MODULAR POTENTIOSTAT/GALVANOSTAT

# SP-2xx / SP-300

## Fast, sensitive, stable and modular... a remarkable combination !

BioLogic Science Instruments

## APPLICATIONS

- Renewable energy sources
- Fundamental electrochemistry
- Corrosion
- Sensors
- Batteries
- Materials

# SP-2XX SP-300 Series

## marks a new step in the combination of high performance and modularity

**SP-2xx/SP-300** are state-of-the-art modular research grade potentiostat/galvanostat/FRAs with remarkable specifications. Drawing upon Bio-Logic's long history of flexible and modular potentiostat design, the breakthrough technology incorporated in the SP-2xx/SP-300 results in exceptional performance.

The main differentiation between the **SP-2xx** and **SP-300** is the chassis size and configuration. The **SP-2xx** chassis offers one slot to insert one potensiostat/galvanostat board equipped with EIS, ARG and/or ULC options whereas **SP-300** chassis offers two slots. One slot in the **SP-300** chassis must be occupied by a potentiostat channel, while the second slot may be occupied by an additional potentiostat channel (for bipotentiostat applications, for example) or a booster kit (to be selected in our range of four internal boosters ±1, ±2, ±4, ±10 A).
Alternatively **SP-240** chassis is available (Chassis with 4 A booster included).

The **SP-2xx/SP-300** are floating instruments, allowing them to be used with grounded cells, autoclaves, and in glove boxes. Thanks to portability and floating, on-site and in-stream corrosion experiments can be performed.The **SP-2xx/SP-300** are supplied with a built-in calibration board. This allows the user to run a calibration routine as needed or when the most accurate measurement is demanded.
Low current sensitivity can be improved using the Ultra Low Current option (down to 1 pA range with 76 aA resolution).

Electrochemical Impedance Spectroscopy (EIS) measurements can be added as an option to the **SP-2xx/SP-300**. The built-in FRA has a frequency range of 10 µHz up to 7 MHz.
This remarkable high frequency measurement can be made with an accuracy of 1%/1° up to 3 MHz and 3%/3° to 7 MHz.

The **EC-Lab®** software package supplied with the system is an easy-to-use, feature-rich interface for new and advanced users alike. It provides a wide range of techniques and applications that can be sequenced and/or linked to design any experiment the user can imagine.
A variety of analysis tools are available for electro-analytical and corrosion data, as well as equivalent circuit modeling for impedance data interpretation.

# Modules

## Standard configuration

### **Communication** board

The communication board of the unit is connected to a computer via USB or 100BaseT Ethernet. The unit can also be installed as a device on a Local Area Network using a static IP address.
Any computer on the network can connect to the unit, even for remote access. Data is stored in a large on-board buffer (700,000 data points) and downloaded continuously.

### **Calibration** board

Using the built-in calibration board, the user initiates a routine to perform a full calibration of the **SP-2xx/SP-300** and of the booster channel when applicable. This procedure checks and adjusts offsets and gains versus internal reference circuits and calibrates the current ranges.

### **Potentiostat/galvanostat** board

The Potentiostat/Galvanostat in the **SP-2xx/SP-300** has 9 available performance bandwidths. As a result, the system exhibits excellent electronic stability while making high speed measurements.
The floating mode (with earth isolated power supply) allows experiments to be run on grounded cells, on pipelines or autoclaves.
An exclusive feature of the **SP-2xx/SP-300** is the on-board operating system. The control of the experiment is provided by the digital board, even when communication with the computer is lost.
Three analog filters are available to remove unwanted noise during an experiment: 50 kHz, 1 kHz and 5 Hz.

## **SP-300 options** (uses the 2nd slot)

### **Booster**

The **SP-300** has one slot available to accommodate a current booster chosen among four differents boosters: ±1 A/±48 V, ±2 A/±30 V, ±4 A/[-3;14] V, ±10 A/[-1;6] V.
This extended range allows all application areas of electrochemistry to be covered.
The **SP-240** chassis includes the 4 A booster by default.

### **Bipotentiostat**

The **SP-300** can accommodate an additional potentiostat board with or without EIS/ULC/ARG options.

## Options

### **Electrochemical Impedance** Spectroscopy (EIS)

By choosing the EIS capable potentiostat (Z option) the user can perform Electrochemical Impedance Spectroscopy up to 7 MHz. This built-in option does not require an external analyzer. In addition to the Single Sine method of EIS measurements, the **SP-2xx/SP-300** can utilize a fast Fourier-based Multi-Sine technique to reduce experimental acquisition time.

### **Analog Ramp** Generator (ARG)

The analog ramp generator is an optional module. It is automatically detected and provides a true analog voltage scan up to 1 MV/s with an acquisition down to 1 µs.

### **Ultra Low** Current (ULC)

An ultra low current option is available for the **SP-2xx/SP-300**. This option lowers the base current range from 1 µA to 1 pA, thus the resolution of the low current option is 76 aA on the 1 pA full scale range. It consists of a cell cable with a high sensitivity electrometer in-line that is located close to the cell.

## FEATURES

- Compliance: ±12 V
- Control voltage: ±10 V
- Maximum current: ±500 mA
- Current resolution: 760 fA (standard board)
- Floating mode
- Analog filtering
- Calibration board
- Full stability control mode (9 bandwidths)

## OPTIONS

- EIS measurement: 3 MHz - 10 µHz (1%, 1°) 7 MHz - 10 µHz (3%, 3°)
- Ultra Low current: additional ranges 100 nA to 1 pA with a resolution of 76 aA
- Analog ramp generator: 1 MV/s, acquisition time 1 µs

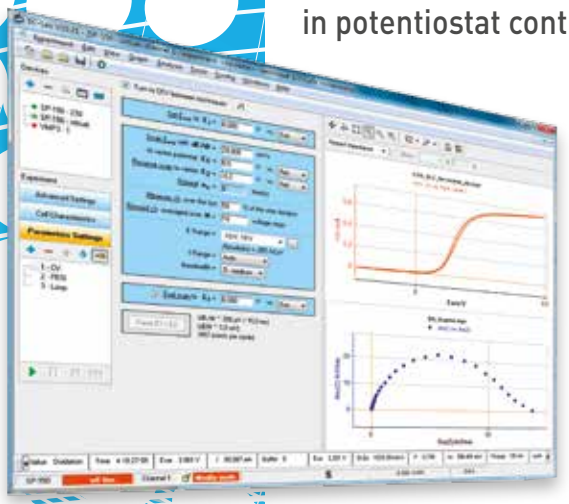
## SP-300 OPTIONS

- Internal boosters: ±1 A/±48 V, ±2 A/±30 V, ±4 A/[-3;14] V, ±10 A/[0;5] V
- Bipotentiostat

# EC-Lab® software package

## A comprehensive software package

**EC-Lab®** is an advanced software package for performing electrochemical measurements. With more than 15 years of development and constant improvement in techniques and features, **EC-Lab®** software has become the benchmark in potentiostat control and analysis software.



## EC-Lab®: modular and powerful for advanced users

### Experimental sequence builder.

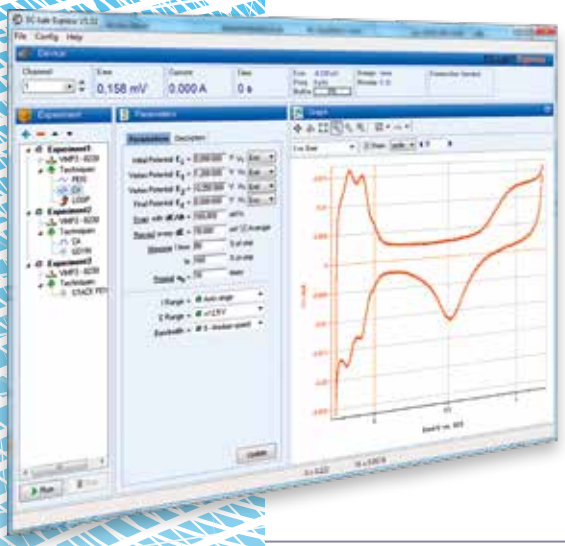
**EC-Lab®** software contains more than 80 techniques. These techniques can address applications in voltammetry, EIS, corrosion and energy source development. A powerful technique builder can execute a series of different modular techniques, wait and loop options to create complex experimental sequences. Even within each technique, the user can create up to 100 linked sequences of the experiment with different parameters.

### Limit detection and cell protection

Several experimental limit parameters are available to protect the electrochemical cell. These limits can be set either for all the experiments in a series or for individual techniques. Special techniques have been added to monitor the external analog input voltage which can be calibrated to a temperature, frequency value, or rotation speed. This allows the experiment to terminate (or skip to the next technique in a series) when a pre-set voltage is reached.

### External device control

Some electrochemical experiments require potentiostats to work with other instruments such as a QCM, a rotating ring-disk electrode or a spectrophotometer. **EC-Lab®** has an advanced "external device configuration" menu that can be configured to control and record data from these separate instruments, such as QCM frequency or temperature.



## EC-Lab® Express: easy to learn software for new users

More than 45 techniques with up to 100 sequences can be linked in **EC-Lab® Express** software.

This software is very easy-to-use. The settings and graph are shown on one screen view. An experiment selector enables the user to quickly switch between techniques.

**EC-Lab® Express** has been optimized to offer short acquisition time down to 12 µs (1 µs coupled with ARG option).

# Analysis tools

- Line Fit...
- Rp Fit...
- Mott-Schottky...
- Peak Analysis...
- Circle Fit...
- Tafel Fit...
- Z Fit...
- Wave Analysis...
- Integral...
- Electrochemical Noise...
- Z Sim...
- CV Fit...
- Min Max...
- Corr Sim...
- Kramers-Kronig
- Linear Interpolation...
- Filtering...
- VASP Fit...
- Process Data (Cycles, R, QCM mass...)
- Fourier Transform...
- CASP Fit...
- Photovoltaic Analysis...

EC-Lab® graphics

# EC-Lab® Graphics

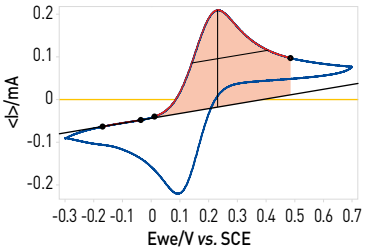
## A comprehensive graphics package.

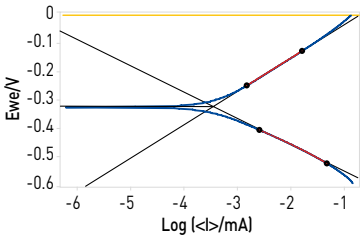
**EC-Lab**'s graphic package is provided with the software and includes a powerful tool to create unique graph templates.

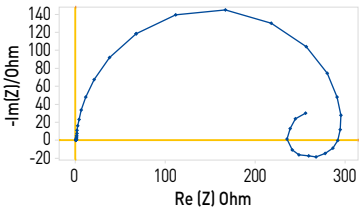
With the advanced graph properties, the user can create new variables for each axis. This enables mathematical functions to be performed on data plotted on any axis.

Powerful analysis tools (such as peak find/height, convection wave, integral, Tafel fit, Rp determination) are available in **EC-Lab®**. These analyses incorporate classical fit routines (linear, circular) and algorithms.
All the analysis results are stored in a separate file.

**EC-Lab**'s EIS modeling package utilizes the equivalent circuit approach. There are over 150 standard circuits and two minimization algorithms available for understanding impedance plot information.
The user can define and build his/her own circuit model using a range of 13 simple elements (R, C, L, La, Q, W, G, Ga, Gb, Wd, M, Ma, Mg).
A batch processing feature allows fitting of multiple cycles in an impedance experiment.




# OEM package

**Bio-Logic** has developed an OEM package and **LabView®** drivers which are available for our customers. This package includes almost all the DC and AC techniques present in **EC-lab® Express**.
A **Delphi®** and **Veepro®** test program and **LabView®** examples are also provided.

# Specifications

## CHANNEL BOARD

### General functions

| | |
|---|---|
| Potentiostat | yes |
| Galvanostat | yes |
| Impedance analyzer | yes (option) |
| Coulometer | yes |
| Analog ramp generator | yes (option) |
| Floating mode | yes |
| IR compensation | yes |
| Analog filtering | yes |
| External input/outputs | yes |
| Cell connection | 2, 3, 4 or 5 terminal leads (+ ground) |
| Sampling rate | 200 µs with EC-Lab® Down to 12 µs with EC-Lab® Express |
| Scan rate | 330 V/s (EC-Lab® Express with dE/dt = 15 mV / 45 µs) |

### Control amplifier

| | |
|---|---|
| Compliance | ±12 V |
| Maximum current | ±500 mA continuous |
| Gain-bandwidth compensation | 9 programmable stability factors |
| Highest unity gain bandwidth | 1.4 MHz |
| Slew rate (no load) | > 20 V/µs |
| Rise/fall time (no load) | < 500 ns<br>< 200 ns with boosters |

### Voltage control

| | |
|---|---|
| Ranges | adjustable from ±10 V down to ±30 mV |
| DC level shift | ±10 V, 300 µV resolution |
| Accuracy | < ±1 mV ±0.03% of setting |
| Lowest resolution | 1 µV |

### Current control

| | |
|---|---|
| Ranges | ±1 A, ±100 mA, ±10 mA, ±1mA, ±100 µA, ±10 µA, ±1 µA (7 ranges) |
| Additional ranges | ±100 nA, ±10 nA with gain |
| Accuracy | < ±0.1% of range ±0.03% of setting |
| Resolution | 0.0033% of range |

### Voltage measurement

| | |
|---|---|
| Ranges | ±10 V, ±5 V, ±2.5 V, ±250 mV, ±25 mV |
| DC level shift | ±10 V, 300 µV resolution |
| Accuracy (DC) | < ±1 mV ±0.03% of reading |
| Maximum resolution | < 0.0033% of range |
| Bandwidth (-3 dB) | 8 MHz |
| Filtering | 50 kHz, 1 kHz and 5 Hz, low-pass 4 poles Sallen-Key filters |
| Data sampling | 1,000,000 samples/s |

### Current measurement

| | |
|---|---|
| Ranges | 9 ranges (auto/auto limited/manual) ±1 A down to ±10 nA (±100 nA, ±10 nA with gain) |
| Accuracy (DC) | < ±0.1% of range ±0.03% of reading |
| Maximum resolution | 0.0033% of range |
| Bandwidth (-3 dB) | 8 MHz |
| Filtering | 50 kHz, 1 kHz and 5 Hz, low-pass 4 poles sallen-key filters |
| Data sampling | 1,000,000 samples/s |

### Electrometer

| | |
|---|---|
| Input impedance | 1 TΩ \|\| 25 pF typical |
| Input bias current | < 10 pA |
| Bandwidth (-3 dB) | 8 MHz |
| Common mode rejection ratio | > 60 dB at 100 kHz |

### Ground to chassis impedance

| | |
|---|---|
| Floating mode | 10 MΩ \|\| 10 nF typical |
| Grounded mode | < 10 kΩ |

### IR compensation

| | |
|---|---|
| Resistance determination | EIS |
| Compensation mode | hardware or software positive feedback |
| Compensation range | programmable from 0 to 100% of the current range resistor |

### Auxiliary inputs/outputs

| | |
|---|---|
| External input | can be used to apply an external waveform directly to the control amplifier |
| 2 analog inputs | automatic ±2.5 V, ±5 V, ±10 V ranges, 16-bit resolution |
| 1 analog output | ±10 V range 16-bit resolution |
| 2 digital inputs | TTL level: trigger input and open input |
| 1 digital output | TTL level: trigger output |
| 2 monitor outputs | cell current and compensated working electrode potential |

## CHASSIS

### General

| | | |
|---|---|---|
| Slot number | SP-200 | 1 |
| | SP-240/SP-300 | 2 |
| Dimensions | SP-200 | 225 x 167 x 410 mm (H x W x D) |
| | SP-240/SP-300 | 225 x 205 x 410 mm (H x W x D) |
| Weight | SP-200 | 6 kg |
| | SP-240/SP-300 | 7.5 kg |
| Power | | 85-264 V, 47-440 Hz |

## ANALOG RAMP GENERATOR (optional)

| | |
|---|---|
| Scan ranges | 1 V/s, 100 V/s, 10 kV/s, 1 MV/s |
| Scan resolution | 0.0015% FSR* (down to 15 µV/s) |
| Voltage range | ±10 V |
| Accuracy | < ±0.1% of range |
| Number of cycles | 1 to 65535 |
| Sampling rate | 1 µs |

* FSR: Full Scale Range

## IMPEDANCE ANALYZER (optional)

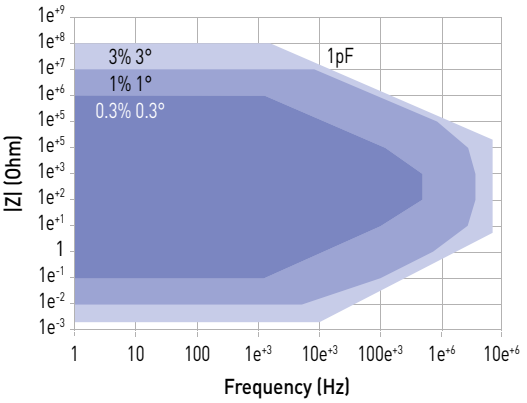
| Impedance | |
|---|---|
| Frequency range | 10 µHz to 7 MHz |
| Frequency resolution | < 10 ppm of the setting |
| Sinus amplitude | 0.5 mV to 2.5 V with 1 mV resolution<br>0.1% to 100% of the current range<br>with resolution of 0.004% of the range |
| Accuracy | see contour plot |
| Mode | single sine, multisine, FFT analysis |

## BOOSTERS (SP-300 only)

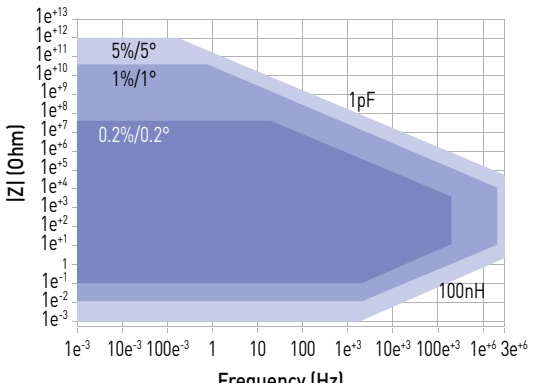
| Boosters | 1 A/48 V | 2 A/30 V | 4 A/14 V | 10 A/5 V |
|---|---|---|---|---|
| Compliance voltage | ±49 V | ±30 V | -3 V ; +14 V | -1 ; +6 V |
| Control voltage | ±48 V | ±30 V | -3 V ; +10 V | -1 ; +6 V |
| Compliance current | ±1 A | ±2 A | ±4 A | ±10 A |
| Current accuracy | 0.1% range | 0.1% range | 0.1% range | 0.3% range |
| EIS frequencies | 10 µHz - 2 MHz | 10 µHz - 1 MHz | 10 µHz - 1 MHz | 10 µHz - 1 MHz |
| Bandwidth (-3 dB) | >2 MHz | >3 MHz | >4 MHz | >8 MHz |
| Slew rate (no load) | >15 V/µs | 50 V/µs | 50 V/µs | 50 V/µs |
| Rise/fall time (no load) | <250 ns | <200 ns | <200 ns | <200 ns |
| Floating mode | yes | yes | yes | yes |
| Parallel ability | no | yes | yes | yes |

**Channel board equipped:**

with standard cell cable




with ultra low current option




## ULTRA LOW CURRENT (optional)

| Cell control | |
|---|---|
| Maximum current resolution | 0.004% of the range (76 aA max) |
| Applied current accuracy | < ±0.1% of range ±0.03% of setting<br>for ±500 mA to ±100 nA ranges<br>< ±0.1% of range ±1% of setting<br>for ±10 nA range to ±1 nA ranges<br>< ±0.2% of range ±2% of setting for ±100 pA range |

| Current measurement | |
|---|---|
| Ranges | 13 ranges (auto/auto limited/manual)<br>±1 A down to ±1 pA<br>(±10 pA, ±1 pA with gain) |
| Maximum resolution | 0.004% of the range (76 aA max) |
| Accuracy (+20°C ⩽ T ⩽ +30°C) | < ±0.1% of range ±0.03% of setting<br>for ±500 mA to ±100 nA ranges<br>< ±0.1% of range ±1% of setting<br>for ±10 nA range to ±1 nA ranges<br>< ±0.2% of range ±2% of setting for ±100 pA range<br>< ±1% of range ±2% of setting for ±10 pA range<br>< ±10% of range ±2% of setting for ±1 pA range |

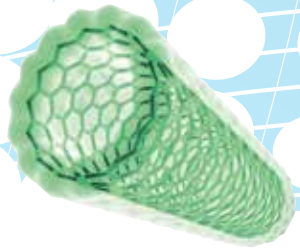
| Electrometer | |
|---|---|
| Impedance | 100 TΩ \|\| 6 pF typical |
| Bias current | < 1 pA (300 fA typical) |
| Bandwidth | 5 MHz |
| EIS accuracy | see contour plot |

Specifications subject to change

# Applications

## Fundamental **electrochemistry**

Fundamental and analytical electrochemistry research is probably the most demanding application with respect to instrumentation. This type of research is aimed at exploring material limits, and therefore requires the most advanced instrument capabilities.
The analog ramp generator combined with a hardware ohmic drop compensation is well adapted to reach very fast scan rates and highlight intermediate reaction species.



## **Nanotechnology**/sensors

**SP-2xx/SP-300** used with an ultra low current option are well suited for nanotechnology research and measurements on ultramicro-electrodes. Currents as low as a few femto amps can be measured with precision. Hardware filtering allows the user to remove unwanted electro-magnetic noise which can affect the quality of the data. EIS measurement using the ultra low current option is able to explore the electrochemical characteristics of nano-devices.

## **Batteries**/fuel cells

Research interest in new energy sources for electric vehicles (EVs) and hybrid electric vehicles (HEVs) is rapidly growing. Researchers in these fields require an instrument that can measure and apply high currents. The **SP-300** with its high current booster option, is the perfect solution. Bio-Logic is experienced in providing instruments to investigate intercalation compounds and batteries. A major feature of the **SP-2xx/SP-300** is the ability to switch from potential control to galvanic control in a very short time. EIS capability is an important tool to study aging of batteries in real operating conditions. A multi-sine EIS technique in **EC-Lab®** software allows measurements to be made quickly to avoid changes during the experiment.

## **Photovoltaic**/solar cells

A major area in renewable energy research is in capturing the energy of sunlight. With the need to develop commercial solar cells and modules, it is becoming increasingly important to improve efficiencies and performance of these devices, as well as their price. The **SP-300** and its high voltage/current capabilities are suitable tools in developing photovoltaic cells and components.

## **Corrosion**/coating

The **SP-2xx/SP-300**'s ultra low current option is ideal for corrosion experiments especially very low corrosion rates determination. With the floating mode, measurements can be carried out on grounded cells, such as pipelines or in autoclaves. The **SP-2xx/SP-300** exhibit extremely high resolution and accuracy in current and potential measurements. Combined with a high acquisition speed, the **SP-2xx/SP-300** are well-suited for making Electrochemical Noise Measurements using dedicated techniques (ZRA - ZVC).
Electroplating is also an application requiring high current. The **SP-300**, with their high current booster option, is the perfect solution.

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