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Princeton Applied Research

PARSTAT 4000

Potentiostat/Galvanostat/EIS Analyzer



- Research Electrochemistry
- Battery/Supercapacitors
- Nanotechnology
- Corrosion & Coatings
- Fuel Cells / Solar Cells
- Sensors

AMETEK

Introducing...

For leading researchers in electrochemistry whose field of study demands performance, reliability, and versatility, the PARSTAT 4000 is a high-end electrochemical system that allows them to meet their present and future needs unlike any other system on the market today. With its wide-ranging specifications backed by a brand with a 50+ year history as the leader and most referenced line of research-grade potentiostats/galvanostats in the world, save a spot in the "Materials and Methods" section for the PARSTAT 4000... it's ready for your next project.

The PARSTAT 4000 builds on the performance-oriented PARSTAT series of systems with improved key specifications and much improved functionality and flexibility via the VersaStudio software interface. An impressive combination of performance and versatility, the PARSTAT 4000 is perfect for the majority of electrochemical applications and techniques carried out in the foremost laboratories throughout the world today.

- High current and current booster options for research in energy storage devices such as Li-ion batteries or supercapacitors.
- Low current sensitivity for DC and AC corrosion measurements on corrosion resistant materials such as bio-implant devices or new coatings technology.
- Fast data acquisition rate for capturing fast transients, applying fast pulse trains, or fast scans on microelectrodes.
- Built-in calibration components and circuits for any-time-calibrations assuring highly accurate measurements.
- Capable of "floating" for operation with grounded cells and electrodes.
- Front panel LCD with customer selectable parameters and custom text input

...the **PARSTAT 4000**



The PARSTAT 4000 is the latest model of high-end potentiostat/galvanostat offered by Princeton Applied Research. It is the ultimate electrochemical research system, boasting superior specifications for virtually any electrochemical application where a single-channel potentiostat/galvanostat/FRA is needed.

The PARSTAT 4000 is a perfect example of how customer feedback advances design. The PARSTAT 4000 combines the flexibility, versatility, and reliability of the extremely popular VersaSTAT series with the broad specification range and experimental capability of the PARSTAT 2273 to create the most powerful potentiostat/galvanostat/EIS analyzer that Princeton Applied Research has ever offered.

Impressive specifications:

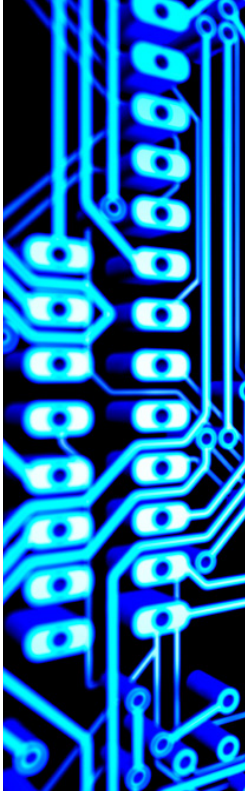
- +/-4 A current max (20A Booster Option) over 13 current ranges (40pA-20A)
- +/-48V compliance (+/-10V reference) voltage
- 1.2fA current resolution on lowest 40pA range (2.5aA with low current option)
- 1µs data sampling capability with 4M point onboard data buffer
- Isolated (floating) lead capability for grounded electrode/cell applications
- Unwanted noise removal via selection of 5 analog E and I filters, as well as available 50Hz and 60Hz notch filters for power noise reduction.

The PARSTAT 4000's hardware is capable of +/- 10V scan/pulse range, +/-4A compliance current, and built-in EIS measurements up to 5MHz. The interface to the computer is Universal Serial Bus (USB), and the system is controlled via VersaStudio software.

Electrochemical Impedance Spectroscopy (EIS) capability is standard on every PARSTAT 4000. The built-in FRA has a frequency range of 10uHz to 5MHz and can measure impedances from Tera-ohms to micro-ohms under the proper experimental conditions and setup.



Applications



The physical nature of electrochemistry has resulted in a broad range of research areas. From determining the kinetics of an electron-transfer process, to developing new and improved materials via unique electrodeposition or electrosynthesis techniques, the PARSTAT 4000 was designed with the flexibility and capability required by today's electrochemical researcher. Whether it is a microelectrode, rotating disk electrode, mercury electrode, or quartz crystal resonator being utilized, the PARSTAT 4000 supports the wide array of electrodes used in a modern electrochemical research lab.

Corrosion

The PARSTAT 4000 is ideal for corrosion research. For measurements of rebar in concrete or titanium in Ringer's solution, the PARSTAT 4000 was designed to address a wide range of corrosion applications. VersaStudio complements the PARSTAT 4000's impressive specifications to create the ultimate tool for any corrosion lab. Are you working with large electrodes or resistive media? The PARSTAT's ±48V compliance voltage takes care of that. Studying a new corrosion inhibitor or coating technology? Femtoamp current resolution and $>10^{13}$ W input impedance make even the toughest EIS measurements seem routine.

Sensors

For potentiometric sensors (such as ion-selective electrodes and coated wire electrodes) and amperometric sensors (gas sensors, thin film microelectrodes, and chemically modified electrodes), the PARSTAT 4000 provides current sensitivities that can surpass the requirements of the most demanding measurement parameters, with a pA current range and fA resolution, high compliance voltage allows for the growth of thin film electrodes and nanodeposition. Need even lower current sensitivity? Add a VersaSTAT LC option to the PARSTAT 4000 and measure currents accurately to the fa levels with aA resolution.

Batteries and Fuel Cells

For many years, Princeton Applied Research potentiostats/galvanostats have been utilized to further the development of energy storage. From the early stages of battery development to the charge/discharge experiments on the final product, the PARSTAT 4000 has the current range to address the challenges that lie ahead for the next generation of batteries. Fuel Cells offer a cleaner energy source for the future and the PARSTAT 4000 helps bring that technology to market. Use EIS to examine the impedance of the PEM at different humidity levels, perform I/V curves on SOFC's, or run CV's on DMFC assemblies. The PARSTAT 4000 and the entire VersaStudio software have the potential to take your research to the next level.

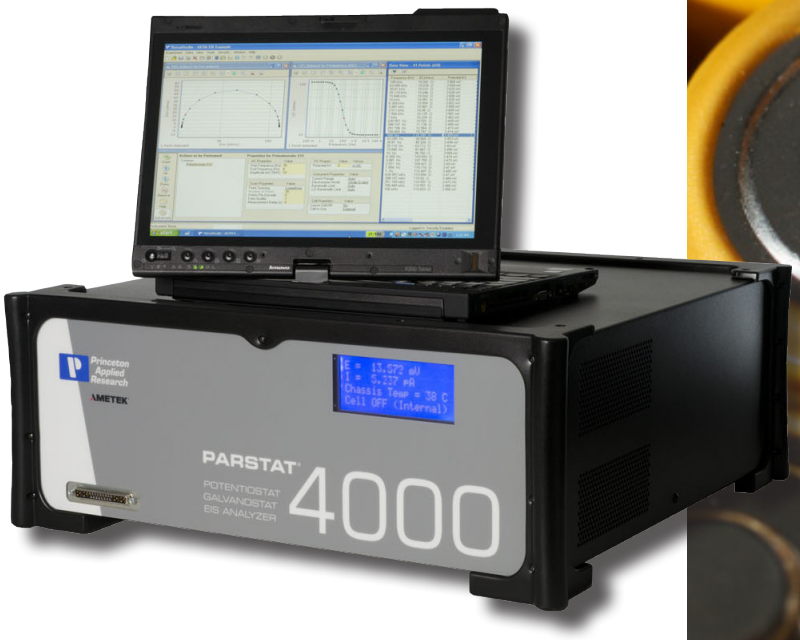
Nanotechnology

The low current measurement capabilities of the PARSTAT series has enabled researchers to continually advance the science of carbon nanotubes and graphene, as well as research in atomic layer electrodeposition. With a VersaSTAT LC option added, measurements can be made accurately in the fA region using proper experimental conditions and accessing the on-board filter technology that enables the system to make these sensitive measurements.

Fundamental Research

Princeton Applied Research continuously strives to provide the broadest range of capability and support needed to cover the diverse requirements of a modern research laboratory. The usability of VersaStudio interface combined with the PARSTAT 4000 makes it THE research tool that every electrochemical researcher needs to insure that their experimental requirements can be met now and in the future.





VersaStudio software

Versatile Software with Powerful Research Capabilities

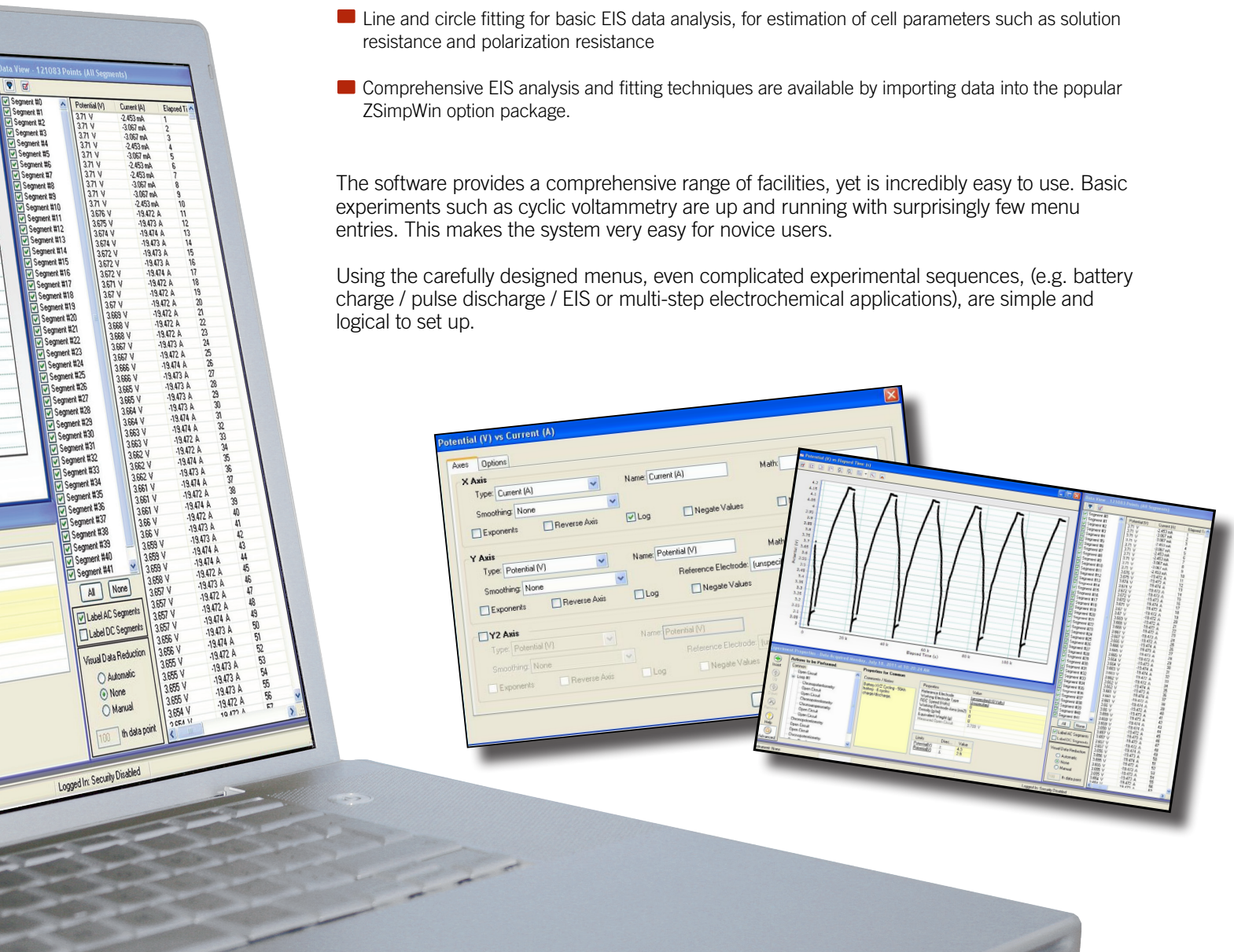
The VersaStudio software provides full access to the capabilities of the PARSTAT 4000, including the ultra low current option and high current booster when present.

An impressive list of electrochemical experiment types are provided that can be run individually or combined in powerful experimental sequences.

- Flexible experiment setup that can automatically sequence the potentiostatic, galvanostatic and impedance capabilities of the PARSTAT 4000
- Advanced actions such as Message Prompts, Run External Applications, and Email are available to add even more flexibility and functionality to the VersaStudio
- Powerful yet easy Copy/Paste and Export capabilities for custom data analysis and/or data presentation outside of VersaStudio.
- Display data in multiple graphs per viewing window with a wide variety of graphing options for both DC and EIS experiments
- DC data analysis and fitting routines including Line, Peak, Rp, and Tafel Fits, as well as special graphing options for EC Noise and Corrosion Rate vs Time
- Line and circle fitting for basic EIS data analysis, for estimation of cell parameters such as solution resistance and polarization resistance
- Comprehensive EIS analysis and fitting techniques are available by importing data into the popular ZSimpWin option package.

The software provides a comprehensive range of facilities, yet is incredibly easy to use. Basic experiments such as cyclic voltammetry are up and running with surprisingly few menu entries. This makes the system very easy for novice users.

Using the carefully designed menus, even complicated experimental sequences, (e.g. battery charge / pulse discharge / EIS or multi-step electrochemical applications), are simple and logical to set up.



Techniques/Actions

Voltammetry

- Open Circuit
- Linear scan voltammetry
- Cyclic voltammetry (single)
- Cyclic voltammetry (multiple cycles)
- Staircase linear scan voltammetry
- Staircase cyclic voltammetry (single)
- Staircase cyclic voltammetry (multiple cycles)
- Chronoamperometry
- Chronopotentiometry
- Chronocoulometry
- Recurrent potential pulses
- Recurrent galvanic pulses
- Square wave voltammetry
- Differential pulse voltammetry
- Normal pulse voltammetry
- Reverse normal pulse voltammetry

Corrosion

- Electrochemical Noise
- Split APR
- Galvanic Control LPR
- Zero resistance ammeter (ZRA)
- Galvanic Corrosion
- Cyclic Polarization
- Linear Polarization
- Tafel
- Potentiostatic
- Potentiodynamic
- Galvanostatic
- Galvanodynamic
- Dynamic IR

Energy

- Constant Current
- Constant Potential
- Constant Resistance
- Constant Power
- Multi-Vertex Scan
- Current CCDPL
- Power CCD
- Resistance CCD

EIS

- Potentiostatic EIS
- Galvanostatic EIS

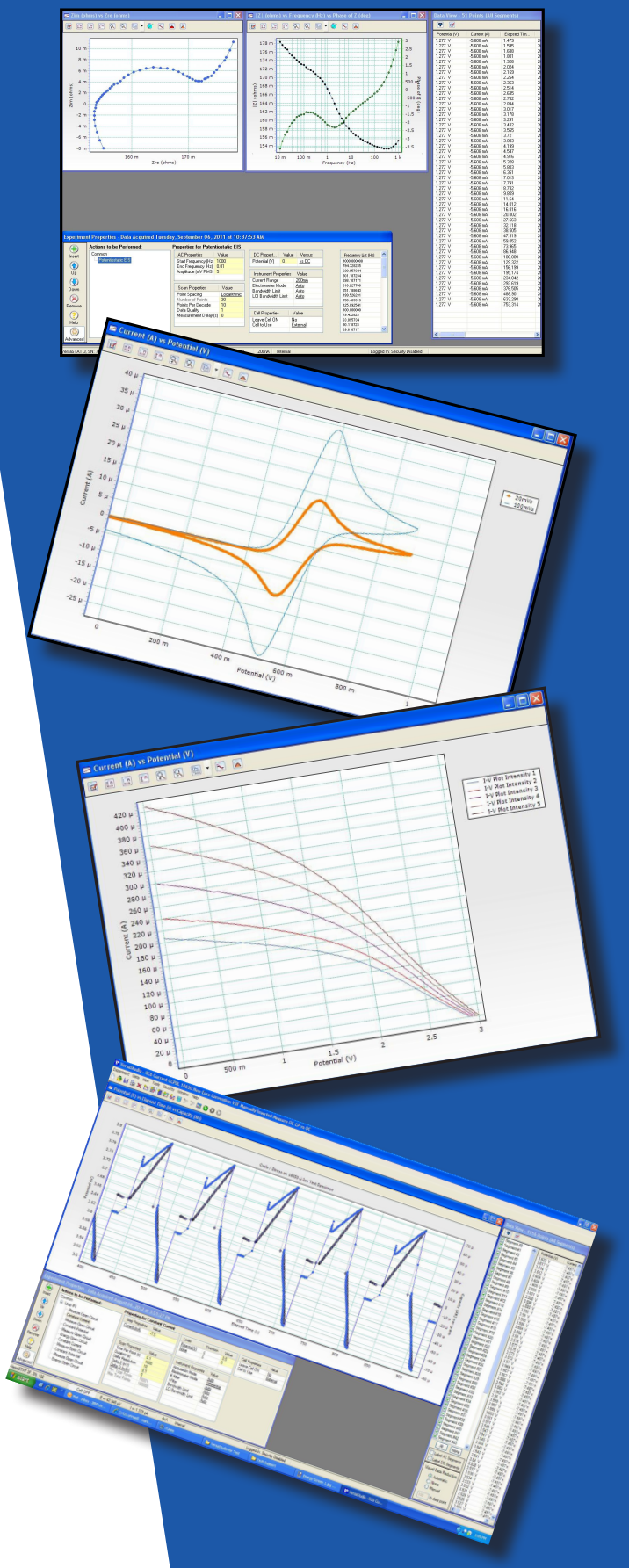
Pre-experiment

- Condition
- Deposition
- Equilibration
- Purge
- iR Determination

Sequence

- Loop
- Time Delay
- Message Prompt
- Measure OC
- Auxiliary Interface
- Email
- Run External Application
- DAC Output Control
- Auto Current Range Setup

Free to download, easy to use



PARSTAT 4000 hardware options

VersaSTAT LC
ultra low current



The VersaSTAT LC is ideal for applications requiring low current accuracy and resolution. Applications such as ultra micro electrodes, coatings research, corrosion testing of bio-implants, and sensor research are all areas where greater current sensitivity may be needed.

The VersaSTAT LC option can be purchased at any time as a plug-in option. It consists of an interface cable to connect to the VersaSTAT, a main body containing the high input impedance electrometer and additional current ranges, and the cell leads. Once attached to the VersaSTAT system and calibrated with the built-in DC Calibration routine, additional bandwidth stabilization filters are provided with the VersaSTAT LC option to provide maximum stability over a wide range of experimental conditions and applications.

- Femtoampere accuracy and attoampere resolution for both DC and AC (EIS) measurements
- Expands E and I filter selection for VersaSTAT 3 and VersaSTAT MC Systems
- Plug-in add-on option
- Auto-current ranging capability from 20mA - 80fA

System Performance	
Minimum Current Range	80fA (80 x 10^{-15} A)
Minimum Current Resolution	2.5aA

Power Amplifier	
Maximum Current	± 20mA

Differential Electrometer	
Input Bias Current	<200 fA at 25°C
Maximum Voltage Range	± 10 V maximum
Input Voltage Differential	± 10 V
Bandwidth	700 kHz (-3dB)
Common Mode Rejection	>60dB @ 100Hz, >50dB @ 100kHz
Input Impedance	>10^{14} Ω in parallel with <200 fF, typical

Current Measurement	
Ranges	14 decades, 20mA to 80fA
Accuracy (dc)	2µ to 20mA < 0.2% full scale
	20nA and 200nA ranges < 0.5% full scale
	200pA - 80fA ranges < 1.0% full scale ± 500fA full scale

Current Control	
Applied Current Range	± full scale per range
Applied Current Resolution	± 1/32,000 x full scale
Applied Current Accuracy	± 0.5% of range, ±0.5% of reading (200mA - 20nA ranges)
Max. Current Range/Resolution	± 20mA / 1µA
Min. Current Range/Resolution	± 80fA / 2.5aA

Above specifications are limitied to the VersaSTAT LC when combined with the PARSTAT 4000



Current Booster option

The Princeton Applied Research Current Boosters are designed to boost the current measuring / applying capabilities of our potentiostats. Each booster option consists of an external power supply interfaced to additional internal circuitry on the rear panel of the potentiostat. A simple cable connection and switch setting converts the potentiostat from normal to boosted mode. These boosters can be supplied as a complete system at the time of original potentiostat purchase or can be added on (factory installation required) at a later time.

PARSTAT 4000 specifications



Configuration	
Cell connections	2, 3 or 4 terminal plus ground

Data acquisition	
Data acquisition	3 x 18-bit 1M samples per second ADCs synchronized - voltage / current / auxiliary
Time base resolution (minimum)	1µs (1M samples / second)
Automatic noise filters	Enabled / disabled

Power amplifier (CE)	
Voltage compliance	± 48V
Current compliance	± 4A (standard) ± 20A (with 20A option)
Potentiostat bandwidth	3.75MHz (typical), 2mA range, 1kohm load
Stability settings	high-speed, high-stability
Slew rate	≥ 25V per µs typical (no load)
Rise time (-1.0V to +1.0V)	<100ns typical (no load)

Voltage control (potentiostat mode)	
Applied voltage range	± 10V
Applied voltage resolution (technique dependent)	for ± 10mV signal = 300nV for ± 100mV signal = 3µV for ± 1V signal = 30µV for ± 10V signal = 300µV
Applied voltage accuracy	± 0.2% of value ± 2mV
Maximum scan rate	$10kVs^{-1}$ (10mV step)
Maximum scan range / resolution	± 10V / 300µV

Current control (galvanostat mode)	
Applied current range	± full scale (depends on range selected) ± 4A (standard)
Applied current resolution	± 1/32,000 x full scale
Applied current accuracy	± 0.2% of reading, ±0.2 % of range, ±2pA
Maximum current range / resolution	± 4A / 123µA
Minimum current range / resolution	± 40pA / 1.2fA

Electrometer	
Max input range	± 10V
Bandwidth	≥ 10MHz (3dB)
Input impedance	≥ $10^{13}\Omega$ in parallel with ≤ 2pF (typical)
Leakage current	≤ 2pA at less than 25°C (typical)
CMRR	60dB at 100kHz (typical)

Voltage Measurement	
Voltage range	± 10V
Voltage resolution	1.5µV (2.5V range, X50 gain applied)
Voltage accuracy	± 0.2% of reading, ± 2mV

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Specifications subject to change.

Current measurement	
Current ranges	Auto-ranging (13 ranges) 20A to 40pA (13 ranges)
Current resolution	1.5fA (40pA range)
Current accuracy (DC)	2nA to 20A, ±0.2% of reading, ±0.2% of range 40pA to 200pA ± 0.5% range, ± 4pA
Bandwidth	>5MHz (signal ≥20mA range typical)
Bandwidth limit filter	Yes, 7 total

IR Compensation	
Positive feedback	Yes
Dynamic IR	Yes

Impedance (EIS) option	
Mode	Potentiostatic / Galvanostatic
Frequency range	10µHz to 5MHz
Minimum AC voltage amplitude	0.1mV RMS
Sweep	Linear or Logarithmic

Interfaces (included as standard)	
Digital inputs / outputs	5 TTL logic outputs, 2 TTL logic inputs
Auxiliary voltage input	Measurement synchronized to V and I ± 10V range, input impedance 10kΩ Filter: off, 1kHz, 200kHz BNC connector
DAC voltage output (standard)	± 10V range, output impedance 1kΩ BNC connector (for stirrers, rotating disk electrode etc.)

PC / Software	
Communications interface	Universal Serial Bus (USB)
Operating system	Windows XP Windows 7 32/64 bit
PC specification (minimum)	Pentium 4 (1GHz) / 2GB memory High data rates may require additional memory
Software	VersaStudio

General	
Ground (selectable)	Isolated (floating) / Earth
Power	700VA Max. Voltage range 90Vac to 250Vac, 50-60Hz
Dimensions (w x d x h)	20.25" x 19.25" x 7.75" 51.5 x 49 x 19.5cm
Weight	50lbs, 23kgs
Operating temperature range	10°C to 50°C
Humidity	Maximum 80% non-condensing
Temperature (specified)	25°C
Dummy Cell	Internal (DC only)
CE approved	Yes



PARSTAT 4000 ordering information

PARSTAT 4000 options

Options	
20A Current Booster option*	20A/PARSTAT4000
Ultra Low Current option	VersaSTAT-LC
12-bit Multi-ADC Input option	AAI/PARSTAT4000

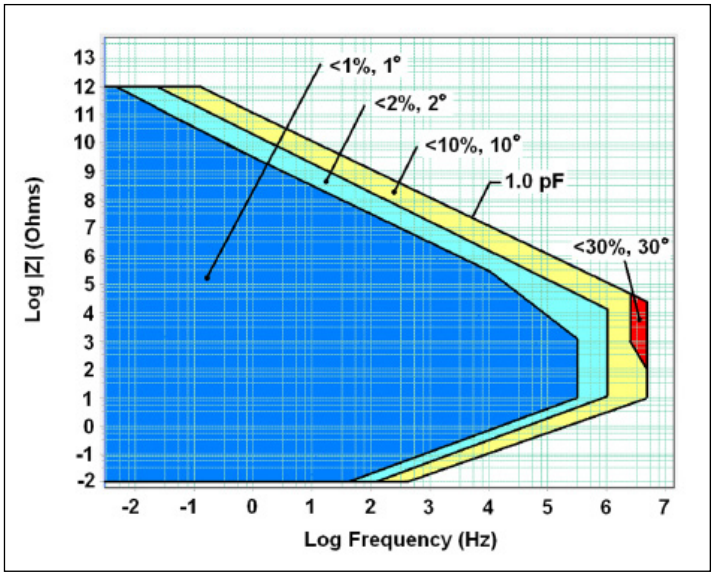
Cell Accessory Options	
K0047	Corrosion Cell Kit
K0235	Corrosion Flat Cell Kit
K0264	Micro-Cell Kit
RDE0018	Analytical Cell Kit for RDE

Ancillary Equipment	
QCM922	Quartz Crystal Microbalance
616A	Rotating Disk Electrode
636A	Rotating Ring-Disk Electrode

*Bandwidth reduced with addition of current boosters

Extended Warranty available: One-year warranty included with the purchase, additional years can be added. Includes labor, materials and return shipping.

PARSTAT 4000 contour map



Typical results for PARSTAT 4000 with standard 2m cable, potentiostatic mode, and Faraday Cage

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