

# PARSTAT®

Reference Grade Electrochemical Workstations

Energy Storage ■ Physical Electrochemistry ■ Corrosion

potentiostat | galvanostat | EIS



# Defining 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 3000

- 6 wire function for simultaneous DC and EIS measurements of Anode/Cathode or a single cell during stack testing
- 7 MHz EIS Frequency range
- Unmatched EIS accuracy in its class
- Small form factor for space conscious laboratories

## PARSTAT 4000+

- Unmatched polarization voltage for the most challenging corrosion research (48V)
- Market leading native current range (40 pA – 4 A)
- 10 MHz EIS Frequency Range for electrochemical studies of high-end materials analysis
- Superior DC resolution for the corrosion scientist conducting static corrosion measurements

**PARSTAT®**  
Reference Grade  
Electrochemical Workstations

# PARSTAT® 3000

potentiostat/galvanostat/EIS

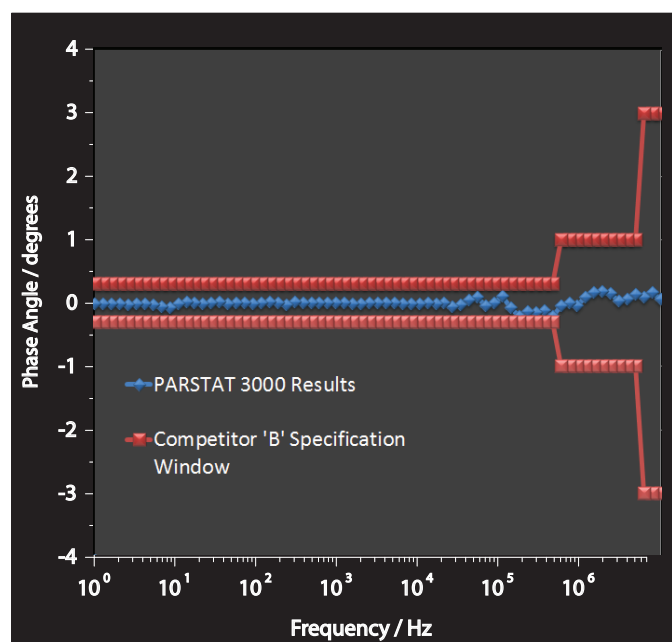
The PARSTAT 3000 represents Princeton Applied Research's latest electrochemical workstation offering for the dedicated electrochemistry researcher. This state-of-the-art potentiostat/galvanostat/FRA comes standard with more functionality than any competitive instrument in its class. With 30 V of both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

To this, the PARSTAT 3000 adds impressive EIS accuracy, with the built-in FRA, across a frequency range of 10  $\mu$ Hz 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 3000 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 3000, VersaStudio, is Princeton Applied Research's comprehensive research electrochemistry package and comes standard with our complete suite of electrochemical tests.



PARSTAT 3000 Phase Angle impedance plot on a 100  $\Omega$  resistor using standard cable.

# PARSTAT® 3000

## Specifications



Compliance Voltage	± 30 V
Polarization Voltage	± 30 V
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	Selectable (Grounded or Floating)

The PARSTAT 3000 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 3000 becomes the ideal electrochemistry workstation for your laboratory. Where other potentiostats require multiple costly options to match the same functionality, the PARSTAT 3000 is designed as standard to maintain bandwidth and accuracy throughout the range of measurement.

feature

allows for



**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

Allows the study of Pb-Acid batteries

Large voltage fields for electrophoretic deposition

Anodization of Titanium or materials that form robust oxides

**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® 4000+

potentiostat/galvanostat/EIS

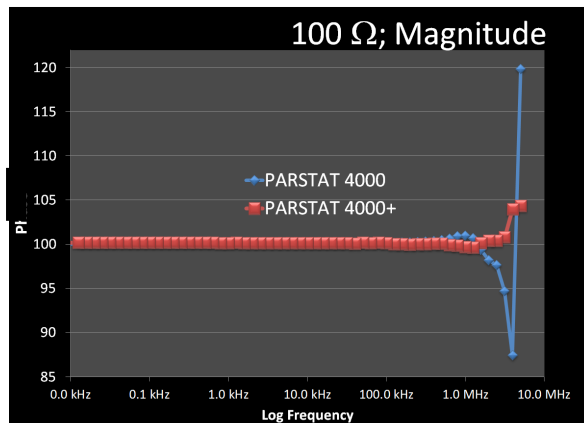


The PARSTAT 4000+ represents the culmination of decades of experience in design and manufacture of research grade potentiostats. Designed to be a complete, single box solution, the PARSTAT 4000+ represents the latest flagship of our proud PARSTAT line of electrochemical workstations. Building on the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

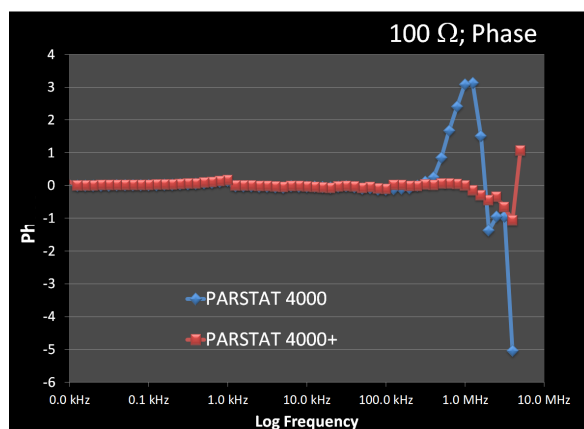
The PARSTAT 4000+ expands the possibilities of your research and prepares you for future expansion as the scope of your research inevitably increases. As the only electrochemical workstation available with the ability to provide you with a 4 A maximum current range, 40 pA minimum current range, 48 V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

The foundation of the PARSTAT 4000+ 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 4000+ provides everything needed without requiring you to buy additional components. For those researchers in the field truly pushing boundaries, however, the PARSTAT 4000+ is compatible with the full Princeton Applied Research line of options to help you reach truly extreme functionality.

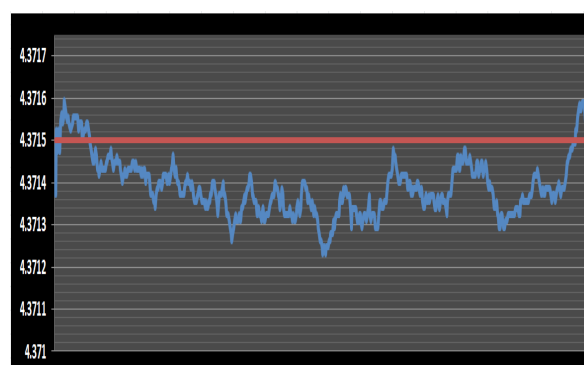
For the materials scientist the PARSTAT 4000+ now offers best in class EIS bandwidth to 10 MHz as well as unrivalled magnitude and phase performance over a wide range of frequency and impedance.



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



PARSTAT 4000+ Phase Angle impedance plot on a 100 Ω resistor using standard cable.



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

# PARSTAT® 4000+

## 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	1E13 Ohms (10 TΩ)
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 4000+ 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 4000+ 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.

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 4000+ (specified at  $\pm 1 \text{ mV} \pm 0.025\%$  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 PARSTAT4000-PLUS in common experiments.

# VersaStudio software

## Versatile Software with Powerful Research Capabilities

The PARSTAT 3000 and PARSTAT 4000+ 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 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 Capacity vs. Cycle Number, 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

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, super capacitors, 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 including EIS if system is properly equipped
- Data acquisition variables to control the volume of data acquired, and stop limits for actions that include Potential (V), Current (A), and Capacity (Ah)

## 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

## 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

## Physical Electrochemistry

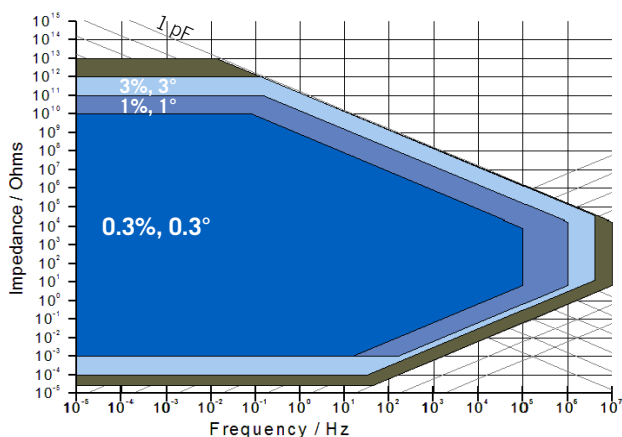


The advanced voltammetry package provides a range of scan, step and pulse techniques that are of importance in analytical electrochemistry, microelectrode studies, sensor research, electrodeposition and battery/fuel cell analysis.

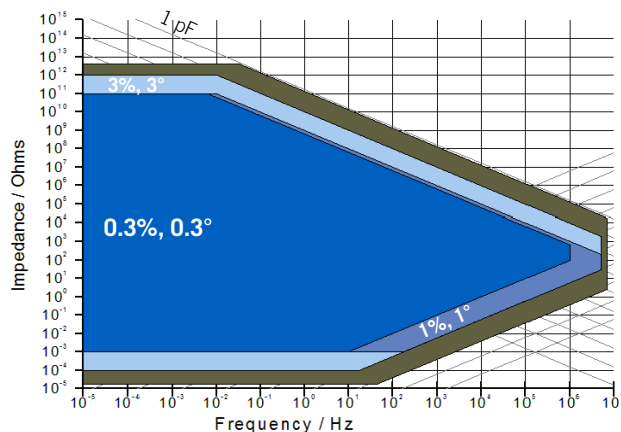
- Recurrent pulse techniques - used in battery / fuel cell analysis (including equivalent series resistance ESR analysis and GSM / CDMA mobile phone pulse test applications). Also used in electrodeposition applications
- Chronoamperometry and chronopotentiometry used in many electrochemical applications
- 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
Corrosion	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
	Zero Resistance Ammeter (ZRA)
Energy	Electrochemical Noise (EN)
	Galvanic Corrosion
	Cyclic Polarization
	Linear Polarization
	Tafel
	Potentiostatic
	Potentiodynamic
	Galvanostatic
	Galvanodynamic
	Split LPR
EIS	Galvanic Control LPR
	Constant Current
	Constant Potential
	Constant Resistance
	Constant Power
	Current CCDPL
	Charge-Discharge
	CC-CV
	GITT
	PITT
Sequence	Power CCD
	Resistance CCD
	Potentiostatic EIS
	Galvanostatic EIS
	Mott-Schottky
	Loop
	Time Delay
	Message Prompt
	Measure OC
	Auxiliary Interface
Pre-experiment	Run External Application
	DAC Output Control
	Email
	Auto Current Range Setup
	Condition
	Deposition
	Equilibration
	Purge
	iR Determination

## PARSTAT 4000+ contour map



## PARSTAT 3000 contour map



## Accessories

### Battery Holders **MACCOR**

Through our collaboration with the world's leading battery cyclor 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 PARSTAT4000+
18650BATT1	18650 Battery Holder PARSTAT4000+
AABATT1	AA Battery Holder PARSTAT4000+
AAABATT1	AAA Battery Holder PARSTAT4000+
2032BATT1	Coin Cell Battery Holder PARSTAT4000+
BUTTONCELL2	Button Cell Battery Holder PARSTAT3000
18650BATT2	18650 Battery Holder PARSTAT3000
AABATT2	AA Battery Holder PARSTAT3000
AAABATT3	AAA Battery Holder PARSTAT3000
2032BATT2	Coin Cell Battery Holder PARSTAT3000

## Current Expansion Options

### PARSTAT 4000+ 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

### PARSTAT 4000+ 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



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