Reference 3000
Potentiostat/Galvanostat/ZRA

GAMRY INSTRUMENTS

Instrument Description

The Gamry Instruments Reference 3000™ is a high-performance high-current Potentiostat/Galvanostat/ZRA similar to Gamry's popular Reference 600™. Building on the success of the Reference Family of Gamry Potentiostats, the Reference 3000 was engineered to meet the demands of higher current applications.

The Reference 3000 is a single Potentiostat sensitive enough for research and capable enough for development of your battery, capacitor, or fuel cell. It is smaller and lighter than most comparable potentiostats. Don't let its size fool you -- it offers research grade performance. While the Reference 3000 can apply and measure ampere level currents, it is also an excellent low noise, small signal potentiostat that can work with picoamp currents.

The Reference 3000 can be used with Gamry Instruments' software for all traditional applications of electrochemistry. These include:

- Synthetic Chemistry
- Sensor Development
- Kinetic and Thermodynamic Measurements
- Electrochemical Impedance Spectroscopy
- Corrosion Measurement
- Plating Research
- Analytical Electrochemistry

While the Reference 3000 is a very good general-purpose potentiostat, it was developed to be especially useful in applications for Energy Storage and Conversion (ESC). This field includes development of new chemistries, devices and systems for batteries, fuel cells, and super-capacitors. ESC Systems include stacks of batteries, fuel cells, or super-capacitors. The Reference 3000 can operate stacks with voltages as high as 32 volts.

The Reference 3000 has features useful in ESC testing that are not found in other potentiostats and electrochemical systems. These include:

- A special stack mode that allows measurement and Potentiostatic control of stack voltages up to ± 32 volts.
- Two switchable compliance voltage and compliance current settings. The two settings are ± 32 Volts at ± 1.5 Amps and ± 15 volts at ± 3.0 Amps.
- EIS measurements in potentiostatic or one of two galvanostatic modes – normal and hybrid. In hybrid mode the AC current at each frequency is dynamically adjusted to give a fixed AC voltage.
- An Auxiliary Electrometer option with an array of eight high-voltage differential voltage inputs. These inputs can be used to measure voltages of cells in an ESC stack or measure reference electrodes within one electrochemical cell.
- Optional Low Impedance Cables that can measure cell impedances as low as 100 μΩ.
- Glitch-free transition from Galvanostatic to Potentiostatic control during battery cycling experiments.

Other Reference 3000 features include:

- 11 decade current auto-ranging
- both analog and digital filtering
- a sine wave generator for EIS up to 1 MHz
- electrical isolation from earth ground
- current interrupt iR compensation
- data acquisition as fast as 300,000 pts/sec

A unique Digital Signal Processing (DSP) data acquisition mode allows the Reference 3000 to reject noise from the instrument, the electrochemical cell, and the lab environment. The Reference 3000 can often be used with its cell exposed on a lab bench when other instruments require a cell in a Faraday shield.

The Reference 3000, like all Gamry potentiostats, requires a computer for its use. It interfaces to the computer through a USB connection. Gamry's software currently supports up to eight Reference Family Potentiostats connected to one computer.

Auxiliary Electrometer Option

The Reference 3000 Potentiostat can be equipped with a unique Auxiliary Electrometer option. This factory installed option is especially useful when you need to measure the performance of several individual cells in a multi-cell fuel cell or battery stack.

Each of the eight channels on this option can measure a completely independent voltage. The voltage measurements are fully differential, so voltages at any point in a stack can be measured. Each input can measure a ± 5 volt signal superimposed on a large common mode voltage (a voltage applied to both inputs equally).

The inputs work over the Reference 3000's entire compliance voltage range (either ± 32 volts or ± 15 volts). The input impedance is greater than 10 GΩ -- allowing connection of the inputs to small high impedance reference electrodes or small diameter Luggin probes.

The primary function of the Auxiliary Electrometer is simultaneous measurement of individual cells within a multi-cell battery, fuel cell, or super-capacitor stack. Both the AC and DC performance of the cells can be measured. The stack can be polarized using galvanostatic control, potentiostatic control of a single cell, or potentiostatic control of the stack's overall voltage.

Since the batteries in a simple ESC stack are connected in series, the current flow though each cell is identical. The Reference 3000 always measures this current (which flows between the Counter and Working leads). Since the current through each cell is known, only a measurement of the cell's voltage (using one Auxiliary Electrometer channel) is needed to fully characterize an individual cell.

Each Auxiliary Electrometer channel includes an offset D/A converter and a filter switchable between unfiltered, 5 Hz, and 1 kHz positions. This allows independent offset, filtering, and gain settings on each channel. AC signals for EIS can be measured on a ± 50 mV range with resolution of about 1.6 μV per bit.

The Auxiliary Electrometer option is not restricted to energy storage and conversion applications. Each electrometer input can be used as general-purpose voltage measurement device. You can measure voltages from temperature, pressure or strain transducers or voltages of multiple reference electrodes in a cell.

System Information

Gamry Instruments currently has software for ESC testing, including Stack Mode operation and Auxiliary Electrometer measurements, under development. Planned experiments include load curves, cyclic battery charge/discharge, and EIS. Contact Gamry for information on pricing and availability.

The Reference 3000 requires electrochemical software for specific electrochemical applications. Gamry Software packages that currently support the Reference 3000 include:

- EIS300™ Electrochemical Impedance Spectroscopy
- PHE200™ Physical Electrochemistry Software
- DC105™ Corrosion Techniques
- PV220™ Pulse Voltammetry Software

Contact your local Gamry sales representative for the availability of other Reference 3000 compatible software packages.

The Reference 3000 is shipped with these items:

- A Universal Input Power Adapter (power brick)
- A two meter USB Cable
- A Universal Dummy Cell 4
- Paired 60 cm Standard Cell Cables
- A Hardware Operator's Manual
- A Faraday cage for reliable calibration
- Gamry Framework™ Software
- Gamry Echem Analyst™ Software
- A Gamry mousepad
- A grounding cable
- A Software Installation Manual

The Reference 3000 is protected by a 2-year factory service warranty.

Special cell cables for low impedance measurements and longer cell cables are also available.

Selected Specifications (TBD = to be determined)

Operating Modes	
Potentiostat	Yes
Galvanostat	Yes
Zero Resistance Ammeter	Yes
Cell Connections	2, 3, or 4
Isolated from earth	Yes

Control Amplifier	
High Voltage Mode	
Compliance Voltage	±32 volts
Compliance Current	± 1.5 amps
High Current Mode	
Compliance Voltage	±15 volts
Compliance Current	± 3.0 amps
Unity Gain Bandwidth (typical)	980, 260, 40, 4, 0.400 kHz

System	
Current Ranges	11 (300 pA-3A)
Current Ranges (with internal gain)	13 (3 pA- 3A)
Max. Applied Potential	±11 V
(in stack mode)	±32 V
Rise Time (1 kΩ cell)	<400 ns
Noise and Ripple	<2 µV rms (DC-1 kHz)
Min. Time Base	3.333 µs

EIS Measurement	
Frequency Range	10 µHz – 1 MHz
Impedance Accuracy	TBD
Max AC Amplitude	2110 mV rms
Min AC Amplitude	4.03 µV rms

Electrometer	
Input Impedance	> 10^{14} Ω
Input Current	< 10 pA
Bandwidth (-3dB) (typical)	>10 MHz
Common Mode Rejection Ratio	>80 dB (3 Hz), >60 dB (1 MHz)

Measured Potential	
Accuracy	± 1 mV ±0.3% of reading
Full-Scale Ranges	32 V, 12 V, 3 V, 300 mV, 30 mV

Applied Potential	
Accuracy	± 1 mV ±0.2 % of setting
Drift	< 20 µV/°C
Noise (DC to 2 kHz)	< 10 µVrms
Potential Scan Range	± 0.4, 1.6 or 6.4V

Applied Current	
Accuracy	±10 pA ±0.3 % of setting
Resolution	0.0033 % full scale/bit

Measured Current	
Accuracy	±0.3% range ± 10 pA
Resolution	0.0033 % full-scale/bit

iR Compensation	
Mode	Current interrupt and positive feedback
Minimum interrupt time	33 µs
Maximum interrupt time	715 s

Rear Panel Auxiliary A/D Input	
Range	±3 V
Input Impedance	100 kΩ or >10 GΩ

Auxiliary D/A Output	
Range	0 – 4.096 V
Resolution	1 mV

Physical	
Weight	< 6 kg
Dimensions (whd)	20 x 23 x 30 cm
Operating Temperature	0 to 45 °C

Selected Aux. Electrometer Specifications

Input Voltage	
Common Mode Range	± Compliance Voltage
Input Resistance	> 10 GΩ
Input Current	< 10 pA

Difference Amp	
Difference Voltage	± 5 volts
CMRR (DC to 1 kHz)	> 86 dB
(1 kHz to 100 kHz)	> 72 dB
Channel Cross-talk	< 80 dB

Voltage Measurement	
Nominal Voltage Range	± 5.12 volts
µV/bit (no gain)	156.25
µV/bit (100x gain)	1.5625

All specifications are at 25°C unless otherwise noted.
All specifications are subject to change without notification.

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