Princeton Applied Research

PARSTAT®

Reference Grade Electrochemical Workstations

Energy ■ Physical Electrochemistry ■ Corrosion

potentiostat | galvanostat | EIS

AMETEK

Redefining Reference Grade...

For 50+ years Princeton Applied Research has been the leader in the development of Reference Grade potentiostats/galvanostats and for the past 15 years the PARSTAT® name has been associated with the top-of-the-line potentiostat of our market leading product offering. With the ever expanding needs of the diverse electrochemistry marketplace today we understand that no one single instrument can meet the needs of every researcher in the field, your needs evolve as your research progresses. Today Princeton Applied Research is proud to offer two PARSTAT potentiostats allowing you to choose the market leading functionality most critical to your research.

PARSTAT 3000A

- 6-WIRE function combines with 30V Range for single cell analysis during Stack Testing and with 6V Range for Anode/Cathode tests
- 7 MHz EIS Frequency range
- Unmatched EIS accuracy in its class
- Small form factor for space conscious laboratories

PARSTAT 4000A

- Unmatched compliance voltage for the most challenging corrosion research (48 V)
- Market leading native current range (40 pA – 4 A)
- 10 MHz EIS Frequency Range for electrochemical studies of high-end materials analysis
- Superior DC Voltage Accuracy benefiting all modes of electrochemical testing

PARSTAT®
Reference Grade
Electrochemical Workstations

PARSTAT® 3000A
potentiostat/galvanostat/EIS

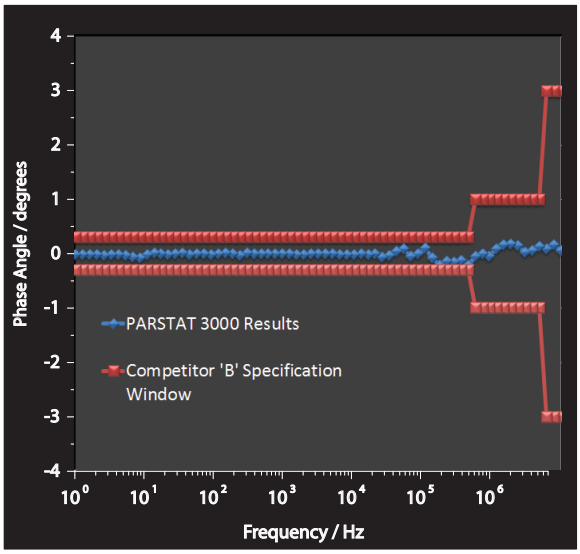
The PARSTAT 3000A represents Princeton Applied Research's latest electrochemical workstation offering for the dedicated electrochemistry researcher. This state-of-the-art potentiostat/galvanostat/FRA comes standard with more functionality than any competitive instrument in its class. With 30 V of both compliance and polarization voltage across a range of currents, from <4 nA to 1 A, the PARSTAT 3000A is capable of analyzing battery stacks, with the included 6-WIRE functionality, as well as conducting large anodization studies.

To this, the PARSTAT 3000A adds impressive EIS accuracy, with the built-in FRA, across a frequency range of 10 µHz to 7 MHz. This accuracy across the entire frequency range provides the energy storage researcher, as an example, with far superior confirmation of the series resistance of the analyzed battery.

EIS Accuracy Chart

With a full array of options and accessories that can be added to the PARSTAT 3000A the system becomes a go-to addition to any Electrochemistry Laboratory. Integrated battery holders are also available to remove the impedance of the cell cable and connect directly to the potentiostat itself, drastically improving overall EIS measurement accuracy.

The included control and analysis software supplied with the PARSTAT 3000A, VersaStudio, is Princeton Applied Research's comprehensive research electrochemistry package and comes standard with our complete suite of electrochemical tests.



PARSTAT 3000A Phase Angle impedance plot on a 100 Ω resistor using standard cable.

PARSTAT® 3000A
Specifications

Compliance Voltage	± 30 V
Polarization Voltage	± 30 V (5 µV resolution measured) ± 6 V (915 nV resolution measured)
Standard Maximum Current	1 A
Standard Lowest Current Range	4 nA
Number of Current Ranges	10 ranges
EIS Frequency Range	7 MHz to 10 µHz
Data Acquisition Rate	1000 kS/sec
Available Mode	AC/DC
Auxiliary Voltage (6-WIRE)	Standard
Connectivity	USB

Voltage Resolution	18-bits
Functionality	All techniques
Software Control	VersaStudio
Data Buffer	4,000,000 data points
Dimensions	17cmx43cmx31cm
Weight	7 kgs, 15 lbs
Orientation	horizontal/vertical
Floating (Grounded or Floating)	Selectable

The PARSTAT 3000A is ideal for the electrochemistry researcher conducting battery research which requires single cell + stack testing or conducting automotive ethanol corrosion research investigations as well as many other applications. Sufficiently compact to fit into the standard glove box, in either horizontal or vertical positioning, and functional enough to provide simultaneous measurement of anode and cathode, the PARSTAT 3000A becomes the ideal electrochemistry workstation for your laboratory. Where other potentiostats require multiple costly options to match the same functionality, the PARSTAT 3000A is designed as standard to maintain bandwidth and accuracy throughout the range of measurement.

feature	allows for		
	Energy	Physical Echem	Corrosion
High Frequency EIS 7 MHz	Solid-state energy materials analysis	Kinetics and mechanism investigations	Determination of uncompensated resistance for iR compensation
Data Acquisition Rate 1000 kS/Sec	Fast transients in electrochemical capacitors	Fast Scan Rate CVs for detection of biological species and rapid kinetics	Oversampling and averaging for noise reduction
Compliance Voltage 30 V	Studying stacks up to: 6 Li-ion batteries or 20 NiMH batteries	Tolerates the use of smaller counter electrodes (CE),frits on CE and nonaqueous electrolyte	Studies in low conductivity environments such as rebar in concrete
Polarization Voltage 30 V Range	Allows the study of Pb-Acid batteries	Large voltage fields for electrophoretic deposition	Anodization of Titanium or materials that form robust oxides
6 V Range	Accuracy for single cell tests	Resolution for aqueous testing	Resolution for LPR and ZRA tests
6-WIRE	Simultaneous DC and EIS measurements of Anode/ Cathode or a single cell during stack testing	Additional sensor measurements and multiple cell impedances	Measurements of a pH probe or compliance voltage

PARSTAT® 4000A

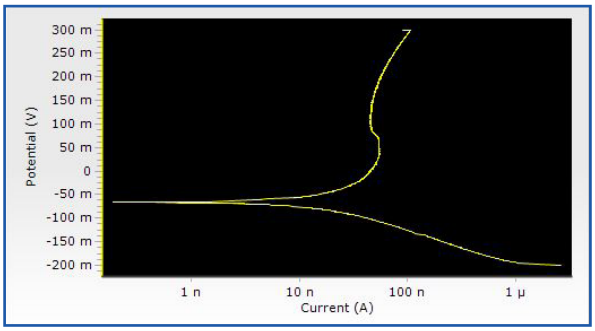
potentiostat/galvanostat/EIS

The PARSTAT 4000A represents the culmination of decades of experience in design and manufacture of research grade potentiostats. Designed to be a complete, single box solution, the PARSTAT 4000A represents the latest flagship of our proud PARSTAT line of electrochemical workstations. Building on the highly popular PARSTAT 4000, the 4000A has improved voltage accuracy and bandwidth to meet the needs of even the most demanding researcher.

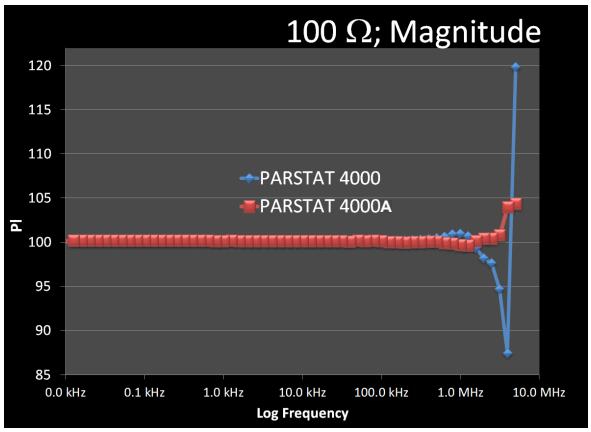
The PARSTAT 4000A expands the possibilities of your research and prepares you for future expansion as the scope of your research inevitably increases. As the only electrochemical workstation available with the ability to provide you with a 4 A maximum current range, 40 pA minimum current range, 48 V of compliance voltage and frequency bandwidth up to 10 MHz, all standard, the PARSTAT 4000A provides today's researchers with the most functionality for your investment. Ideal for Energy Storage, Physical Electrochemistry, Nanotechnology Research and Corrosion Studies the PARSTAT 4000A delivers unparalleled performance and functionality.

The foundation of the PARSTAT 4000A is the combination of more functionality in a single system than is available anywhere else. Where other instruments require costly optional additions to meet the same specifications, such as boosters or low current options, the PARSTAT 4000A provides everything needed without requiring you to buy additional components. For those researchers in the field truly pushing boundaries, however, the PARSTAT 4000A is compatible with the full Princeton Applied Research line of options to help you reach truly extreme functionality.

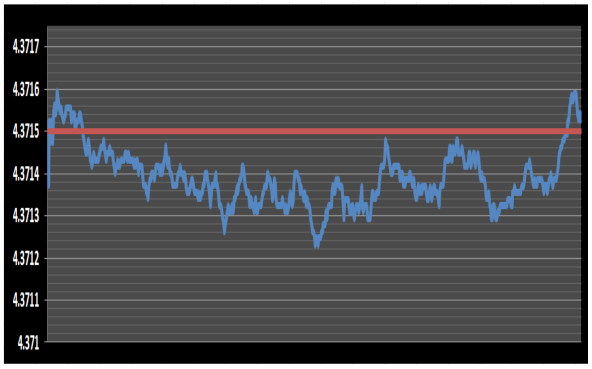
For the materials scientist the PARSTAT 4000A now offers best in class EIS bandwidth to 10 MHZ as well as unrivalled magnitude and phase performance over a wide range of frequency and impedance.



PARSTAT4000A Tafel plot experiment in K0047 Corrosion Cell as described in ASTM



PARSTAT 4000A Magnitude impedance plot on a 100 Ω resistor using standard cable.



Voltage vs.Time Trace for a requested 4.3715 V(←)
The PARSTAT 4000A is a perfect example of how customer feedback advances design.

PARSTAT® 4000A

Specifications

Compliance Voltage	± 48 V
Polarization Voltage	± 10 V
DC Voltage Accuracy (Measured)	±0.025% of reading ±1 mV; impacts every experiment
DC Voltage Accuracy (Applied)	±0.025% of setting ±1 mV; impacts all potentiostatic experiments
Input Impedance of Electrometer	1E14 Ohms (100 TΩ) Typical
EIS Frequency Range	10 MHz to 10 µHz
Maximum Current	4-Amps 20-Amps with option
Lowest Current Range	40-pA (40E-12 Amps) 80-fA (80E-15 Amps) with option
Dynamic Current Range (mA/pA)	100
Data Acquisition Rate	1000 kS/sec (1 µs time base resolution)
EIS Bandwidth	10 MHz
Functionality	All techniques, including FRA for EIS
Software Control	VersaStudio and VersaStudio Developer's Kit (VDK)
Connectivity	USB

Building on the strengths of the PARSTAT 4000, including market leading compliance voltage, range of current measurement, and data acquisition rate the updated PARSTAT 4000A has improved DC Voltage Accuracy. This allows superior control in potentiostatic mode and measurement in galvanostatic mode thus impacting every electrochemical experiment by improving either the intended signal applied to the cell or the measured response obtained. The application that benefits most directly from this is the study of low impedance devices (batteries, capacitors, fuel cells).

In addition to improved DC accuracy the PARSTAT 4000A also adds improved EIS accuracy as well as bandwidth. As EIS results are interpreted through equivalent circuit analysis, improved EIS accuracy provides superior characterization of series resistance, double layer capacitance and charge transfer resistance. The increased bandwidth, to 10 MHz, provides for the ability to measure electronic and ionic conductivity for the purpose of evaluating solid state battery materials. The PARSTAT4000A includes hardware-based, user-selectable Stability Modes for increased compatibility with a wide range of electrochemical cells and experiments.

feature	allows for
DC Voltage Accuracy Measured & Applied	• **4 times better voltage accuracy at 4.3 V** **The nominal voltage of energy-storage devices under test is increasing with new materials and stack configurations. The impedance of these devices is also being driven lower through engineering advancements. This combination of high voltage and low impedance showcases the impact of voltage accuracy.** **The PARSTAT 4000A (specified at <±1 mV ±0.025% of reading) has an error band at 4.3 Volts of only 2 mV....which is 4-times better than other systems.** **The voltage error band of other systems generates 11x unintended DC current than that of the PARSTAT4000A in common experiments.**

VersaStudio software

Versatile Software with Powerful Research Capabilities

The PARSTAT 3000A and PARSTAT 4000A operate within the popular VersaStudio software which provides access to a full suite of electrochemical tests. This range of experiments is specifically designed to assist researchers in Energy Storage, Corrosion, and Physical Electrochemistry, including Voltammetry, Pulsing, and EIS applications.

VersaStudio software provides full access to the capabilities of the PARSTAT Series, including the ultra low current option and high current boosters, 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
- Advanced actions such as message prompts, external applications prompts, and email notification are available to add even more flexibility and functionality to VersaStudio
- Powerful yet easy Copy/Paste and Export capabilities for custom data analysis and/or data presentation outside of VersaStudio
- Display data in tabbed single or multiple graph windows 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 Capacity vs. Cycle Number, Coulombic efficiency, Corrosion Rate vs. Time, and EC Noise
- Circle fitting for basic EIS data analysis, and 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 Software option package
- Cut, Copy, Paste experiment actions for more convenient setup of experimental sequences

VersaStudio provides a comprehensive range of facilities, yet is incredibly easy to use making it the ideal software for both novice and advanced users. Basic experiments such as cyclic voltammetry are up and running with surprisingly few menu entries. 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.

Energy

The energy systems package provides techniques designed for testing and research of energy devices such as batteries, supercapacitors, and fuel cells. These techniques include:

- Static (constant) applied techniques for current, potential, power, and resistance aimed at charging/ discharging energy devices
- Cyclic Charge/Discharge (CCD) techniques which can be easily modified for addition or subtraction of different actions
- Data acquisition variables to control the volume of data acquired, and stop limits for actions that include Potential (V), Current (A), and Capacity (Ah)

Corrosion

The corrosion system package provides a range of DC electrochemical measurement techniques that are of particular importance for the corrosion scientist investigating coatings, rebar corrosion, inhibitors, biomedical implants etc. These techniques include:

- Coatings and Inhibitor Evaluation: EIS, Rp-versus-Time, Loop functions
- Uniform Corrosion: Linear Polarization (LPR), Split LPR, Tafel
- Non-uniform Corrosion: Cyclic Non-uniform Corrosion: Cyclic Polarization, Potentiodynamic
- Galvanic Couples: Galvanic Corrosion, Electrochemical Noise in ZRA mode
- Disbondment: Potentiostatic, Galvanostatic

Impedance

Electrochemical Impedance Spectroscopy (EIS) capabilities are standard on all PARSTAT potentiostats. This provides a range of fully integrated techniques for studying the impedance of electrochemical cells, sensors, batteries / fuel cells, corrosion / coatings etc.

- Potentiostatic EIS - widely used for the analysis of electrochemical, battery and corrosion cells providing information on electrode kinetics, diffusion and mass transfer
- Galvanostatic EIS - particularly useful for characterizing batteries and fuel cells under DC current load conditions
- EIS analysis of batteries and fuel cells using the high current capability or external power boosters
- Automatic charge / discharge / EIS experiment sequencing for battery, supercapacitor and fuel cell lifetime investigations
- Automatic sequencing of loop, EIS and delay steps to investigate trends of impedance over time, (e.g. the development of corrosion induced defects in a coating)
- Automatic sequencing of EIS and linear polarization resistance (LPR) techniques to verify corrosion rate data and to provide impedance analysis of corrosion mechanisms

Physical Electrochemistry

The advanced voltammetry package provides a range of scan, step and pulse techniques that are of importance in analytical electrochemistry, microelectrode studies, sensor research, electrodeposition and battery/fuel cell analysis.

- Recurrent pulse techniques - used in battery / fuel cell analysis (including equivalent series resistance ESR analysis and GSM / CDMA mobile phone pulse test applications). Also used in electrodeposition applications
- Chronoamperometry and chronopotentiometry used in many electrochemical applications
- Control of power booster options for testing high power cells for electrodeposition and energy storage applications
- Multi-Vertex Scan technique for application of a linear ramp voltage with up to three separate vertices
- Normal and differential pulse voltammetry - used in analytical electrochemistry applications

Voltammetry / Pulse

- 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)
- Multi-Vertex Scan
- Chronoamperometry
- Chronopotentiometry
- Chronocoulometry
- Fast Potential Pulses
- Fast Galvanic Pulses
- Recurrent Potential Pulses
- Recurrent Galvanic Pulses
- Square Wave Voltammetry
- Differential Pulse Voltammetry
- Normal Pulse Voltammetry
- Reverse Normal Pulse Voltammetry

Corrosion

- Zero Resistance Ammeter (ZRA)
- Electrochemical Noise (EN)
- Galvanic Corrosion
- Cyclic Polarization
- Linear Polarization
- Tafel
- Potentiostatic
- Potentiodynamic
- Galvanostatic
- Galvanodynamic
- Split LPR
- Galvanic Control LPR

Energy

- Constant Current
- Constant Potential
- Constant Resistance
- Constant Power
- Current CCDPL
- Charge-Discharge
- CC-CV
- GITT
- PITT
- Power CCD
- Resistance CCD

EIS

- Potentiostatic EIS
- Galvanostatic EIS
- Mott-Schottky

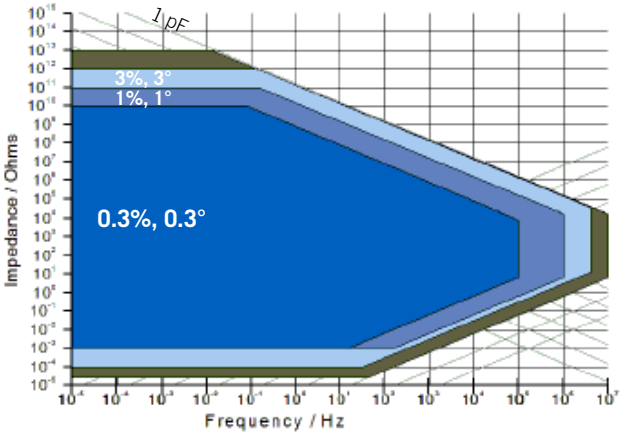
Sequence

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

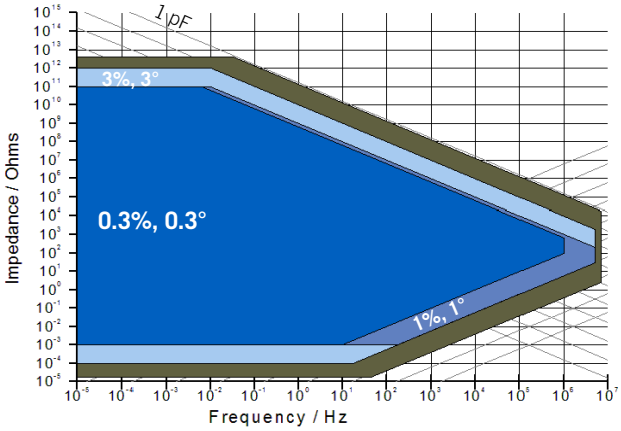
Pre-experiment

- Condition
- Deposition
- Equilibration
- Purge
- iR Determination

PARSTAT 4000A contour map



PARSTAT 3000A contour map



Accessories

Battery Holders

Through our collaboration with the world's leading battery cycler manufacturer, MACCOR, we are proud to offer battery holders designed specifically to connect directly to any of the PARSTAT's completely replacing the cell cable. This clean design provides for a cleaner lab area, cleaner applied signal and ultimately a cleaner measured response. These holders are designed in a slim form factor to allow installation on the PARSTAT front cover and are available in common/standard form factors including - 18650, AA, AAA, coin cell (2032) and a flexible screw-based design for custom cell geometries.

Model Number	Option
BUTTONCELL1	Button Cell Battery Holder PARSTAT4000A
18650BATT1	18650 Battery Holder PARSTAT4000A
AABATT1	AA Battery Holder PARSTAT4000A
AAABATT1	AAA Battery Holder PARSTAT4000A
2032BATT1	Coin Cell Battery Holder PARSTAT4000A
BUTTONCELL2	Button Cell Battery Holder PARSTAT3000A
18650BATT2	18650 Battery Holder PARSTAT3000A
AABATT2	AA Battery Holder PARSTAT3000A
AAABATT3	AAA Battery Holder PARSTAT3000A
2032BATT2	Coin Cell Battery Holder PARSTAT3000A

Current Expansion Options

PARSTAT 4000A Power Boosters

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 (factory installation required) at a later time.

Model Number	Option
20A/PARSTAT 4000	20 A Current Booster Option

*10 A / 20 V and 8 A / 50 V available

Low Current Interface

The Low Current Interface is ideal for applications requiring ultimate low current accuracy and resolution. Applications such as ultra-microelectrodes, coatings research, corrosion testing of bio-implants, and sensor research are all areas where greater current sensitivity may be needed.

Model Number	Option
VersaSTAT-LC	Low Current Interface

Princeton Applied Research
www.princetonappliedresearch.com

USA
Tel: (865) 425-1289
or (865) 482-4411
Fax: (865) 481-2410

Europe
Tel: +44 (0)1252 556800
Fax: +44 (0)1252 556899

Please see our website for a complete list of our global offices and authorized agents