



# Reference 3000™

Potentiostat/Galvanostat/ZRA

- High Power
- Fully Featured
- High Accuracy
- High Speed
- Versatile Software
- Electrically Isolated

*Premium Performance for  
High Power Electrochemistry*



C3 PROZESS- UND  
ANALYSETECHNIK GmbH

**GAMRY**  
INSTRUMENTS

*The Innovation You Expect.*



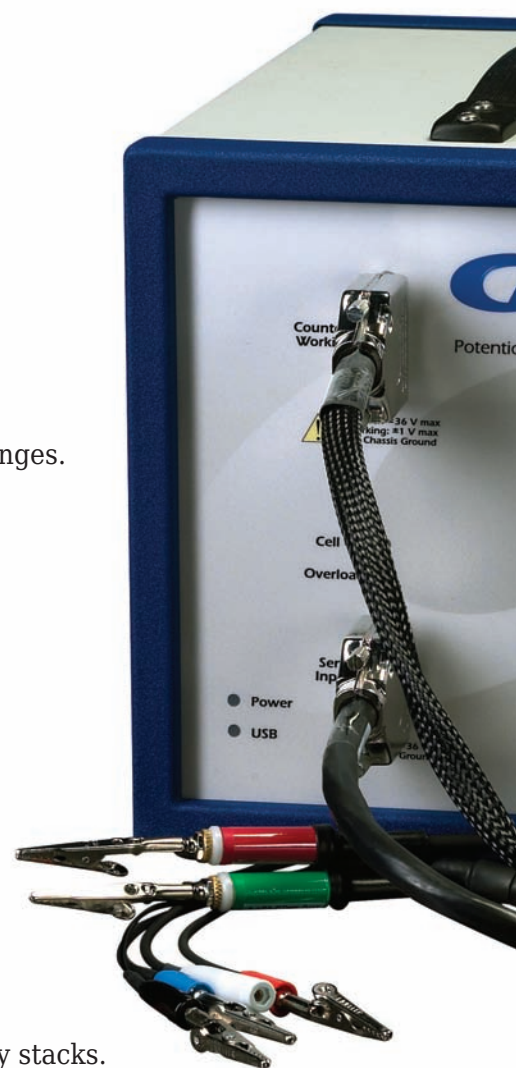
# Reference 3000™

## Outstanding Capability Out of the Box...

- **Dual Power Mode**  
3A/15V compliance or 1.5A/32V compliance.
- **Noise and Ripple <10  $\mu$ V rms**  
Lowest noise specification of any commercial potentiostat.
- **Wide Range Current Measurement**  
11 decade current ranges from 3A to 300 pA.
- **3 Decade Dynamic Current Range Boost**  
DC Subtraction and x100 Gain for 3 pA full-scale.
- **100 aA ( $1 \times 10^{-16}$  Amps) Current Resolution**  
For demanding low-current experiments.
- **3½ Decade Dynamic Voltage Measurement**  
DC Subtraction and x400 Gain for 30 mV to 12V full-scale ranges.
- **Electrical Isolation**  
Easy operation with grounded electrodes.  
Isolated power and communications.
- **Outstanding Front-End Specs for Accuracy and Speed**  
>10<sup>14</sup>  $\Omega$  Input Impedance  
<0.2 pF Input Capacitance  
<10 pA Input Current
- **High Performance EIS**  
Built-in EIS performs from 10  $\mu$ Hz to 1 MHz with < 1% error.
- **Multichannel Potentiostat Systems**  
Up to 24 Reference 3000s run from one computer.
- **Secondary High Voltage, Full Compliance, Electrometer**  
32 V compliance for controlling and measuring multicell battery stacks.

## ...And Powerful Options!

- **Optional 8 Channel Auxiliary Electrometer**  
For measuring voltages within multicell stacks or multiple voltages in a single cell.
- **Add-On 30 Amp Current Booster**  
Develop the newest generation of electrochemical power devices. Measure impedances to 10  $\mu$ Ohms or better!



# Overview



The Reference 3000 continues Gamry's tradition of building *high performance, affordable potentiostat/galvanostat/ZRAs* for demanding laboratory applications.

With ample compliance voltage and *11 decades of current measurement* from 3A full scale to 300 pA (to 3 pA with 100X gain), the Reference 3000 handles the full range of laboratory electrochemistry.

The Reference 3000 can operate as a potentiostat, galvanostat, ZRA, or FRA. It handles 2, 3, and 4 electrode measurements with ease, even dual reference electrode membrane measurements.

Like our Reference 600 potentiostat, the Reference 3000 maintains the high level of functionality you need in a modern lab.

- Electrical Isolation from Earth Ground
- A 3rd channel Auxiliary Input with Full Gain and Offset Control
- Thermocouple Temperature Measurement
- Both Current Interrupt and Positive Feedback iR Compensation
- Embedded Floating Point CPU
- Auxiliary Analog Output and Digital I/O
- External Signal Input, I&E Monitor Outputs



Weighing in at only 7 kg, the Reference 3000 packs tremendous capability into a *small footprint*. It easily interfaces to your lab computer or notebook via an industry standard USB cable.

## The Reference 3000 Handles High Current Applications Like...

Batteries	Electroplating
Fuel Cells	Electrowinning
Super Caps	Industrial Electrolysis

## ...and Low Current Ones Like...

Corrosion	Bioelectrochemistry
Sensors	Physical Electrochemistry
Coatings	Microelectrode Studies

## ...and Everything In Between!

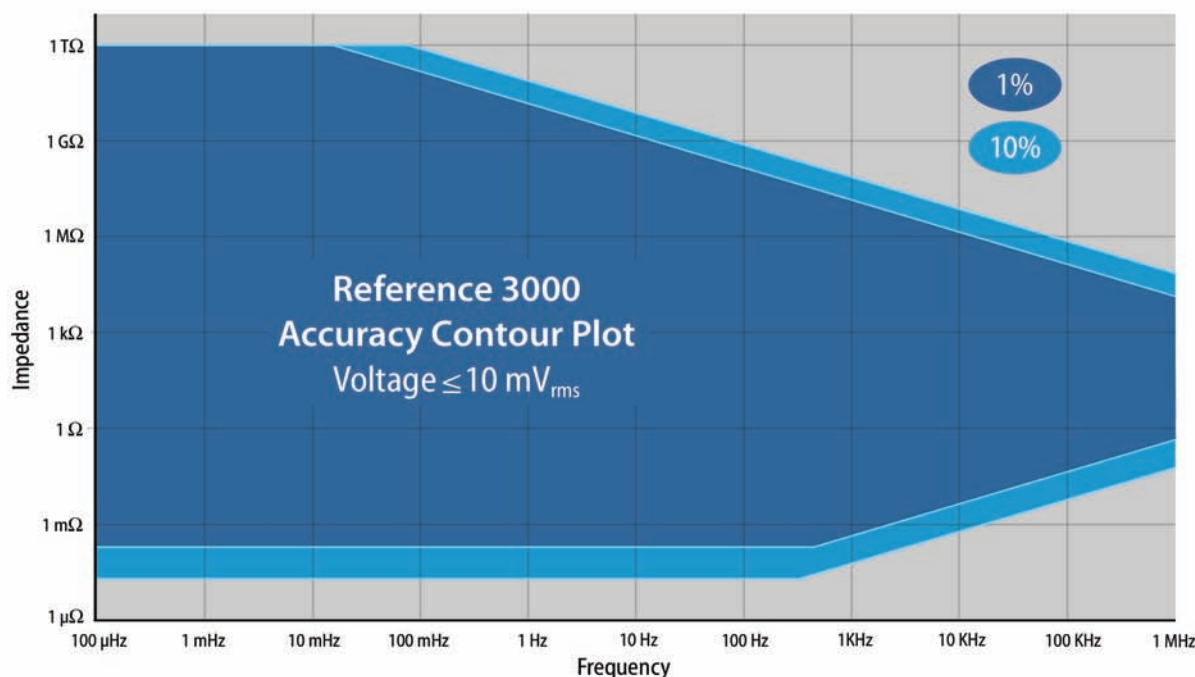




# Accurate

In the Reference 3000 accuracy has been designed in from the start. From the alligator clips to data analysis, we've paid attention to every design detail that can affect your results.

The result: an accuracy contour plot in a high current potentiostat that defies comparison.



## EIS Incorporated

Every Reference 3000 is equipped to perform EIS:

- With Direct Digital Synthesis for pure single sine signals above 10 Hz.
- With Dual DAC Synthesis from DC to 1 KHz for single sine and rapid multisine techniques.
- With Offset and Gain for detecting small AC signals on top of big DC backgrounds.

Finally, one instrument that can address the challenge of impedance measurement from Hi-Z coatings to Lo-Z supercapacitors!

## High Resolution

All of the data converters in the Reference 3000 are 16-bit devices, processing at up to 300 kHz for fast waveforms. Add offset and gain circuitry to get the equivalent of 22-bit resolution! And multisample averaging yields even higher resolution.

## Pushing the Envelope

Utilizing low inductance layout, cables, and connectors, the Reference 3000 pushes the inductive limit well past ordinary potentiostats. Coupled with Gamry's tradition of designing high impedance potentiostats, the Reference 3000 also performs superbly for low current.

Together these yield a wide range of accurate measurements, from 5 decades at 1 MHz to 15 decades at DC.

## Low Noise

Thanks to a well-designed electronics, the Reference 3000 enjoys an intrinsic noise level of  $<10 \mu\text{V rms}$ ! It further reduces the noise levels to  $<1 \mu\text{V rms}$  by oversampling and averaging. In comparison to other commercial potentiostats, this noise level is astounding.

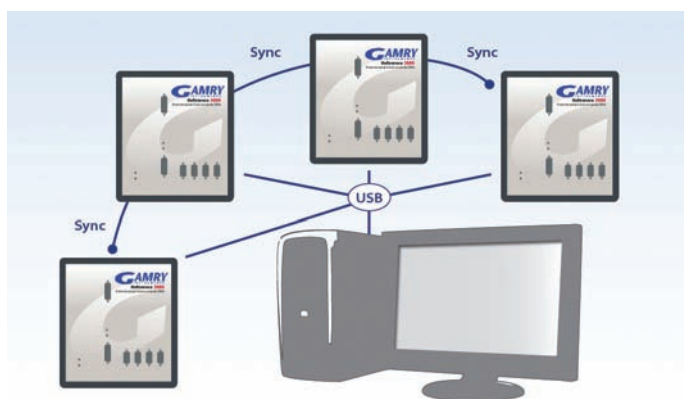
# Innovative



## Clustered Potentiostats

Using a USB hub, you can configure many Reference 3000s into a MultEchem™ Electrochemistry System. Up to 24 Reference 3000s can be operated by one computer, each running a different experiment.

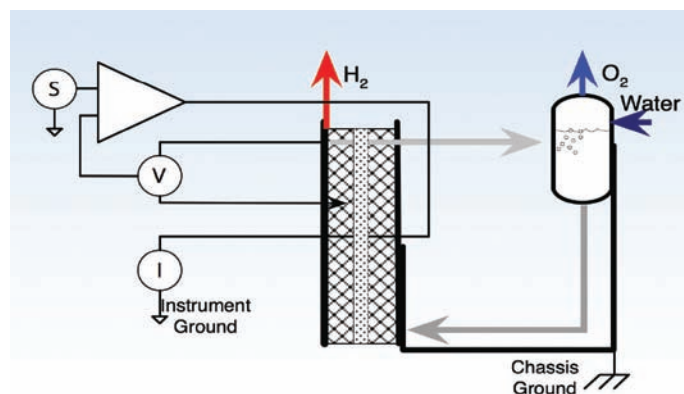
Unlike Big-Box multichannel potentiostats, the MultEchem is designed to *put each instrument next to the cell it controls* for better performance and cable layout. But to the operator, it is one instrument cluster with one user interface.



## Electrical Isolation

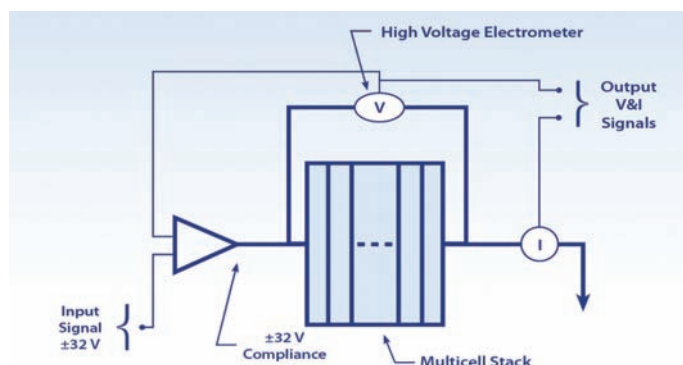
Like other potentiostats from Gamry, the Reference 3000 is electrically isolated from AC power mains. Our transformers are designed to minimize capacitive coupling and DC Leakage for maximum isolation from earth ground.

On top of that, the Reference 3000 offers isolated digital I/O, and isolated USB allowing communications to your computer and to external devices while still floating! Even in a MultEchem cluster, electrical isolation is maintained.



## High Voltage Electrometer

Continuing Gamry's long tradition of innovation, the Reference 3000 adds new functionality for multicell battery stacks. Not limited to the input voltage of the normal electrometer, you can use the High Voltage Electrometer to measure and control stack voltages *up to 32 V*. Coupled with the 8 channel Aux Electrometer, you now can deal with cells individually and the stack as a whole.

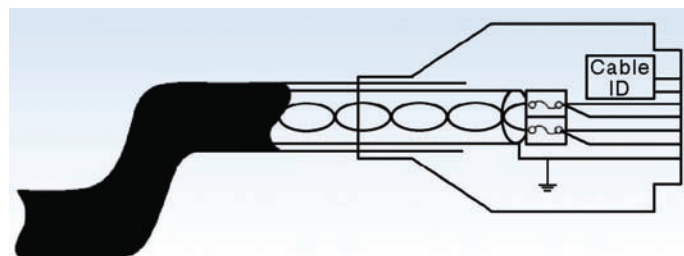


## Smart Cables

Standard Reference 3000 cables are internally coded and recognized by the instrument for the best performance.

Calibration data is stored inside the instrument and not in the computer so you can move an instrument from one host to another without recalibrating.

Each cable set is separately calibrated so if you use several types of cell cables, the Reference 3000 allows you to change cables without recalibrating.



# Versatile



## 8 Channel Auxiliary Electrometer Option

### Multipoint Measurements...

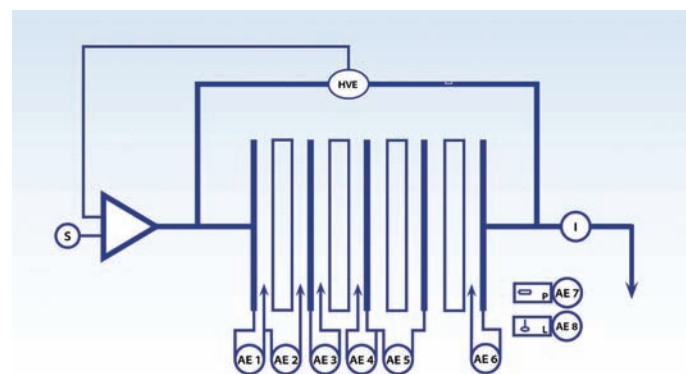
The Aux Electrometer Option brings an enticing array of new measurement capabilities to the Reference 3000.

We added *8 additional differential electrometers* which can be used in separate cells in a stack to monitor:

- half-cell potentials
- whole cells
- separator voltage drops
- ancillary process values.

### ...With Wide Dynamic Range...

Each Aux Electrometer channel measures an independent  $\pm 5$  Volt differential span within the compliance voltage range, from +32 to -32 V



### ...And EIS, too...

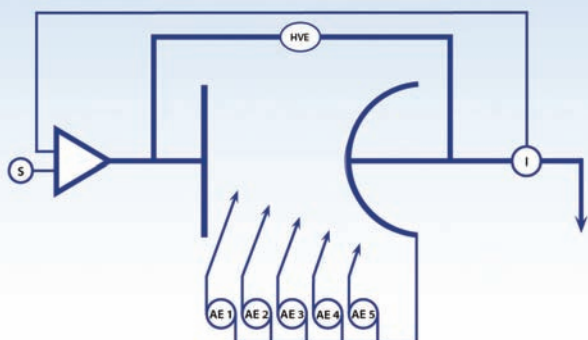
Gamry's Aux Electrometer technology doesn't stop with DC signal. You can measure EIS signals up to 300 kHz *on each electrometer*.

Imagine being able to acquire independent Electrochemical Impedance Spectra, *concurrently*, on 8 cells in a multicell stack. You can see which cell is going bad, when, and why.

### ...Without Compromise!

The Aux Electrometer measurements piggy-back on the Aux channel of the Reference 3000. Normal instrument functions are still operational and making measurements.

*It's like having 8 more windows into your system. Imagine the questions you can answer!*





# Powerful



## Reference 30K Booster

### High Power Electrochemistry...

Whether you're working with Energy Storage and Conversion (E.S.C.) systems like fuel cells, advanced batteries, super caps, or with traditional high power electrochemical systems like plating and industrial electrolysis, the Reference 30K Booster gives you current without compromise.

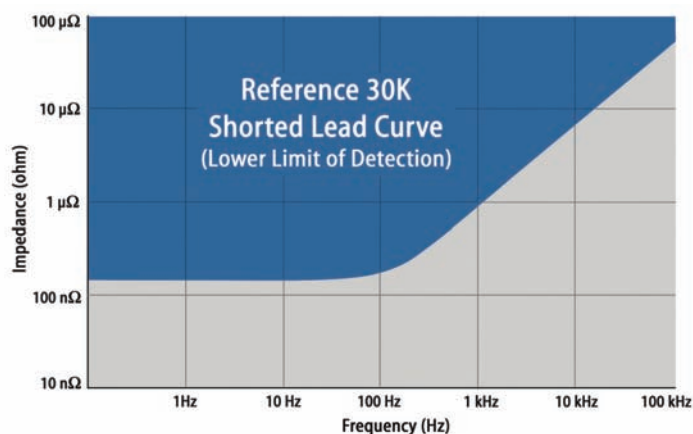
The Reference 30K Booster adds an additional current range to a Reference 3000 providing for currents from  $+30\text{ A}$  to  $-30\text{ A}$  at voltages up to  $+20\text{ V}$ .

The  $-2.5\text{ V}$  lower voltage limit allows you to completely discharge a battery and even reverse its polarity. The Reference 3000/Reference 30K Booster combo allows 5 selectable current ranges from  $\pm 3\text{ mA}$  to  $\pm 30\text{ A}$ .

OPERATION	
Modes	Pstat, Gstat, ZRA, FRA
Agency Approval	CE
DC CHARACTERISTICS	
Compliance Voltage	$+20\text{ V}$ , $-2.5\text{ V}$
Output Current	$\pm 30\text{ A}$
Accuracy	$\pm 0.3\%$ of range
Power Dissipation	600 W to + rail 750 W to - rail
AC CHARACTERISTICS	
Slew Rate	20 V/ $\mu\text{S}$ (max)
Unity Gain BW (typ)	500 kHz (min)

### ...Without Sacrificing Speed and Accuracy...

Developing modern E.S.C. devices requires speed as well as power. The Reference 30K Booster satisfies this requirement with a bandwidth of up to 500 kHz and EIS measurements over 200 kHz, with an accuracy of  $>99\%$ . So what do speed and accuracy give you? The ability to measure the next generation of low impedance devices, down to  $10\text{ }\mu\text{Ohm}$ .



### ...Or Utility.

The Reference 30K Booster uses all the capability of the Reference 3000 including *normal and high voltage electrometers*, aux channel, digital IO, control modes, and so on.

For multicell/multiprobe testing, the Booster is fully compatible with the Ref 3000 Aux Electrometer option.

# Detail



## System Information

The Reference 3000 is shipped with the Gamry Framework and Echem Analyst Software, a Hardware Manual, an Installation Manual, a Universal Dummy Cell 4, one 60 cm Standard Cell Cable Set, and a Gamry Mouse Pad. When shipped with an Aux Electrometer, a 90 cm AE Cable Set is also included. The Reference 3000™ is protected by a 2-year factory service warranty.

## Available Configurations

992- 00051	Ref. 3000 Potentiostat/Galvanostat/ZRA
992- 00055	Ref. 3000 Potentiostat/Galvanostat/ZRA w/Aux Electrometer
992- 00056	Aux Electrometer upgrade to Ref. 3000
992- [00085, 00086]	Ref. 30K Booster [120V, 230V]

## Available Cell Cables

985- [00111, 00112, 00113]	Cell Cable Set [60 cm, 1.5 m, 3 m]
990- [00244, 00251, 00252]	Aux Electrometer Cable Sets [90 cm, 1.5 m, 3 m]

## Front Panel

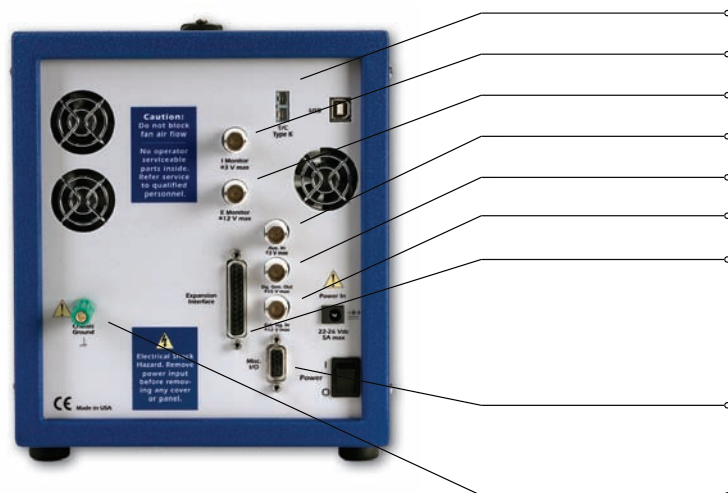
Current Cable: Low Inductance Working/Counter  
Cell: Green LED indicates that the cell is ON  
Overload: Red LED indicates an out-of-range  
Sense Cable:

System Ground  
Working Sense  
Reference  
Counter Sense

Current: Blue LED indicates that the power is ON  
USB: Red/Green LED Indicates USB bus activity  
Aux Electrometer: 8 Differential Channels



## Back Panel



Type K Thermocouple Input  
I Monitor: Proportional to WE current Output  
E Monitor: WE voltage vs RE Output  
3<sup>rd</sup> Channel (Aux) Input  
Internal Signal Generator Output  
External Signal Generator Input  
Expansion Connector to 30 K Booster  
Miscellaneous I/O Connector  
software-controlled analog output  
input & output acquisition triggers  
4 software-controlled digital inputs  
4 software-controlled digital outputs  
Instrument Ground

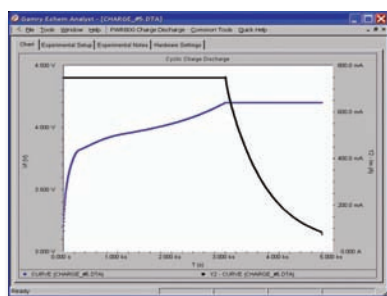


# Software Solutions



## Electrochemical Software for the Reference 3000

Gamry offers a *complete library* of electrochemical application software for the Reference 3000. Electrochemical experiments are performed in the Gamry Framework™ and the data are analyzed in the Gamry Echem Analyst™.

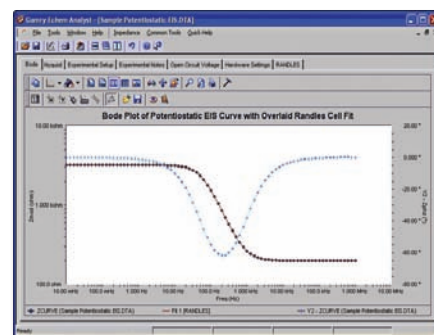


## PWR800™ Electrochemical Energy Software

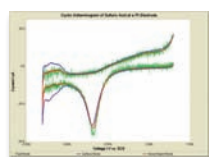
The PWR800 software package provides standard techniques used for testing and characterizing energy storage and conversion devices and materials. It is fully compatible with the auxiliary electrometer for battery/supercapacitor/fuel cell experiments. We've included Power CV, Charge, Discharge, Cyclic Charge/Discharge, and other common high current test protocols. Of course, you can use sequencing to create specialized combinations of tests as well.

## EIS300 Electrochemical Impedance Spectroscopy

EIS is a powerful tool for a variety of applications, and is an excellent compliment to the PWR800 software. Gamry has civilized EIS - it's easy to use, it's compact, and it's very affordable. Gamry offers a wide range of EIS techniques, including potentiostatic, galvanostatic, and hybrid control modes. We've also added OptiEIS™, our multiple sine wave approach for fast EIS. EIS300 is fully compatible with the Reference 3000 Aux Electrometer running EIS on up to 8 locations in a cell or stack!



## Also From Gamry's Extensive Software Library...



**PHE200** Physical Electrochemistry- general electrochemical research package.

**PV220** Pulse Voltammetry- standard and customizable pulse experiments.

**DC105** DC Corrosion - all the standard techniques for corrosion testing.

**ESA410** Electrochemical Signal Analyzer - EN signal acquisition and analysis.

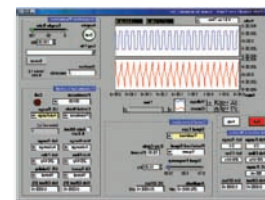
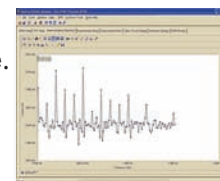


**EN120™** Electrochemical Noise- simple noise software

**EFM140™** EFM- Simultaneous Tafel constants and corrosion rate.

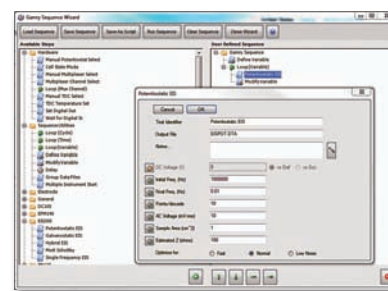
**CPT110** Critical Pitting Temperature- ASTM standard test.

**VFP600** Virtual Front Panel - basic control, very low cost.



## Flexibility Through Software: Scripting, Sequencing and the Toolkit

While the Reference 3000 works with a fully featured compliment of software techniques, we also allow virtually unlimited flexibility in creating unique tests using our powerful Explain™ Scripting language. A simplified automation tool, the Sequence Wizard™, can be used to join together various Explain components. And finally, for the OEM and developer, we provide COM toolkits for basic operation, advanced DC testing, and advanced AC testing. These components can be inserted into your own unique software.



*And if that isn't enough, talk to Gamry's software engineering experts about custom applications.*

# Reference 3000 Specifications

SYSTEM	
Control Modes	Pstat, Gstat, ZRA, FRA
Cell Connections	2, 3 or 4 electrode
Isolation	Yes
Max. Current	±3 A
Current Ranges	11 (300pA-3A)
Current Ranges (including internal gain)	13(3pA-3A)
Min. Voltage Resolution	1 $\mu$ V
Min. Current Resolution	100 aA
Rise Time	<250 ns
Noise and Ripple	<10 $\mu$ V rms
Min. Time Base	3.333 $\mu$ s
Max. Time Base	715 s
Min. Potential Step	12.5 $\mu$ V
A/Digital Converters	16 bit
EIS MEASUREMENT	
Frequency Range	10 $\mu$ Hz - 1 MHz
Impedance Accuracy	See accuracy contour map
Max AC Amplitude	1425 mV rms
Min AC Amplitude	2.75 $\mu$ V rms
CONTROL AMP	
Compliance Voltage	>±32 V, at 1.5 A fs >±15 V at 3.0 A fs
Output Current	>±3 A
Speed Settings	5
Unity Gain Bandwidth (typical)	980, 260, 40, 4, 0.4 kHz
iR COMPENSATION	
Current Interrupt	Yes
Positive Feedback	Yes
Minimum interrupt time	33 $\mu$ s
Maximum interrupt time	715 s
AUXILIARY D/A OUTPUT	
Range	0-4 V
Resolution	1 mV
SIZE	
Weight	7 kg
Dimensions	20 x 21 x 28 cm

AUXILIARY A/D INPUT	
Range	±3 V
Resolution	0.1 mV
Input Impedance	100 k $\Omega$ or >10 G $\Omega$
HIGH RESOLUTION ELECTROMETER	
Max. Measured Potential	±11 V
Input Impedance	>10 <sup>14</sup> $\Omega$    < 0.2 pF
Input Current	<10 pA
Bandwidth (typical)	> 15 MHz at -3 dB
Common Mode Rejection	>80 dB (3 Hz), >60 dB (1 MHz)
Accuracy	± 1 mV ±0.3% of reading
Full-Scale Ranges	± 12 V, 3 V, 300 mV, 30 mV
Resolution	400 $\mu$ V, 100 $\mu$ V, 10 $\mu$ V, 1 $\mu$ V
Offset Range	±12 V
HIGH VOLTAGE ELECTROMETER	
Max. Measured Potential	±32 V
Input Impedance	>100 G $\Omega$    < 40 pF
Input Current	<10 pA
Bandwidth (typical)	> 250 KHz (±30 V)
Common Mode Rejection	>80 dB (3 Hz), >60 dB (100 KHz)
Accuracy	± 4 mV ±0.3% of reading
Full-Scale Ranges	± 48 V, 12 V, 1.2 V, 120 mV
Resolution	1.6 mV, 400 $\mu$ V, 40 $\mu$ V, 4 $\mu$ V
Offset Range	±48 V
APPLIED SIGNAL (AS POTENTIOSTAT)	
Accuracy	± 1 mV ±0.2 % of setting
Resolution	12.5 $\mu$ V, 50 $\mu$ V, 200 $\mu$ V/bit
Scan Range	±0.4 V, ±1.6 V, ±6.4V
APPLIED SIGNAL (AS GALVANOSTAT)	
Accuracy	±10 pA ±0.3% of setting
Resolution	0.0033% full-scale/bit
MEASURED CURRENT	
Accuracy	±0.3% range ± 10pA
Resolution	0.0033% full-scale/bit
Bandwidth(-3dB) (Depends on current range)	>10 MHz (3 A-600 $\mu$ A), >1.5 MHz (60 $\mu$ A), >0.15 MHz (6 $\mu$ A)
Post Offset Gain	1, 10, 100
Offset Range	±1X full-scale

Gamry Instruments designs, manufactures and sells a variety of electrochemical instrumentation and accessories that are designed to fit your needs and budget. We are, first and foremost, electrochemists and materials scientists who love creating quality instrumentation, and enjoy seeing it used creatively.



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