b) General aqueous electrochemistry, corrosion experiments, and most EIS experiments are connected using a three-terminal connection (Figure 8). The voltage at the working-sense is controlled relative to a stable reference electrode positioned in close proximity to the working electrode.

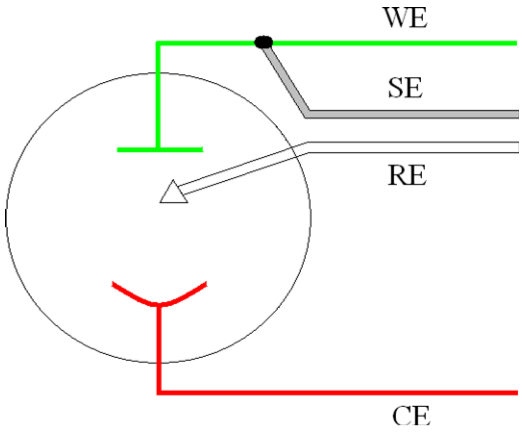


Figure 8. Three-Electrode Connection

c) There are some applications for which a four-terminal (Figure 9) connection is required. In this case, the potential between the reference and sense are controlled and measured. This can be a 4-terminal connection to a low impedance battery or capacitor, or the Sense electrode can be an additional reference electrode (for instance, in controlling the potential across a membrane in a H-cell setup).

NOTE	Running experiments in this mode requires that the Electrometer Mode setting in the software be set to Differential for the correct potential to be applied and read.

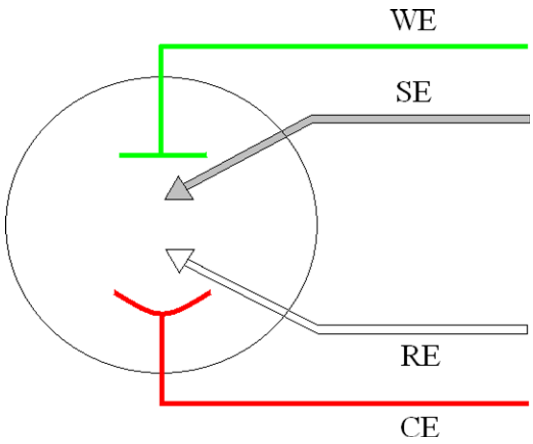


Figure 9. Four-Electrode Connection

CAUTION **Take care that the leads *do not accidentally short together.* Because the black ground lead is often unused, it tends to be overlooked and is more likely to accidentally short together with another lead.**

The polarity of the potential at the counter electrode will be opposite the “applied potential.” This is necessary to establish the correct polarity relationship at the working electrode versus the reference electrode.

After all other connections to the PARSTAT 4000 are complete, experiments can be set up and performed.

3.3.3. Connecting the External Dummy Cell

The external dummy cell for the PARSTAT 4000 (part number 3680-1300-06S, pictured below) consists of a 10ohm resistor in series with a 100ohm || 100uF time constant. This dummy cell is utilized in ASTM G106 (Verification of Algorithm and Equipment for Electrochemical Impedance Measurements) and can be used for DC tests as well as EIS testing. The relationship for these measurements is:

E=IR

E=voltage
I=current
R=resistance

For example, a constant potential of 1V applied to the should produce a current of 9.09mA (milliamps):

1=110 (I)

I= 1/110 = 9.09mA

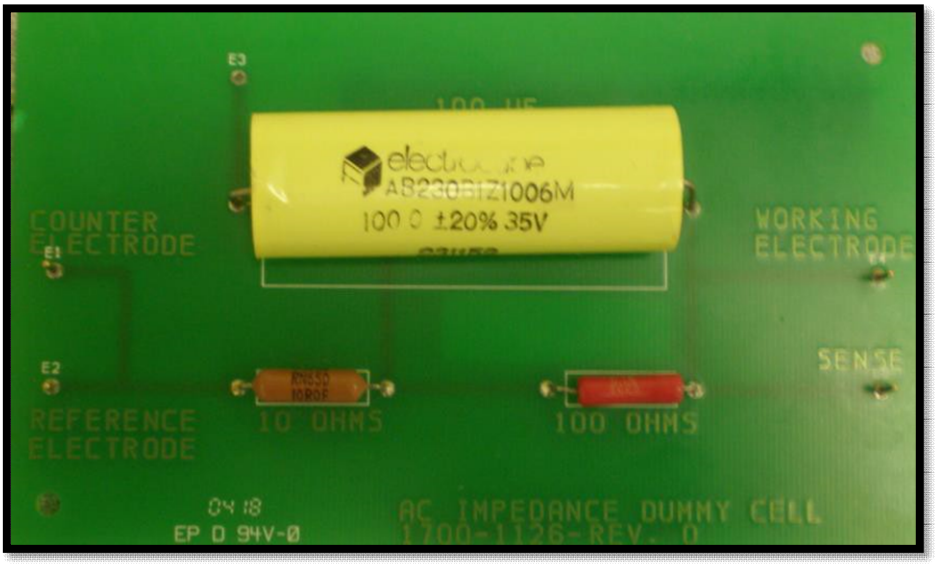


Figure 10. Dummy Cell

The sense (gray) and working (green) leads are connected to the working and sense terminals, while the reference (white) and counter (red) leads are connected to the reference and counter terminals. The picture blow demonstrates the connection to the dummy cell:

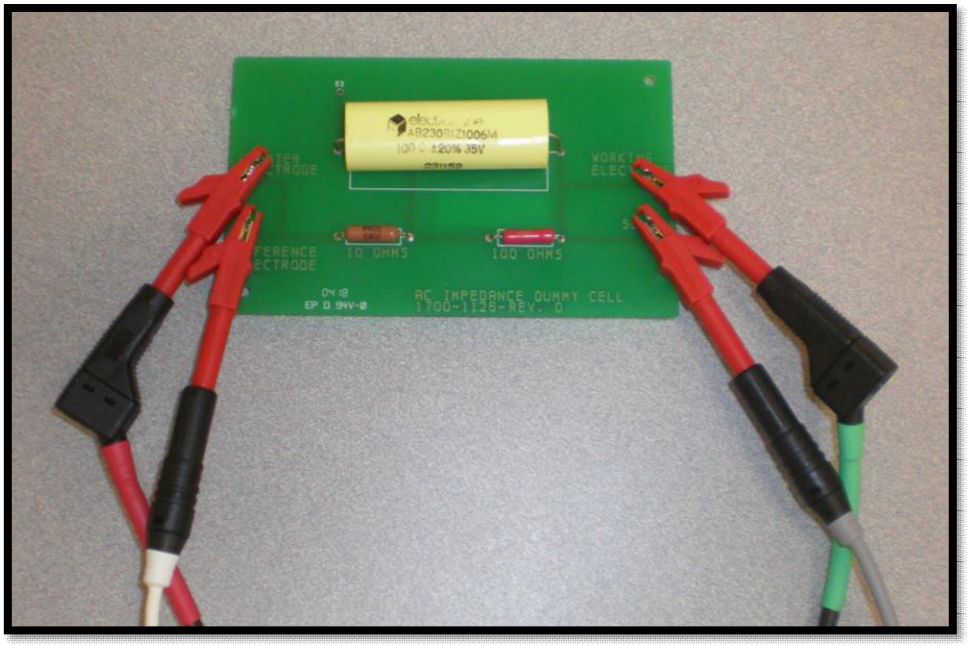


Figure 11. Dummy Cell with Connections

As this is an AC Dummy Cell, it is designed to provide a means of evaluating the EIS performance of the system. A Potentiostatic EIS frequency scan from 100 KHz to 100 mHz at an ac amplitude of 10mV (10 points/decade sampling rate) should provide a Bode Z plot and Nyquist Plot as follows:

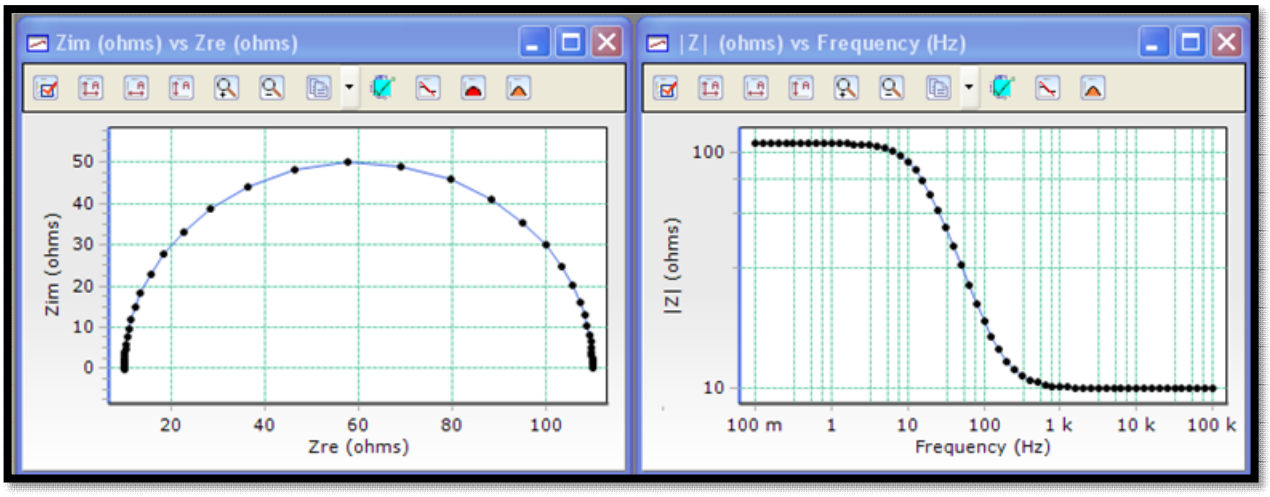


Figure 12. Nyquist Plot (Left) and Bode Z Plot (Right)

The Bode Z plot (right plot above) should be horizontal at 10ohm at higher frequencies, and horizontal at 110ohm (10 +100) at lower frequencies. The Nyquist semicircle should terminate at those same impedances on Zre and have a diameter of 100ohm, with a maximum Zim of close to 50ohm (top of semicircle).

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4. SPECIFICATIONS AND PINOUTS

4.1. Electronic Specifications

4.1.1. System Performance

Minimum Time Base: 1 µs
Minimum Potential Step: 1 µV
Minimum Current Range: 2nA (hardware)
Minimum Current Range: 40 pA with 50X gain
Minimum Current Resolution: 1.2 fA

4.1.2. Power Amplifier

Compliance Voltage: ±48V
Maximum Current: ±4 A (standard) ±20 A (with 20 A option)
Rise Time (-1.0V-+1.0V): < 100 ns (typical)

4.1.3. Voltage Control

Applied Voltage Range: ±10V maximum
Applied Voltage Resolution (with LSV and CV):
for ±10 mV signal = 305 nV
for ±100 mV signal = 3 µV
for ±1 V signal = 30 µV
for ±10 V signal = 300 µV

Applied Voltage Accuracy: ± 0.2% of setting ± 2 mV
Maximum Scan Rate: 25 KV/s Staircase Voltammetry (25 mV step)
Maximum Scan Range/Resolution: ±10V / 300 µV

4.1.4. Current Control

Applied Current Range: 0 to ±4 A (standard)
Applied Current Resolution: ± 1/32,000 x full scale
Applied Current Accuracy: ± 0.2% of reading, ± 0.2% of range +/-2pA
Minimum Current Range/Resolution: ± 40 pA/61 fA

4.1.5. Differential Electrometer

Leakage Current: < 2 pA at less than 25ºC (typical)
Input Voltage Differential: ±10V
Bandwidth: ≥10 MHz (-3 dB)
Common Mode Rejection: 60 dB at 100 kHz, typical
Input Impedance: ≥ 10^{14} Ω in parallel with ≤ 2 pF (typical)

4.1.6. Voltage Measurement

Voltage Range: ±10V
Minimum Voltage Resolution: 1.5 µV (2.5 V range, X50 gain applied)
Voltage Accuracy: ±0.2% reading, ±2 mV

4.1.7. Current Measurement

Current Ranges: 13 decades, 20A to 40pA, 200 mA to 80 fA (with low current option)
Current Measurement Accuracy (dc):
2 nA to 20A ± 0.2% reading, ± 0.2% range
40 pA and 200pA ranges ± 0.5% range, ± 4pA

4.1.8. iR Compensation

Positive Feedback Range: 50 MΩ to 122 mΩ depending on current range
Dynamic iR: 2s/pt rate limit (Corrosion techniques)
Supported Current Ranges: 40pA to 20mA

4.1.9. Potential/Current Control

Digital/Analog Converters (DACs)

Bias DAC
Resolution: 18 bits
Range (potentiostat): +10V
Range (galvanostat): +100% of full-scale current

Modulation DAC
Resolution: 18 bits
Range (potentiostat): +10V
Range (galvanostat): +100% of full-scale current

4.1.10. Impedance Specifications

Frequency Range: 10 µHz – 5 MHz
Maximum AC Voltage Amplitude: 1000mV RMS
Minimum AC Voltage Amplitude: 0.1mV RMS

4.2. Physical and Power Specifications

Computer Interface: Universal Serial Bus (USB)

Weight: 23 kg (50 lbs.)

Dimensions: 51.5 cm W x 49 cm D x 19.5 cm H (20.25 in x 19.25 in x 7.75 in)

Power Requirements: 750 VA Max

Voltage Range: 90 Vac to 250 Vac, 50-60 Hz

4.3. Standard Environmental Conditions

This equipment is designed to meet or exceed the requirements of the following standards:

- LVD: EN61010-1:1993, Amendment 2
- EMC: EN61326: 1998 Emissions
- EN55011:1991, Group 1, Class A

Immunity:

- IEC 61000-4-2:1995, ESD
- IEC 61000-4-3:1995, EM field
- IEC 61000-4-4:1995, Burst
- IEC 61000-4-5:1995, Surge
- IEC 61000-4-6:1995, Conducted RF

Operating Temperature: 10°C to 50°C
Humidity: maximum 80% non-condensing
Protection against ingress of water, IPX0.

4.4. Auxiliary Interface Pinouts

Table 1. Auxiliary Interface Pinouts

Pin	Signal	Function
1	GROUND	
2	TRIG IN	Using the VersaStudio software, an experiment can be held, waiting on this TTL trigger input signal to be read.
3	DISPENSE	When using the PARSTAT 4000 with a Model 303 or 303A Static Mercury Drop Electrode (SMDE) via a Model 507 interface, this signal causes the electrode to perform a DISLODGE/DISPENSE operation on command from the host PC.
4	TRIG OUT	A TTL trigger output is provided on this line with the VersaStudio software.
5	BIT O IN	Not used.
6	-	Not used.
7	BIT O OUT	Not used.
8	PURGE	When using a Model 303 or 303A SMDE via a Model 507 Interface, this signal controls the electrode's PURGE function in response to commands from the host PC.
9	STIR	This signal controls the Model 303 or 303A's STIR function in response to commands from an external computer. It is assumed that the electrode is being used with a Model 305 stirrer.

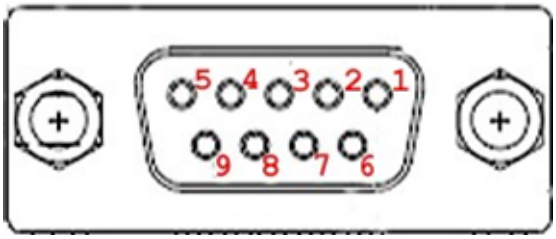


Figure 13. Labeling of Pins on DB9 for AUX and Analog

4.5. Cell Cable Pinouts

Table 2. Cell Cable Pinouts

Pin	Signal	Function
A1	SENSE	See Section 3.3.2.
A2	WORKING	See Section 3.3.2.
A3	COUNTER	See Section 3.3.2.
A4	REFERENCE	See Section 3.3.2.
1	GROUND	See Section 3.3.2.
9	GROUND	See Section 3.3.2.
2-8	RESERVED	Reserved for future options
10-17	RESERVED	Reserved for future options

5. AVAILABLE OPTIONS

The factory installed options available for the PARSTAT 4000 are as follows:

- Advanced Auxiliary Interface (4 x 12-bit ±10V inputs)
- 20A Current booster Option.
- VersaSTAT LC Ultra Low Current Option

5.1. Advanced Auxiliary Interface Option

The Advanced Auxiliary Interface (AAI) Option allows for an additional four (4) A/D inputs for the VersaStudio software to acquire along with data recorded directly from the PARSTAT 4000.

The AAI is an external unit that plugs directly into the same PC as that interfaced by the PARSTAT 4000 into an available USB port. The VersaStudio auto-detects the AAI and collects data on the additional four A/D inputs along with data directly from the hardware (E, I, AUX, etc.).

The AAI is a ±10V DC input, 12-bit unit (±5mV resolution) system, and is recommended for when several variables need to be collected concurrently with the electrochemical data, such a pH, temperature, etc.

Although an external unit, the AAI requires that it must be purchased at the same time along with the base unit, or at a later time by returning the base unit to a qualified Princeton Applied Research Service Center for installation and calibration of necessary components internal to the hardware.

5.2. Power Booster Options

The current booster option for the PARSTAT 4000 is a 20V/20A.

> **NOTE** The voltage component for the boosters is compliance voltage increase, not reference voltage increase. The maximum reference voltage (applied voltage) remains at ±10V.

Each current booster includes an external power supply interfaced to additional internal circuitry of the PARSTAT 4000 system via the rear panel. Once connected, the system can be operated in either boosted mode or normal mode depending on a switch setting at the rear panel, as well as some cell cable changes. When set to “Booster” mode and interfaced correctly to the external power supply, currents up to the maximum for each option can be applied or measured. The VersaStudio software auto-detects the booster mode, and automatically sets the parameters needed to operate correctly in that mode.

> **NOTE** In boosted mode, the system is required to stay on a single current range and is limited in this mode to current measurements at a resolution of 16 bits for the boosted range.

This option has components that are built into the base unit, so it must be purchased at the same time along with the base unit, or at a later time by returning the base unit to a qualified Princeton Applied Research Service Center for installation and calibration.

Refer to Appendix A in this hardware section for power booster setup and connections.

5.3. VersaSTAT LC Ultra Low Current Option

The VersaSTAT LC Ultra Low Current Option is a plug-and-play add-on option that provides current ranges down to a minimum range of 80fA. Please see product brochure for additional details.

6. WARRANTY

Advanced Measurement Technology, Inc.

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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.

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SHOULD THE EQUIPMENT REQUIRE SERVICE

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

A. If it is necessary to send any equipment back for service, the following information will be required.

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

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

Advanced Measurement Technology, Inc.
801 S. Illinois Avenue
Oak Ridge, TN 37831
ATTN: Customer Service

PHONE: 865-482-4411
FAX: 865-483-2133

C. 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.

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APPENDIX A. PARSTAT 4000 EXTERNAL CURRENT BOOSTER CONNECTIONS

General

This add-on option consists of a specially configured bipolar power supply from KEPCO®, Inc., an internal (inside PARSTAT 4000 chassis) Princeton Applied Research Current Booster Interface, and cabling.

> **NOTE** The PARSTAT 4000 is factory configured and calibrated to operate with the bipolar power supply purchased with the option. ***Using a different power supply could damage the system***. Before using a different KEPCO with the PARSTAT 4000 with booster option, contact the local Princeton Applied Research representative or service center.

All experiments are computer-controlled via the VersaStudio software which correctly scales the current entry and measurement. No correction factor is required as with some other power booster options.

The PARSTAT 4000 functions on a fixed current range of 2mA when operating in “Booster Mode” with the KEPCO power supply. The interface board scales the current signals from the KEPCO to allow current measurements to ±20 amps.

The system frequency response has been modified in booster mode to provide stability for the complete closed-loop response for electrochemical cells with a very high capacitance and very low resistance.

Connections and settings are identical among the three external power booster options.

The power booster interface operates in power-boosted or normal modes – a simple cable connection and flip of a switch convert between the two modes. This section discusses the boosted mode only.

Interconnections

The PARSTAT 4000 and KEPCO connect to the cell (electrochemical cell, battery, etc.) by two marked cables, 223673 for the KEPCO and 223859 for the PARSTAT 4000 (replacing the normal cell cable used for “Normal” mode). All the interconnections for the PARSTAT 4000 and KEPCO are shown below.

CAUTION **Make all connections with the power off.**

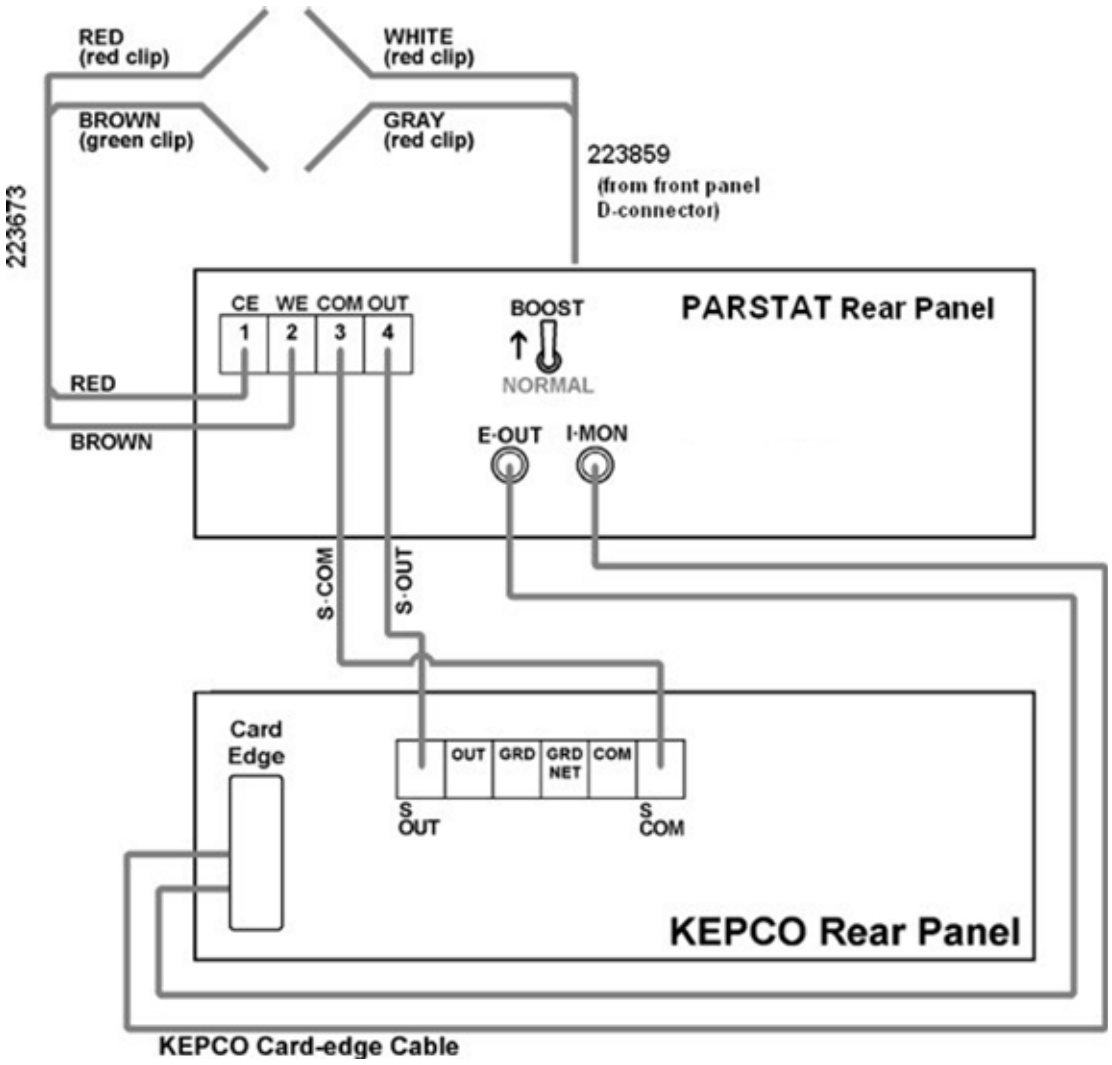


Figure 14. PARSTAT 4000 and KEPCO Connections

KEPCO Front-Panel Setup

- The **MODE** switch on the front panel of the KEPCO should be set to Voltage mode (left position).
- The **Voltage CONTROL** switch (red toggle on left side) should be in the OFF (down) position.
- The **Current CONTROL** switch (red toggle on right side) should be in the OFF (down) position.
- The **SENSE/COMMON** (black banana jacks at bottom-center) should be inter-connected with a shorting bracket.
- The **OUTPUT/SENSE** (red banana jacks at bottom-center) should be inter-connected with a shorting bracket.

External Cell Connection and Checkout

Use the cables 223859 and 223673 to connect the cell being tested.

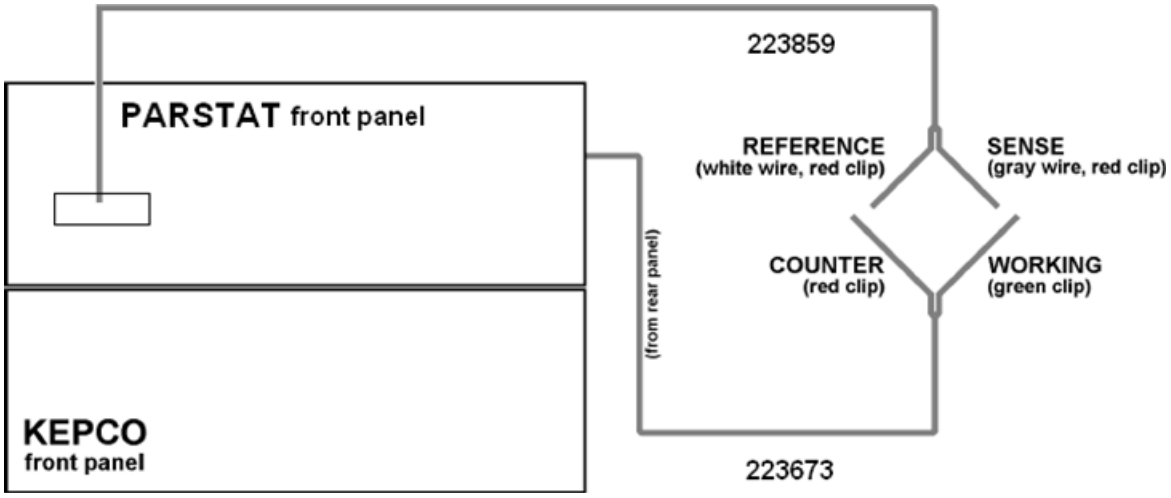


Figure 15. External Cell Connection

DANGER **Dangerous and possible lethal voltages may be present on the COUNTER lead. Never touch the leads while mains power is supplied to the KEPCO. For more information, see the accompanying KEPCO manual.**

Once all the interconnections have been made, it is recommended that a checkout be performed on a known valued resistor (not supplied), also referred to as a “dummy cell,” to insure that the system is connected and functioning correctly. A value of 1 ohm is recommended, and it must have a power rating of at least 5 watts.

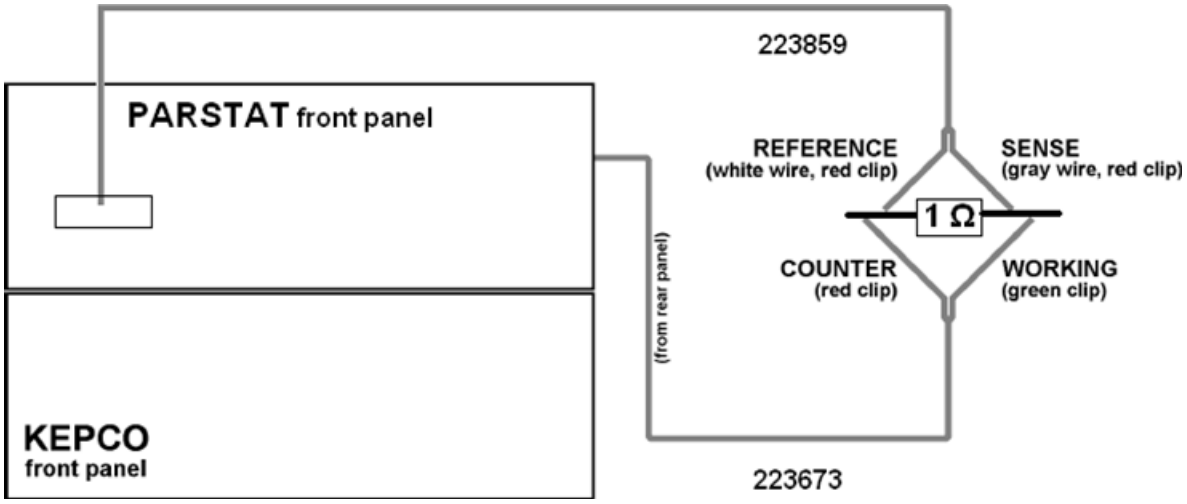


Figure 16. Dummy Cell Connection

Dummy Cell Connections

1) Ensure the power is off on both the PARSTAT 4000 and KEPCO.
2) Connect dummy cell (resistor) as shown above with Counter/Reference connected to one side of the resistor and Working/Sense connected to the opposite side.
3) Set the PARSTAT 4000 rear panel NORMAL/BOOST to BOOST mode.
4) Turn on the power to the PARSTAT 4000.
5) Turn on the power to the KEPCO.
6) Start the VersaStudio software and select “New Experiment.” Select the “Chronoamperometry” action.
7) Once the software has established communications with the PARSTAT 4000, ensure that the status bar in the lower right-hand corner of the screen shows “Booster Mode”.
8) In the Experiment Properties window for the Chronoamperometry action, ensure that the applied voltage is 1V, time per point is 1s, and duration is 10s. Select the “Advanced” button and set the “Electrometer Mode” to the setting of “Differential.”
9) Select the “Run” button at the top of the window to start the experiment and acquire data.
10) After the experiment finishes, verify that the applied potential was 1V, and that the resulting current was 1A (for a 1ohm resistor) for the data (10 points) collected.

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