

Review

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Your Guide to Select the Commercial Electrochemical Instrument

[Paolo Yammine](#) , Ali Al-Zein , [Tony Tannous](#) , Hanna El-Nakat , [Doris Homsy](#) , Elie Atieh , Zeinab Matar , [Pierre J. Obeid](#) , [Ayman Chmaysssem](#) *

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Review

Your Guide to Select the Commercial Electrochemical Instrument

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Abstract

This paper serves as a practical guide to help the readers select electrochemical instruments with a focus on potentiostats / galvanostats. It is dedicated to professionals in industry, students and researchers from various fields. We provide an overview of the main potentiostats / galvanostats and related electrochemical instruments currently available on the market and the main suppliers worldwide. For each device, we summarize its technical specifications including current and potential ranges as well as the methods the instrument is able to support. We also discuss the limitations of each instrument in order to provide the readers with a clear and comprehensive understanding. Finally, the paper aims to help the readers in selecting the most suitable instrument for their needs while considering performance and budget.

Keywords: electrochemical instrument; potentiostat/galvanostat; technical guide; electrochemistry; suppliers

Introduction

Potentiostat is an instrument used in electrochemical studies where a potential (voltage) is applied to an electrochemical cell and typically measures the current [1]. Potentiostat / Galvanostat is a more advanced device capable of both applying a specific potential to measure varying currents (potentiostat mode) and managing the current to observe changes in potential (galvanic mode) [2,3]. These instruments are often referred to as electrochemical workstations. Both types are essential for investigating electrochemical processes, but they operate differently depending on the users' needs to control during the experiment [4]. These instruments are widely used in many fields such as battery research [5], corrosion studies [6], electrolysis [7], sensors [8], processes and surface modification [9].

In addition to the electrochemical techniques embedded within each instrument, potentiostats / galvanostats can be combined with specific modules to extend their measurements capabilities. For example, electrochemical impedance spectroscopy (EIS) module enables detailed analysis of a system's resistance and capacitive properties, providing valuable information about charge transfer and interfacial phenomena [10,11]. Furthermore, these devices can be coupled with different optical measurements techniques such as ultra-violet spectrophotometry (UV-VIS), infrared spectroscopy (IR), Raman spectroscopy (RS) or chemiluminescence. Combining electrochemical and optical measurements offers insights into the physicochemical characteristics of the investigated system enhancing the understanding of reaction mechanisms / rates, surface states and molecular interactions.

Many manufacturers offer a variety of potentiostats / galvanostats characterized by their size, number of channels, current and potential ranges [12], embedded methods, precision and cost [13]. Typically, compact models are designed for applications with limited spatial constraints while modular line, usually larger and more versatile, better suits comprehensive studies in electrochemical research. In healthcare and wearable applications, there is a growing need for portable devices that

are lightweight and capable of operating in close proximity to or in contact with the human body [14,15]. For such cases, battery powered devices are essential enabling real-time monitoring outside of the traditional laboratory setting [16]. Bluetooth-connected devices (wireless connectivity) are also highly important for such applications which reduce the need for physical wiring and enable greater freedom movement during measurements [17,18].

Moreover, potentiostats / galvanostats can be categorized according to their current / potential ranges [19]. These parameters are critical for matching the instrument to specific electrochemical applications. High current devices (e.g., 1 A to > 100 A) are typically used in applications such as battery, fuel cells, metal plating and electrolysis. Conversely, low-current devices are designed for sensitive applications such as corrosion studies, (bio)sensing [20] and nanoelectrochemistry [21,22]. These devices are equipped with well-isolated channels to avoid noises during the measurements [23,24].

On the other hand, some Potentiostats / Galvanostats are designed as single-channel instruments allowing measurements in only one electrochemical cell at a time. However, multichannel devices equipped with two or more channels enable simultaneous electrochemical measurement across two or more independent cells [6,25]. Many manufacturers offer today the possibility of personalizing the number of added channels into the provided potentiostat / galvanostat. Additionally, certain systems can be connected to a multiplexer which sequentially switches between multiple electrochemical cells (up to 96 independent cells) [26]. This configuration is particularly interesting in high-throughput experiments or long-term potentiometric monitoring where measurements are made across several independent electrochemical setup without requiring multiple instruments [27,28]. Typically, this configuration is used during cell-cultures where electrodes are integrated in each well for real-time monitoring of the cell-culture media [29–31].

In this paper, we review the main global manufacturers of potentiostats / galvanostats. For each provider, we analyze the models available in their product catalogues based on parameters such as device size, number of channels, current and potential ranges, embedded techniques, portability, and application-specific features.

Main Suppliers

- **Metrohm**

Metrohm is one of the most important companies that provides high-precision instruments for chemical analysis. Founded in 1943 Switzerland, Metrohm has expanded to reach the entire world with a presence in over 80 countries. It offers a diverse portfolio of electrochemical instruments, including potentiostats, galvanostats, and multichannel systems, targeting many research and industrial applications (Table 1). According to Metrohm catalogue, instruments are divided into different families (Figure 1). Below is a comprehensive overview of each family [32]:

Family 1: VIONIC

VIONIC is the most advanced potentiostat/galvanostat system. It offers a compliance voltage of ± 50 V and a current of ± 6 A, making them suitable for applications such as battery research, and corrosion studies. VIONIC supports electrochemical impedance spectroscopy (EIS) at frequencies up to 10 MHz. VIONIC uses INTELLO software designed for flexible experiment setup and thorough data analysis. VIONIC has other important features like selectable floating and a second sense connection for monitoring additional electrodes. VIONIC offers the most versatile combined specifications of any single instrument currently on the market.

Family 2: Compact line

This lightweight and portable potentiostat/galvanostat is used for routine electrochemical analysis, making it ideal for education as well as research. Several models belong to this family. **PGSTAT101** is a small, lightweight, and affordable potentiostat/ galvanostat that is ideal for most basic electrochemical research applications. It offers a compliance voltage of ± 10 V and a maximum current of ± 100 mA. It includes an onboard integrator for coulometric measurements and current integration cyclic voltammetry. **Autolab IMP** represents same characteristics as PGSTAT 101 with

EIS included covering frequencies from 10 μHz to 1 MHz and is equipped with the full NOVA software. The **PGSTAT204** excels with its compact and modular design allowing for superior flexibility in your research. It offers a compliance voltage of $\pm 20\text{ V}$ and a maximum current of $\pm 400\text{ mA}$, along with a modular expansion option that allows users to add one technique like EIS. All Compact Line instruments are supported by NOVA software.

Family 3: Modular line

The Modular Line consists of a range of instruments to suit any requirements in electrochemical research, from low to high voltage and from low to high current. These instruments can be combined with a range of modules allowing you to customize the instrument to your requirements, greatly increasing the possibilities of electrochemical research. NOVA2 software powers all these systems. This line is centered around the **AUTOLAB PGSTAT302N**, a high-performance potentiostat/galvanostat offering a compliance voltage of $\pm 30\text{ V}$ and a current of $\pm 2\text{ A}$ and a bandwidth of 1 MHz. Combined with the FRA32M module, it can accommodate EIS. **PGSTAT302N MBA** (Multi BA) is a special version of the PGSTAT302N which can be fitted with up to 6 working electrodes. Besides the main working electrode, 5 additional bipotentiostat modules (BA module) can be installed in the instrument, alongside the optional FRA32M module. Another setup within this family is the **ECAT** complete package, which includes the full **AUT302N.MBA.S** loaded with additional functional modules including Electrochemical Impedance Spectroscopy (EIS) and true linear voltammetry, pH and temperature sensor, and dual mode bipotentiostat.

Family 4: Multichannel line

The Multichannel Line is designed for applications where simultaneous measurements across multiple electrodes are needed. This family includes two main variants: **Multi Autolab M101** and **Multi Autolab M204**. The M101 model features individual modules capable of delivering up to $\pm 100\text{ mA}$ with a compliance voltage of $\pm 10\text{ V}$, while the M204 modules provide more performance with up to $\pm 400\text{ mA}$ and a compliance voltage of $\pm 20\text{ V}$. The software used for this line is NOVA2 and can support up to twelve independent potentiostat/galvanostat modules in a single cabinet, offering true parallel processing for large-scale experiments. Electrochemical impedance spectroscopy (EIS), dual mode bipotentiostat module, current booster (Booster10A), pH/pX measurement (pX1000), electrochemical quartz crystal microbalance (EQCM), and automation with multiplexing (MUX) – these are the additional capabilities that can be added to the Autolab Multichannel M204 and M101 instruments through a dedicated module.

Family 5: Portable line

The portable potentiostats / galvanostats / EIS are small and affordable instruments that are designed to meet the needs of researchers and professionals requiring mobility, versatility, and ease of use in their electrochemical analyses. They are easily connected to a PC via USB or through wireless connection. Various instrument versions are available:

The **$\mu\text{Stat 400}$** is a compact and portable bipotentiostat / galvanostat that can be applied for voltametric, amperometric or potentiometric measurements and can be used with one- or two-working electrodes configuration. Li-ion battery powered, it can be easily connected to a PC via USB and wireless.

The **$\mu\text{Stat 300}$** is a portable bipotentiostat that can be applied for voltametric or amperometric measurements and can be used with one- or two-working electrodes configuration. Li-ion Battery powered, it can be easily connected to a PC via USB and wireless.

The **DropSTAT** is a hand-held, single-technique, potentiostat-based custom electrochemical reader that is configured attending to customer's needs, allowing the researcher to have a unique instrument able to show in an LCD screen the concentration of the analyte for which an electrochemical sensor has been developed. The device is lightweight and stores data internally, which can be exported via USB

The **DropSTATPLUS** is a customized electrochemical reader intended for having immediate results based on an optimized procedure. With a touch screen, li-ion battery and the possibility of wireless data transfer, it can store up to 3 methods and up to 8 calibrations per method.

The **ORPKIT** is a portable oxidation reduction potential (ORP) reader kit. Suitable for in situ measurements with small sample volumes. This system uses disposable ORP sensors and can store data internally.

The **µStat-i 400** is a portable bipotentiostat / galvanostat / impedance analyzer (EIS) that can be applied for voltametric, amperometric, potentiometric and EIS measurements and can be used with one- or two-working electrodes configuration. Li-ion Battery powered, it can be easily connected to a PC via USB and wireless.

The **µStat-i 400s** is an enhanced version of the µStat-i 400, offering similar features with additional capabilities for more advanced electrochemical analyses.

Family 6: Portable multichannel line

The portable multichannel potentiostats / galvanostats / EIS are affordable instruments that enable you to optimize your time. You will be able to develop applications not only in your lab but also in the field with conventional electrodes and with screen-printed electrodes.

They are an ideal and practical solution in many research areas such as (bio)sensor, corrosion, electrocatalysis, coin-cell batteries, fundamental electrochemistry, or (bio)fuel cells among others. They show flexibility with future expandability up to 16 channels, easily connected to a PC via USB, through wireless or even remotely. They allow configurations with multiple working electrodes (WEs) sharing auxiliary (AE) and reference electrodes (RE). Various systems are available:

The **µStat 8000** is portable multi potentiostat / galvanostat that can be applied for voltametric, amperometric or potentiometric measurements, being able to perform up to 8 different independent measurements at the same time, including also a multichannel mode that allows you to work with up to 8 working electrodes sharing auxiliary and reference electrode. Li-ion Battery powered, it can be easily connected to a PC via USB or wireless.

The **µStat 8000P** is an enhanced version of the µStat 8000, providing similar capabilities and characteristics with additional features tailored for specific research needs

The **µStat 4000** is a compact portable multi potentiostat / galvanostat that can be applied for voltametric, amperometric or potentiometric measurements, being able to perform up to 4 different independent measurements at the same time and including also a multichannel mode that allows you to work with up to 4 working electrodes sharing auxiliary and reference electrode. Li-ion Battery powered, it can be easily connected to a PC via USB or wireless.

The **µStat 4000P** extends the capacity of the µStat 4000 by offering four independent channels that can operate simultaneously. This multichannel capability allows for synchronized measurements across multiple working electrodes.

The **H2PERMKIT** is a kit used to perform hydrogen permeation experiments. It includes one µStat-i Multi4 (4 channels galvanically isolated), one cell and the electrode cable connectors needed. DropView 8400M software allows to evaluate the permeability of the sample with a very straight forward calculation.

The **µStat-i MultiX** is a multichannel instrument (bipotentiostat / galvanostat /EIS) with up to 16 channels that allows multi-user and multidisciplinary electrochemical research. The system supports a wide range of electrochemical techniques, including voltammetry, amperometry, impedance spectroscopy, and potentiometry.

The **µStat-i MXONE**, **MXONES**, **MXONEP**, and **MXONESP** are modular configurations of the µStat-i MultiX. Multichannel impedance analyzer for multi-user and multidisciplinary electrochemical research that can be designed according to needs.

Add to all these Metrohm's potentiostat/galvanostat can be integrated in spectroelectrochemistry electrochemiluminescence (ECL). They represent advanced techniques that combine electrochemical measurements with different spectroscopic methods (UV-Vis, Raman, or IR) in the objective of obtaining deeper details of chemical and biochemical processes.



Figure 1. Main electrochemical workstations supplied by Metrohm (potentiostats/galvanostats).

Table 1. Main electrochemical instruments supplied by Metrohm: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Supported methods	Specifications	Potable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Limitations
METROHM (Switzerland)	VIONIC	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, PDEIS, OCP	± 50 V ± 6 A	No	Not Specified	Mono	Not Supporting	High voltage
	PGSTAT101	Same as Vionic	± 10 V ± 1 00 mA	No	9 x 15 x 2 cm	Mono	Not Supporting	Limited current range
	Autolab IMP	Same as Vionic	± 10 V ± 100 mA	No	Not Specified	Mono	Not Supporting	Limited current range
	PGSTAT204	Same as Vionic	± 20 V ± 400 mA	No	Not Specified	Mono	Not Supporting	Limited current range
	PGSTAT302N	Same as Vionic	± 30 V ± 2 A	No	52 × 16 × 42 cm	Mono	Not Supporting	Limited current range
	PGSTAT302N.MBA	Same as Vionic	± 30 V ± 100 mA	No	52 × 16 × 42 cm	Mono	Not Supporting	Limited current range
	PGSTAT302N.MBA.S	Same as Vionic	± 30 V ± 100 mA	No	52 × 16 × 42 cm	Mono	Not Supporting	Limited current range
	Multi Autolab M101	Same as Vionic	± 20 V ± 400 mA	No	52 × 16 × 52 cm	Multi	Supported through modular designs	Modules purchased separately
	Multi Autolab M204	Same as Vionic	± 20 V ± 400 mA	No	52 × 16 × 42 cm	Multi	Supported through modular designs	Modules purchased separately
	μStat 300	CA, CV, LSV, SWV, DPV, NPV, (limited or no EIS, CP, PDEIS, OCP)	± 2 V ± 3 mA	yes	13.2 x 10 x 3.6 cm	Mono	Not Supporting	Limited current range

μStat 400	CA, MPA, CV, LSV, SWV, DPV, NPV, ASV, OCP, EIS	± 4 V ± 40 mA	yes	13.2 x 10 x 3.6 cm	Mono	Not Supporting	Limited current range
DropSTAT	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, OCP (No EIS or PDEIS support)	± 2 V ± 200 μA	yes	6 x 8 x 2.3 cm	Mono	Not Supporting	Limited current range
DropSTATPLUS	Same as DropSTAT	± 2 V ± 200 μA	yes	6 x 8 x 2.3 cm	Mono	Not Supporting	Limited current range
ORKPIT	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, OCP (No EIS or PDEIS support)	± 2 V ± 200 μA	yes	6 x 8 x 2.3 cm	Mono	Not Supporting	Limited current range
μStat-i 400	CA, CP, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, OCP	± 4 V ± 40 mA	yes	13.2 x 10 x 3.6 cm	Mono	Not Supporting	Limited current range
μStat-i 400S	Same as μStat- i 400	± 4 V ± 40 mA	yes	13.2 x 10 x 3.6 cm	Mono	Not Supporting	Limited current range
STAT8000	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, OCP	± 4 V ± 80 mA	Yes	20.5 x 7.5 x 22 cm	Multi 8 independen t channels	Supporting up to 8 working electrodes	Limited to 8 channels
STAT8000P	Same as STAT8000	± 4 V ± 80 mA	Yes	20.5 x 7.5 x 22 cm	Multi 8 independen t channels	Supporting up to 8 working electrodes	Limited to 8 channels
STAT4000	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, OCP	± 4 V ± 80 mA	Yes	20.5 x 7.5 x 22 cm	Multi 4 independen t channels	Supporting up to 4 working electrodes	Limited to 4 channels
STAT4000P	Same as STAT4000	± 4 V ± 80 mA	yes	20.5 x 7.5 x 22 cm	Multi 4 independen t channels	Supporting up to 4 working electrodes	Limited to 4 channels
H2PERMKIT	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, OCP	± 4 V ± 40 mA	yes	44 x 30 x 14 cm	Multi 4 independen t channels	Supporting up to 4 working electrodes	Limited to 4 channels
μStat-i MultiX	Same as H2PERMKIT	± 4 V ± 40 mA	yes	44 x 30 x 14 cm	Multi 16 independen t channels	Supporting up to 16 working electrodes	
μStat-i MXONE, MXONES, MXONEP, MXONESP	Same as H2PERMKIT	± 4 V ± 40 mA	yes	44 x 30 x 14 cm	Multi 8 independen t channels	Supporting up to 8 working electrodes	Limited to 8 channels

- BioLogic

BioLogic is a French Company founded in 1983 in France. With more than 40 years of expertise it has established a worldwide presence. It offers a comprehensive range of electrochemical workstations designed to various research and industrial applications [33]. Concerning potentiostat / galvanostat they are divided to 2 major families (Figure 2): essential and premium potentiostats. Below is an overview of several key models, detailing their specifications and capabilities (Table 2). All models operate via EC-Lab control and analysis software.

Essential Potentiostats:

SP-50e

The SP-50e is monochannel instrument designed for basic applications. It has a voltage compliance of ± 10 V and current ranges from ± 10 μ A to ± 1 A. It is not portable and requires an external power source. It supports EIS ranging from 1 MHz to 10 μ Hz. The SP-50e operates via Ethernet, Wi-Fi, and USB connections. It operates with EC-Lab control and analysis software. Limitations include the absence of multi-channel capabilities and portability.

VSP

The VSP is a highly modular electrochemical workstation designed for a wide range of applications. It has a voltage compliance of ± 20 V up to 60 V with FlexP-0060 module and current ranges from ± 10 μ A to ± 1 A with the possibility to extend up to 800 A using FlexP-0012 modules. It is not portable and requires an external power source. It supports EIS ranging from 1 MHz to 10 μ Hz. The VSP operates via Ethernet, LAN, Wi-Fi, and USB 2.0 connections. The instrument is multi-channel with up to 5 channels. Multiplexing is supported. Limitations include the need for external modules for high current applications and the absence of portability.

SP-150e

The SP-150e is a Mono-channel electrochemical workstation designed for general electrochemistry applications. However, it is modular and can be upgraded to a dual-channel (bipotentiostat) configuration by adding a second independent channel. It offers a voltage compliance of ± 20 V and current ranges from ± 10 μ A to ± 1 A, with the possibility to extend up to 800 A using FlexP-0012 modules. It is not portable and requires an external power source. EIS capabilities range from 1 MHz to 10 μ Hz. The SP-150e operates via Ethernet, LAN, Wi-Fi, and USB connections. It supports three EIS quality indicators (THD, NSD, NSR). Limitations include the absence of multi-channel capabilities and portability.

VMP-3e

The VMP-3e is a High-Performance Multichannel Potentiostat/Galvanostat designed for a wide range of applications. It supports up to 16 channels offering a voltage compliance of ± 10 V extendable to ± 20 V, and current ranges from ± 10 μ A to ± 1 A extendable to 800 A using FlexP-0012 modules. EIS capabilities range from 1 MHz to 10 μ Hz. The VMP-3e operates via Ethernet, Wi-Fi, and USB connections. It is not portable and requires an external power source. Multiplexing is supported, with the number of channels depending on the specific setup. Limitations include the need for external modules for high current applications and the absence of portability.

VSP-3e

The VSP-3e is an electrochemical workstation tailor-made for energy research. It features up to 8 channels, allowing for customization with potentiostat/galvanostat, EIS, and booster modules. The instrument offers a voltage compliance of ± 20 V, adjustable from ± 10 V, and current ranges from ± 10 μ A to ± 1 A, with the possibility to extend up to 800 A using FlexP-0012 modules. EIS capabilities range from 1 MHz to 10 μ Hz. The VSP-3e operates via Ethernet, Wi-Fi, and USB connections. It is not portable and requires an external power source. Multiplexing is supported, with the number of channels depending on the specific setup. Limitations include the need for external modules for high current applications and the absence of portability.

HCP-803

The HCP-803 is a high-current electrochemical workstation designed for applications requiring high current capabilities. It is capable of managing ± 80 A with a voltage range of ± 3 V. The

potentiostat has the same specifications as the VMP-3e potentiostat boards (with EIS option). It is suitable for single-channel applications requiring high current. Limitations include the absence of multi-channel capabilities and portability.

ﷲ **HCP-10005**

The HCP-1005 is a compact high-current potentiostat designed to study high-capacity secondary batteries with a voltage range of 0.6 to 5 V and a current range of ± 100 A. The EIS capability integrated in the chassis also makes it ideal for following up the performances of cells during ageing tests. It combines the precision and control of a research-grade potentiostat operating via Ethernet, Wi-Fi, and USB connections. It is not portable and requires an external power source. The instrument is suitable for single-channel applications requiring ultra-high current. Limitations include the absence of multi-channel capabilities and portability.

Premium Potentiostats:

ﷲ **SP-200**

The SP-200 is an ultra-low current electrochemical workstation designed for applications requiring high sensitivity. It is a single channel transportable potentiostat, offering a voltage compliance of ± 12 V, and current ranges of ± 1 A going to 10 nA and even to ± 1 pA with external modules. EIS capabilities range from 7 MHz to 10 μ Hz. The SP-200 operates via ethernet, Wi-Fi, and USB connections. Limitations include the absence of multi-channel capabilities and limited current range.

ﷲ **VSP-300**

The VSP-300 is a high-performance electrochemical workstation. It's a multichannel potentiostat supporting up to 6 channels. It offers a voltage compliance of ± 12 V, and current ranges from ± 10 μ A to ± 1 A, with the possibility to extend up to 120 A using modules. EIS capabilities range from 7 MHz to 10 μ Hz. The VSP-300 operates via ethernet, Wi-Fi, and USB connections. It is not portable and requires an external power source. Multiplexing is supported, with the number of channels depending on the specific setup. Limitations include the need for external modules for high current applications and the absence of portability.

ﷲ **SP-300**

The SP-300 is a bichannel research-grade electrochemical workstation. It offers a voltage compliance of ± 12 V and current ranges from 1 A to 10 A with the possibility to extend the current using appropriate modules. EIS capabilities range from 7 MHz to 10 μ Hz. The SP-300 operates via ethernet, Wi-Fi, and USB connections. It is not portable and requires an external power source.

ﷲ **VMP-300**

It is a high-end, modular multichannel potentiostat supporting up to 16 independent channels. The system offers a voltage compliance of ± 12 V and a current ranges from ± 1 A to 10 nA, both voltage and current can be extended using appropriate modules. Electrochemical impedance spectroscopy (EIS) is available from 10 μ Hz to 7 MHz. The VMP-300 is non portable and operates via ethernet, Wi-Fi, and USB connections.



Figure 2. Main electrochemical workstations supplied by Biologic (potentiostats/galvanostats).

Table 2. Main electrochemical instruments supplied by Biologic: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Supported methods	Specifications	Portable	Size of instrument	Mono- or Multi-channels	Multiplexing	Limitations
Biologic (France)	VSP-3e	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, PDEIS, OCP	± 10 V extended up to ± 20 V $\pm 10 \mu\text{A}$ to ± 1 A	No	225 x 320 x 405 mm	Multi up to 8 channels	Supporting	High current handling; limited portability
	VMP-3e	Same as VSP-3e	± 10 V extended up to ± 20 V $\pm 10 \mu\text{A}$ to ± 1 A	No	448 x 455 x 280 mm	Multi up to 16 channels	Supporting	High current handling; limited portability
	SP-150e	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, PDEIS, OCP	± 20 V $\pm 10 \mu\text{A}$ to ± 1 A	No	136 x 372 x 209 mm	Mono	Not Supporting	absence of multi-channel capabilities and portability
	SP-50e	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, OCP (EIS/PDEIS available only if equipped with impedance module)	± 10 V $\pm 10 \mu\text{A}$ to ± 1 A	No	136 x 372 x 209 mm	Mono	Not Supporting	absence of multi-channel capabilities and portability
	VSP	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, PDEIS, OCP	± 20 V $\pm 10 \mu\text{A}$ to ± 1 A	No	435 x 335 x 95 mm	Multi up to 5 channels	Supporting	Limited to 5 channels; requires external boosters for high current applications
	HCP-803	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS (optional), OCP	± 3 V ± 80 A	No	495 x 465 x 262 mm	Mono	Not Supporting	absence of multi-channel capabilities and portability

HCP-10005	Same as HCP-803	0.6 to 5 V ± 100 A	No	495 x 465 x 262 mm	Mono	Not Supporting	High Current range, absence of multi-channel capabilities and portability
SP-200	CA, CP, CC, MPA, CV, LSV, SWV, DPV, NPV, ASV, CSV, EIS, PDEIS, OCP	± 12 V ± 1 A going to 10 nA and even to ± 1 pA	Yes	167 x 410 x 225 mm	Mono	Not Supporting	Limited current range; single channel operation
VSP-300	Same as SP-200	± 12 V from ± 10 µA to ± 1 A extended to 120 A using modules	No	254 x 517 x 337 mm	Multi up to 6 channels	Supporting	Requires external boosters for high current; larger size for portability
SP-300	Same as SP-200	± 12 V ± 1 A to 10 nA extended using modules	No	205 x 410 x 225 mm	2 channels	Supporting	requires booster for higher currents, non- portability.
VMP-300	Same as SP-200	± 12 V ± 1 A to 10 nA Extended using modules	No	534 x 565 x 315 mm	16 channels	Supporting	requires booster for higher currents, non- portability.

• TOB

Xiamen TOB New Energy Technology Co., Ltd. is a high-tech enterprise specialized in high-end equipment of lithium-ion battery and supercapacitor [34]. It provides many potentiostat cited below (Table 3):

Single-channel potentiostat / galvanostat / electrochemical workstation consists of DDS arbitrary function generator, high power potentiostat/galvanostat, dual-channel correlation analyzer, dual-channel high-speed 16-bit / high-precision 24-bit AD converter and extension interfaces. Max. current is ± 2 A, potential range is ± 10V. EIS frequency range is 10 µHz ~ 1MHz. It can be used for various electrochemical fields such as corrosion, energy, material and electroanalysis. The current can be boosted up to 20 A / 40 A with a current booster CS2020B/ CS2040B. It can be applied to test the corrosion. the tester includes all the electrochemical techniques for corrosion measurement such as OCP, polarization curve (potentiodynamic), EIS, Cyclic polarization CPP (passivation curve), Electrochemical Potentiokinetic Reactivation (EPR), Hydrogen diffusion test, ZRA, Electrochemical noise, etc. It can be used to study metal corrosion mechanism and corrosion resistance, and evaluate the coating durability and sacrificial anode current efficiency. It can also be used for rapid screening of corrosion inhibitors, fungicides, etc. It provides many techniques LSV, CV, galvanostatic charge and discharge (GCD), Constant potential/ current EIS, and precise IR compensation circuit, Corrtest potentiostats that are widely used in supercapacitor, Li-ion batteries, sodium-ion batteries, fuel cell, Li-S batteries, solar cell, solid-state batteries, flow batteries, metal-air batteries etc. It is an excellent scientific tool for researchers in the fields of energy and materials. It is also a corrtest potentiostat that includes all the voltammetric methods such as NPV, DNPV, SWV, ACV, and can be used for fast analysis of the trace elements in the solution. Voltammetry stripping methods can do the Quantitative analysis according to the stripping peak current (please refer to the table for more specifications).

The Portable Potentiostat is internally powered by a lithium battery, which can be placed in a glove box or used outdoors (Figure 3). The lithium battery can be charged in advance, and the type-C interface is used for charging and communication. The circuit adopts a floating-ground design, and the electrochemical parameters of the grounding system can be measured without an isolation transformer. CS100 is mainly used for battery testing, electroanalytical chemistry, and corrosion electrochemical testing. The voltage control range is ± 10V, compliance voltage is ± 12V, the current output range is ± 45 mA, and the minimum current resolution can reach 100 fA. CS studio software provides users a versatile smoothing/differential/ integration kit, which can complete the calculation

of peak height, peak area and peak potential of CV curves. It also provides powerful non-linear fitting on Butler-Volmer equation of polarization curve. It can calculate Tafel slope, corrosion current density, limitation current, polarization resistance, corrosion rate. It can also calculate the power spectrum density, noise resistance and noise spectrum resistance based on the electrochemical noise measurements. CS Studio software can achieve real time saving of the measuring data. The data can be automatically saved even in case of sudden power off. CS studio kit has a built-in versatile timing policy for combined measurements, which can facilitate the automation of experiments and save time. CS potentiostat has many technical advantages where its impedance EIS applies correlation integral algorithm and dual-channel over-sampling technique, and has strong anti-interference ability. It is suitable for EIS measurements of high-impedance system ($> 10^9 \Omega$, such as coating, concrete etc.). It can also be used to obtain Mott-Schottky curve and differential capacitance curve. During the test, the software can display real-time open circuit potential (OCP) without entering. (Please refer to the table for more specifications).

Bipotentiostat / Bigalvanostat with built-in EIS model CS2350M has two sets of built-in independent potentiostat /galvanostat. So, it equals that you have 2 sets potentiostat in one instrument. Full floating module and electrical isolation design guarantee each channel is totally independent, which ensures accurate data. Each set provides full electrochemical techniques including EIS. Experiments can be conducted simultaneously on each channel. Besides this, the two channels can jointly complete experiments of two-working electrode system such as RRDE and hydrogen diffusion. CS2350M bipotentiostat is the real double-channel potentiostat. It uses an ethernet connection. EIS module is included in both channels. It is applied for many missions such as: (1) Electrosynthesis, electrodeposition (electroplating), anodic oxidation, electrolysis (2) Electrocatalysis such as Oxygen reduction reaction (ORR), OER, HER, CO₂ reduction. (3) Li-ion battery, solar cell, fuel cell, supercapacitor, advanced function materials, sensor, etc (4) Corrosion behavior of metals, and anti-corrosion evaluation (5) Fast evaluation of inhibitor, water quality stabilizer, coating, and cathodic protection efficiency. CS2350M bipotentiostat has many technical advantages like the impedance feature where it applies correlation integral algorithm and dual-channel over-sampling technique, and has strong anti-interference ability. It is suitable for EIS measurements of high-impedance system ($> 10^9 \Omega$, such as coating, concrete etc.). CS2350M bipotentiostat applies correlation integral algorithm and dual-channel over-sampling technique, and has strong anti-interference ability. It is suitable for EIS measurements of high-impedance system ($>10^9\Omega$, such as coating, concrete etc.), (please refer to the table for more specifications).

Concerning the **Multichannel potentiostat / galvanostat/ EIS** is a versatile instrument offering 8 slots. Full floating module and electrical isolation design guarantee each channel is totally independent, which ensures accurate data and efficient simultaneous measurements. Multichannel potentiostat brings convenience to those who have many samples, and is an ideal device for studies of energy materials, battery study, metal corrosion etc. Number of channels can be customized. Different configuration ensures you get desired product suiting to various budgets. The number of channels is expandable by adding and installing more boards, thanks to the intelligent chassis and plug-in design. Each channel's potential control range is 10 V, current control range ± 1 A, can meet experiment requirement for most people. It is applied for many tasks like the study of Energy materials (Li-ion battery, solar cell, fuel cell, supercapacitors), advanced functional materials, electrosynthesis, electroplating / electrodeposition, anode oxidation, electrolysis, corrosion study and corrosion resistance evaluation of metals; quick evaluation of corrosion inhibitors, coatings, and cathodic protection efficiency and finally electrocatalysis (HER, OER, ORR, CO₂RR, NRR). It has many advantages such as a high current / voltage: Applied potential range ± 10 V, current ± 1 A. It can meet the needs of most studies. It has comprehensive techniques: an equipped Built-in EIS (10 μ Hz ~ 1 MHz). There are comprehensive techniques on each channel. They are the manufacturer, and they have been in the market for 20 years, and now is the no. 1 brand of potentiostat product in China (please refer to the table for more specifications).



Figure 3. Main electrochemical workstations supplied by TOB machine (potentiostats/galvanostats).

Table 3. Main electrochemical instruments supplied by TOB instruments: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Supported methods	Specifications	Portable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Price
TOB instruments (CHINA)	TOB-CS-2350	CV, LSV, CA, CC, CP, CC, LSV, CV, SCV, SWV, NPV, DNPV, ACV, SHACV, FTACV, HDT, RRDE, FE, DPA, DDPA, TPA, IPAD	± 10V ± 1A		36.5 x 30.5 x 16 cm	Dual-channels (2 channels)		10300 \$
	TOB-CS-3				Weight: 12.5 Kg 40 x 40 x 14 cm		CS3008 model : -8 Channels -every channel has EIS (EIS*8) CS3108 model : -8 channels -only one channel has EIS (EIS*1) CS3004 model : -4 channels -every channel has EIS (EIS*4) CS3104 model : -4 channels	CS3004 model : -4 channels -every channel has EIS (EIS*4) Price 13800 usd CS3104 model : -4 channels -only one channel has EIS (EIS*1) Price 11500 usd

				-only one channel has EIS (EIS*1)	
TOB-CS310X	OCP, DGP, VSTEP, ISTEP, CP, CA, CC, EIS, CPP, LPR, EPR, EN, ZRA, GCD, PITT, GITT, LSV, CV, SCV, SWV, DPV, NPV, DNPV, ACV, SHACV, FTACV, DPA, DDPA, TPA, IPAD	± 10 V ± 1 A	Weight: 12.5 Kg 40 x 40 x 14 cm	Multichannel (number of channels can be customized)	Each channel is independent
					Option A: 4- 12100USD Option B: 4- 14500USD Option C: 8- 17380USD Option D: 8- 22380USD
TOB-CS Series	CP, CA, CC, CV, LSV, SCV, SWV, DPV, NPV, DNPV, ACV, CPP, LPR, EPR, EN, ZRA, GCD, PCD, PITT, GITT, DDPA, TPA, IPAD	± 10 V ± 1A	Only CS100 is portable	Net weight: 6.5kg Gross weight: 10kg 36.5 x 30.5 x 16 cm	Mono channel
					CS300M no EIS 4550 usd CS310M with EIS 6400 usd CS350M with EIS 8300 usd CS100 price 2650usd CS100E price 4300 usd

• CORRTEST

CorrTest Instruments, based in China, manufactures a range of electrochemical devices used in corrosion analysis, coatings evaluation, battery diagnostics, and material research (Figure 4). Their systems function as combined potentiostat / galvanostat and support both direct current (DC) and alternating current (AC) testing techniques (Table 4). None of the models are designed for portability or battery-powered operations, they are intended for lab use and connect to a computer via standard cables. All systems are controlled using CorrTest Soft, the company’s proprietary software [35].

CS300M

The CS300M is a single-channel instrument suited for everyday corrosion studies. It handles typical electrochemical techniques such as linear polarization, cyclic voltammetry, and chronoamperometry, and it also includes support for impedance spectroscopy (EIS). It operates within a potential range of ± 10 volts and supports currents from 10 nanoamperes up to 1 ampere. This model does not support multiplexing, and its capabilities are limited by its basic, non-expandable design.

CS310M

An upgraded option, the CS310M, offers greater precision and better sensitivity for low-current measurements. Like the CS300M, it supports a wide set of DC and AC methods, including EIS, and works across the same ± 10 V potential range. Its current range is from 2 nA to 2 A. The CS310M is also a single-channel unit not supporting multiplexing. Its limitations lie mainly in its fixed configuration and lack of channel expandability.

CS310X series (A, B, C and D)

The CS310X series (A through D) delivers multichannel functionality. Depending on the version, these instruments provide either 4 or 8 fully independent channels, each capable of running simultaneous experiments. They support the full suite of electrochemical methods, including EIS, voltammetry, and polarization studies. These units also accommodate wider current ranges, from

extremely low levels to several amps, depending on configuration. Even though, they do support multiplexers, they may require a more involved setup process and are not designed for portability.

CS2350M

The CS2350M is a two-channel potentiostat geared toward coatings and corrosion-related testing. It includes standard DC techniques and EIS capability with a working potential range of ± 10 V. It's intended for low-to-mid current tasks and, like other mono-channel models, it does not support multiplexing.

CS350M

The CS350M offers ultra-sensitive current detection, extending down into the picoampere range. It is ideal for thin-film and sensor research and supports both DC and EIS measurements. Its design, however, remains single-channel and fixed, with no multiplexing support or portable use.

CS2150M

The CS2150M serves as a versatile option for general-purpose electrochemical work. It handles common methods such as voltammetry, amperometry, and EIS, and is capable of delivering up to 2 amperes of current across a ± 10 V potential window. As with other dual-channel devices, it lacks channel expansion options or support for multiplexing.

Across the entire product line, CorrTest Soft is the central software platform used to manage experiments, collect data, and customize testing procedures. Its user interface is built to support advanced control while remaining accessible to new users.



Figure 4. Main electrochemical workstations supplied by CORRTEST Instruments (potentiostats/galvanostats).

Table 4. Main electrochemical instruments supplied by CORRTEST: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Instrument name	Supported methods	Specifications (ranges)	Portable	Size	Mono- or Multi-channel(s)	Multiplexing	Limitations	Price range (USD)
CS300M	CV, LSV, DPV, SWV, NPV,	± 10 V pA to mA	No	28 x 20 x 8 cm	Mono-channel	Not supported	No multiplexing,	3,000 – 3,400 \$

	DNPV, CSV, ASV						limited channels	
CS310M	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	28 x 20 x 8 cm	Mono-channel	Not supported	No multiplexing	5,000 – 6,000 \$
CS310X-A	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	40 x 30 x 15 cm	Multi-channels (4 channels)	Multiplexer supported	Requires power supply, larger size	8,800 – 18,000 \$
CS310X-B	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	40 x 30 x 15 cm	Multi-channels (4 channels)	Multiplexer supported	Requires power supply	8,800 – 18,000 \$
CS310X-C	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	50 x 35 x 18 cm	Multi-channels (8 channels)	Multiplexer supported	Requires power supply	8,800 – 18,000 \$
CS310X-D	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	50 x 35 x 18 cm	Multi-channels (8 channels)	Multiplexer supported	Requires power supply	8,800 – 18,000 \$
CS2350M	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	30 x 22 x 10 cm	Dual-channels (2 channels)	Not supported	No multiplexing	7,500 – 8,200 \$
CS350M	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV, EIS	± 10 V pA to mA	No	28 x 20 x 8 cm	Mono-channel	Not supported	No multiplexing	3,000 – 3,400 \$
CS2150M	CV, LSV, DPV, SWV, NPV, DNPV, CSV, ASV	± 10 V 2 nA to 2A	No	28 x 20 x 8 cm	Dual-channels (2 channels)	Not supported	No multiplexing	3,000 – 3,400 \$

• Kanopy

Kanopy Techno Solutions is a prominent organization specializing in electrochemical science and engineering. Established in 2014 by Joy Bhattacharjee alongside researchers from the Indian Institute of Technology (IIT) Kanpur, the company collaborates with multiple research laboratories across India to support the research and development of its diverse products [36].

Comprehensive solutions for electrochemical laboratory instruments and accessories, including potentiostats, galvanostats, electrodes and various electrochemical cells are provided in this company (Figure 5). This section discusses three instruments under the Potentiostat and Potentiostat/Galvanostat category: **K-Lyte 1.0**, **K-Lyte 1.2** and **K-Lyte 1.3** (also referred to as **PG-Lyte 1.0**). Detailed specifications for each instrument are provided below (Table 5):

1. Potentiostat:

- a) **K-Lyte 1.0** is an entry-level Potentiostat designed to support the initiation of electrochemistry research at both undergraduate and postgraduate levels. It offers fundamental potentiostatic techniques and is suitable for use in aqueous as well as most non-aqueous systems. The instrument has five current ranges from 1 μ A to 10 mA with an input Bias (leakage current) of $\pm$ 15pA. It offers a compliance voltage of $\pm$ 15 V, an applied voltage range of $\pm$ 2 V with a resolution $\leq$ 150 μ V and supports scan rates from 1 mV/s to 1000 mV/s.

K-Lyte software is a user-friendly application. It is lightweight and runs smoothly on Windows 7 and later versions. The software enables effective setting of experimental parameters for each technique and allows data to be viewed and saved both as images and in .xls/.csv format.

In the potentiostatic mode, three different experimental techniques are included: Linear Sweep Voltammetry, Cyclic Voltammetry and Chronoamperometry. The instrument is equipped with auto-

cut protection circuitry to safeguard the PCB from overvoltage and overcurrent conditions. The hardware consists of three main components: analog circuitry, digital circuitry and switching circuitry. **K-Lyte 1.0** operates on a 220 V AC power supply and consumes approximately 300 watts. An inbuilt cooling fan maintains the internal circuitry temperature. This device includes a USB connection cable for data transfer. It is powered via a standard **C13 IEC** connector.

A standard one-year warranty covering failure of any internal electronic components is provided. However, the main limitations for **K-Lyte 1.0** **include** its mono-channel operation and the absence of an internal battery, Bluetooth, wireless connectivity and internal storage.

- b) K-Lyte 1.2** is a high-end Potentiostat designed to perform a wide range of electroanalytical techniques relevant to physical electrochemistry, nanotechnology, corrosion studies and sensor applications. The instrument can accommodate both aqueous and non-aqueous systems, offering high sensitivity and the capability of recording electrical signals in the nanoampere range. Eight current ranges could be used from 100 nA to 1 A with an input Bias (leakage current) of $\pm 15\text{pA}$. It has a compliance voltage of $\pm 15\text{ V}$, applied voltage ranges of $\pm 5\text{ V}$ and $\pm 10\text{ V}$, a voltage resolution $\leq 150\text{ }\mu\text{V}$ and supports scan rates between $1\text{ }\mu\text{V/s}$ to 1000 mV/s .

K-Lyte 1.2 shares the same software, hardware features and calibration facilities as **K-Lyte 1.0**. However, it offers a broader range of experimental techniques compared to **K-Lyte 1.0**. This device is equipped with a USB connection cable for data transmission between the instrument and a computer, and it is powered using a standard **C13 IEC** connector. It comes with a one-year warranty that covers failures of internal electronic components. **K-Lyte 1.2** shares the same limitations as **K-Lyte 1.0**.

2. Potentiostat/Galvanostat:

- a) K-Lyte 1.3** (or referred to as **PG-Lyte 1.0**) is a high-end Potentiostat/Galvanostat designed to perform a wide range of electroanalytical techniques relevant to physical electrochemistry, nanotechnology, corrosion studies, sensor applications and battery research. Like **K-Lyte 1.0** and **K-Lyte 1.2**, the apparatus provides high sensitivity and capability to record electrical signals in nanoamperes.

This instrument allows switching between two measurement modes: Potentiostatic and Galvanostatic. The compliance voltage is $\pm 15\text{ V}$. For Potentiostatic mode, the applied voltage range is $\pm 5\text{ V}$ and $\pm 10\text{ V}$ with a voltage resolution is $\leq 150\text{ }\mu\text{V}$ and a scan rate ranging between $1\text{ }\mu\text{V/s}$ to 1000 mV/s . Eight current ranges are available from 100 nA to 1 A with an input Bias (leakage current) of $\pm 15\text{ pA}$. Concerning Galvanostatic mode, the applied current range is up to $\pm 1\text{ A}$ with an applied current resolution up to 15 nA and a scan rate between $1\text{ }\mu\text{A/s}$ to 1000 mA/s .

K-Lyte 1.3 maintains the software, hardware features, calibration facilities, cable connections, warranty and limitation found in both **K-Lyte 1.0** and **K-Lyte 1.2**. In addition, this device designed for mono-channel applications supports the widest range of experimental techniques. Finally, the supplier recommends the **K-Lyte Z** model for electrochemical impedance measurements (EIS).

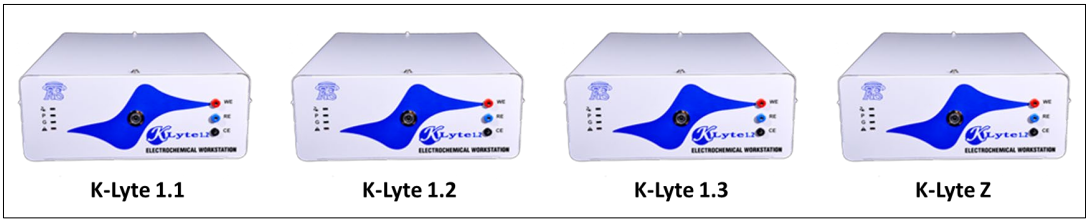


Figure 5. Main electrochemical workstations supplied by Kanopy Tech. (potentiostats/galvanostats).

Table 5. Main electrochemical instruments supplied by Kanopy Techno Solutions: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Supported methods	Specifications	Portable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Limitations	Price range
Kanopy Techno Solutions (India)	K-Lyte 1.0	LSV, CV, CA	± 2.0 V 1 μ A to 10 mA	No	32 x 22 x 9 cm	Mono-channel	Not supporting	No integrated multiplexing and limited to a single channel No Battery included No Bluetooth or wireless connectivity Exposing instruments to wet environments. Currents and voltages exceeding the mentioned specifications. Operating at low (< 0 °C) or high temperatures (> 50 °C)	
	K-Lyte 1.2	LSV, CV, CA, OCP, Tafel Analysis, LP, SCP, NPV, DPV, SWV, I-V_Plot	± 5 V, ± 10 V 100 nA to 1 A	No	32 x 22 x 9 cm	Mono-channel	Not supporting	Same as K-Lyte 1.0	
	K-Lyte 1.3 (or referred to as PG-Lyte 1.0)	LCV, CV, CA, OCP, Tafel Analysis, LP, SCP, NPV, DPV, SWV, I-V_Plot, LCV, CV, CP, GCD	± 5 V, ± 10 V 100 nA to 1 A	No	32 x 22 x 9 cm	Mono-channel	Not supporting	Same as K-Lyte 1.0	

• PalmSens / HTDS

PalmSens BV was founded in 2001 by Dr. Kees Van Velzen, a key figure in the digitization of potentiostats during the late 1980s and 1990s. **PalmSens BV** was the first company to develop a research-grade potentiostat compact enough to fit in a pocket. It is committed to making electrochemistry more accessible, more portable, and user-friendly for researchers and entrepreneurs. The company offers a wide range of instruments suitable for various electrochemical applications, with a strong emphasis on mobility [37]. In collaboration with **Analog Devices**, **PalmSens BV** produces the **EmStat Pico**, the world’s smallest commercially available potentiostat module with EIS capabilities. This section categorizes instruments into three groups (Figure 6): Premium potentiostats, research potentiostats and potentiostats for applications. Further details are provided below (Table 6):

1) Premium Potentiostats:

a) Nexus

Nexus incorporates the latest technological advancements, utilizing a high-performance dual-core microcontroller to enable rapid, continuous measurements while efficiently managing data storage. It provides current ranges from 100 pA to 1 A (11 ranges, with femtometer resolution) with a compliance voltage of ± 12 V. It supports a wide range of electrochemical techniques, including Electrochemical Impedance Spectroscopy (EIS) up to 1MHz. It features a data acquisition rate of up to 1 μ s and 32 GB of internal for extended measurements. The device includes an optional built-in bipotentiostat functionality, enabling experiments such as rotating ring-disc and scanning electrochemical microscopy that require a second working electrode. It features **MethodSCRIPT**, a scripting language developed by PalmSens that allows users to write custom scripts, providing full

control over experimental protocols. **Nexus** operates via Ethernet and USB cables. Moreover, it functions with **PSTrace** free software platform that is compatible with all **PalmSens** potentiostats. **PSTrace** has three modes: scientific, corrosion and analytical modes. Limitations include the absence of multi-channel capabilities, lack of battery operation and portability.

b) **PalmSens4**

The **PalmSens4** is an economical, portable, fully equipped laboratory instrument. It is a potentiostat, galvanostat and optionally an FRA / EIS with maximum frequency of 100 kHz or 1MHz, powered via USB or battery. Bluetooth connectivity enables fully floating measurements. It offers a wide potential range (± 5 or ± 10 V) and a current range from 100 pA to 10 mA (for Potentiostat) and 1 nA to 10 mA (for Galvanostat), providing high resolution with less noise. **PalmSens4** supports several electrochemical techniques such as: voltammetric, pulsed, amperometric, galvanostatic, mixed mode and EIS/GEIS. This device can be configured with a bipotentiostat module to enable measurements using a second working electrode. An optional iR Compensation module is available, providing positive feedback to correct the iR-drop between Reference electrode and the outside of the double layer of the electrochemical cell. **PalmSens4** functions with the same software (**PSTrace**) as **Nexus**. By default, the **PalmSens4** operates as a single-channel device. However, by adding external multiplexers - **MUX8-R2** (8 channels) and **MUX16** (16 channels) – the device can perform measurements on up to 8 and 16 electrodes respectively.

c) **MultiPalmSens4**

MultiPalmSens4 is a versatile multi-channel potentiostat, galvanostat, and impedance analyzer that can be configured to meet specific requirements and budgets. **MultiPalmSens4** supports the same electrochemical techniques as **PalmSens4**. By default, the **MultiPalmSens4** operates as a single-channel device, but it can be extended to 8 channels with the addition of external the multiplexer **MUX8-R2**. Additionally, each channel includes an auxiliary port for controlling external devices or monitoring temperature and other analog signals. These channels can be configured with ± 5 V or ± 10 V potential range, 100 pA to 10 mA, EIS/FRA with maximum frequency of 100 kHz or 1 MHz, bipotentiostat module for use with a second Working Electrode, iR-compensation add-on module and galvanic isolation. **MultiTrace** software enables each channel to be operated individually, simultaneously, or in automated sequences. However, this device is not portable, lacks internal battery and Bluetooth connectivity with a limited current range.

2) **Research Potentiostats:**

a) **MultiEmStat4**

The **MultiEmStat4** is a compact potentiostat, galvanostat and optional frequency response analyzer for electrochemical impedance spectroscopy (up to 200 kHz) available with 4, 8 or 12 channels. It is offered in two versions: a low range version (**LR**), ideal for applications requiring measurement of low currents down to the picoampere range, and a high range version (**HR**) suitable for applications requiring high currents with a maximum capacity up to 200 mA. It supports the following electrochemical techniques: voltammetric, pulsed, amperometric, galvanostatic, mixed mode and EIS/GEIS. **MultiEmStat4** operates via Ethernet and USB cables and is supplied with **MultiTrace** software that enables the device to function in two modes: individual or simultaneous channel control.

b) **EmStat4X**

The **EmStat4X** is a compact potentiostat, galvanostat and optional frequency response analyzer for electrochemical impedance spectroscopy (up to 200 kHz), powered via battery or USB connection. It also offers two ranges: low and high ranges. The low range version (**LR**) is suitable for applications requiring the measurement of low currents down to picoampere level, such as biosensor. The high range version (**HR**) is used for applications requiring high currents with a maximum capacity up to 200 mA. These two ranges have several features including fast EIS capabilities, allowing fixed-frequency EIS measurements with intervals as short as 1 ms. Moreover, auxiliary ports are present enabling them to connect to multiplexers such as **MUX8-R2**, temperature and pH sensors, stirrers

and external triggers. iR compensation corrects the voltage drop occurring between the reference electrode and the exterior of the electrochemical cell's double layer. **EmStat4X** can be operated using **PSTrace** software or controlled from any platform or operating system by using **MethodSCRIPT** commands.

c) **EmStat4 MUX**

EmStat4 MUX is a versatile semi-portable potentiostat, galvanostat and impedance analyzer (up to 200 MHz) that supports all popular electrochemical techniques. It features a compliance potential of ± 5 V and supports a current range between 1 nA and 10 mA. It is also known as a two in one potentiostat with an integrated multiplexer. When **EmStat4 MUX** is paired with **MUX8-R2**, it can provide 8 channels, enabling sequential measurements for up to 8 working electrodes. By stacking additional **MUX8-R2** modules, the system can be expanded to 128 channels. This instrument operates in two modes: consecutive and alternate modes. Consecutive mode switches to the next channel after completing a full measurement on the current channel, whereas the alternate mode cycles through all active channels within a defined measurement interval. There are four options to connect the sensor: double-shielded sensor cables, high-density cable, screw terminal and screen-printed electrode connector. **EmStat4 MUX** can be operated using **PSTrace** software or controlled from any platform or operating system by using **MethodSCRIPT** commands. However, it lacks Bluetooth and wireless connectivity.

d) **EmStat4R**

EmStat4R is a portable battery or USB-powered Potentiostat, Galvanostat and optional frequency response analyzer for electrochemical impedance spectroscopy. It is suitable for sensor applications requiring low current ranges. Like previous devices, it can be operated using **PSTrace** software or using **MethodSCRIPT** commands. An Android application "**PStouch**" is also provided. The **EmStat4R** is offered with either a cell cable or a screen-printed electrode connection module. Both configurations can be equipped with optional EIS/FRA capabilities up to 200 kHz. **EmStat4R** is powered by USB cable or LiPo battery. Nevertheless, it is limited to a single channel and a narrow current range compared to other devices.

e) **EmStat4S**

EmStat4S operates as a USB-powered potentiostat, galvanostat and optional frequency response analyzer for electrochemical impedance spectroscopy (up to 200 kHz). **EmStat4S** can be controlled using **PSTrace** Windows or through custom **MethodSCRIPT**, enabling control from any platform or operating system. Two versions are available, the **LR** and **HR** models for low/high currents and potentials respectively. Nonetheless, it has several limitations: it is restricted to a single channel, lacks an internal battery, does not offer Bluetooth or wireless connectivity and has a limited current range.

3) **Potentiostats for Applications:**

a) **Sensit Wearable**

Sensit Wearable, a compact portable potentiostat, accelerates the development of new electrochemistry-based wearable sensors. Flexible, wearable electrochemical sensors such as those integrated on the skin's surface. **Sensit Wearable** has many applications: continuous glucose monitoring, sweat analysis of athletes and molecular biomarkers. It supports the most common electrochemical techniques and is built around the **EmStat Pico Core** capable of EIS up to 200 kHz. It has a potential range from -1.7 V to $+2.0$ V and a current range from 100 nA to 5 mA ($\max \pm 3$ mA). **Sensit Wearable** comes with accessories that work with one or two working electrodes, a reference electrode and a counter electrode. It is wireless and includes Bluetooth connectivity as well as a battery for portable use. However, it has a limited battery life, a constrained current and potential and a restricted mono-channel measurement with no built-in multiplexing.

b) **Sensit BT**

The **Sensit BT** is well suited for electrochemical sensor applications. It is a portable potentiostat wirelessly connected to a smartphone or a tablet and is operated using the Android App "**PStouch**". A USB cable port can be used for charging or connecting to a PC to control the Sensit BT via the

PSTrace software. It supports a wide range of commonly used electrochemical techniques including Cyclic Voltammetry, Square Wave Voltammetry and electrochemical impedance spectroscopy (FRA/EIS). Two versions are supplied: The **Sensit (SPE)** and the **Sensit BT (SNS)**. The **Sensit (SPE)** allows sequential measurements on two separate Screen-Printed Electrodes whereas the **Sensit BT (SNS)** comes with a lead connected to the working electrode of channel 2 enabling immediate Bipotentiostat measurements out of the box. It is equipped with 500 MB internal storage memory.

c) Sensit Smart

Sensit Smart is built around the **EmStat Pico** potentiostat module and can be plugged into a smartphone or tablet via USB cables. It is portable and controlled via **PSTrace** software. Like **Sensit BT**, **Sensit Smart** supports the commonly used electrochemical techniques and offers the same potential and current ranges. However, **Sensit Smart** is limited to mono-channel operation with no internal battery, Bluetooth, wireless connectivity and internal storage.

Table 6. Main electrochemical instruments supplied by PalmSens B.V.: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Supported methods	Specifications	Portable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Limitations	Price range
PalmSens B.V. (Netherlands)	Nexus	LSV, CV, FCV, ACV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, EIS/GEIS	± 10 V 100 pA to 1 A (for potentiostat) 1 nA to 1 A (for galvanostat)	No	20 x 21 x 4.5 cm	Mono-channel	Not supporting	No integrated multiplexing and limited to a single channel No internal battery and Bluetooth connectivity Not portable	
	PalmSens4	LSV, CV, FCV, ACV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, MPAD, LSP, CP, MP, OCP, SCP, MM, EIS/GEIS	± 5 V or ± 10 V 100 pA to 10 mA (for potentiostat) 1 nA to 10 mA (for galvanostat)	Yes	15.7 x 9.7 x 3.5 cm	Mono-channel	Multiplexer supporting: MUX8-R2 (8 channels) MUX16 (16 channels)	Limited current range Multichannel measurements require external multiplexers Battery life constraints	
	MultiPalmSens4	Same as PalmSens4	± 5 V or ± 10 V 100 pA to 10 mA (for potentiostat) 1 nA to 10 mA (for galvanostat)	No	15 x 25 x 25 cm	Mono-channel	Multiplexer supporting: MUX8-R2 (8 channels)	Limited current range Not portable No internal battery and Bluetooth connectivity	
	MultiEmStat4	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, PAD, LCP, CP, MP, OCP, MM, EIS/GEIS	± 3 V (for LR) and ± 6 V (for HR) 1 nA to 10 mA (8 ranges for LR) and 100 nA to 100 mA (7 ranges for HR)	No	21.2 x 22.1 x 7.7 cm	Multi-channels (4, 8 or 12 channels)	Supporting	Limited current range Not portable No internal battery and Bluetooth connectivity	
	EmStat4X	LSV, CV, FCV, ACV, DPV, SWV, NPV, CA, ZRA, CC, MA, PAD, LCP, CP, MP, OCP, MM, EIS/GEIS	Same as MultiEmStat4	Yes	11.4 x 8.0 x 4.5 cm	Mono-channel	Multiplexer supporting:	Limited current range	

	DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS/GEIS, FEIS/FGEIS							MUX8-R2 (8 channels)
EmStat4 MUX	LSV, CV, FCV, ACV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, MPAD, LSP, CP, MP, OCP, SCP, MM, EIS/GEIS, FEIS/FGEIS	± 3 V 1 nA to 10 mA	Yes	13.8 x 12.1 x 3.7 cm	Multichannels (8 channels)	Supporting	No internal Battery	No Bluetooth and wireless connectivity
EmStat4R	LSV, CV, FCV, ACV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LSP, CP, MP, OCP, MM, EIS/GEIS, FEIS/FGEIS	± 3 V 1 nA to 10 mA	Yes	Alumium body only: 11.1 x 6 x 2.7 cm With rubber sleeve: 11.8 x 6.8 x 3.3 cm	Mono-channel	Not supporting	No integrated multiplexing and limited to a single channel Limited current range	
EmStat4S	Same as EmStat4X	Same as MultiEmStat4	Yes	7.2 x 5.5 x 2.6 cm	Mono-channel	Not supporting	No integrated multiplexing and limited to a single channel No internal battery No Bluetooth and wireless connectivity Limited current range	
Sensit Wearable	LSV, CV, DPV, SWV, NPV, CA, MA, PAD, MM, OCP, EIS	- 1.7 V to + 2 V 100 nA to 5 mA	Yes	35 x 35 x 12 mm	Mono-channel	Not supporting	No integrated multiplexing and limited to a single channel Battery life constraints Limited current-potential range	
Sensit BT	LSV, CV, DPV, SWV, NPV, CA, MA, PAD, OCP, EIS	Same as Sensit Wearable	Yes	75 x 55 x 23 mm	Mono-channel, but certain configurations allow two-working electrode (BiPot)	Not supporting	Battery life constraints Limited current-potential range	

							No integrated multiplexing and limited to a single channel
							No internal battery
							No Bluetooth and wireless connectivity
							No internal storage
Sensit Smart	Same as Sensit Wearable	Same as Sensit Wearable	Yes	43 x 25 x 11 mm	Mono channel	Not supporting	



Figure 6. Main electrochemical workstations supplied by HDTS / PalmSens (potentiostats/galvanostats).

• **GAMRY Instruments.**

GAMRY Instruments is an American company founded in 1989 with headquarters based outside of Philadelphia, Pennsylvania, USA. It specializes in designing and manufacturing precision electrochemical instrumentation and their accessories [38]. GAMRY claims to be the first company to:

- Integrate a potentiostat into a computer.
- Run a potentiostat on Microsoft Windows.
- Add Electrochemical Impedance Spectroscopy (EIS) to a potentiostat without external hardware.
- Offer fully customizable software for electrochemical experiments (using their Explain™ language).

GAMRY’s focus on performance, reliability, and customer satisfaction has driven their growth and solidified their position in the electrochemistry research market. They currently have distributors and representatives in more than 50 countries worldwide. They commercialize and resell the PTC range of high end potentiostats and galvanostats manufactured by Kolibri, which is a company founded and based in the Czech Republic. More importantly, GAMRY produces its own lines of high-end instruments like the interface and the reference range of devices (Figure 7), as well as the usb-like **GAMRY PAL** (Table 7).

The Interface Family

The **Interface 1010E** is a full-featured potentiostat capable of performing all techniques, including electrochemical impedance spectroscopy, for applications such as physical electrochemistry, electrochemical corrosion, battery testing, fuel cell testing, dye solar cell testing, and

sensor development. It can operate as a potentiostat, galvanostat, Zero Resistance Ammeter (ZRA) and it is Floating (Isolated from Earth Ground). It supports methods such as EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel. It operates using Gamry's proprietary software Virtual Front Panel™ and eChem Toolkits™. It is a portable device as it only weighs around 3 kg with a size of 24 cm × 6 cm × 27 cm. It has a max applied current of ± 1 A, maximum applied potential of ± 12 V and EIS ranging from 10 μHz to 2 MHz. It can operate as a single-channel potentiostat, bipotentiostat, or multichannel-potentiostat. It is also compatible with Gamry ECM8 Electrochemical Multiplexer.

The **Interface 1010B** is a general-purpose potentiostat for cyclic voltammetry or similar studies for basic research such as determining redox potentials, reaction mechanisms, diffusion coefficients, rate constants and electrochemical surface area. It can also run electrochemical plating and electrodeposition experiments or experiments for determining concentrations of trace analytes in solution. It is a potentiostat, galvanostat, ZRA and it is Floating (Isolated from Earth Ground). It supports methods such as EIS, CV, CA, CP, CC, NPV, CYP, SWV, EFM using the software eChem Toolkits™. It is a portable device weighing only 3 kg with a size of 24 cm × 6 cm × 27 cm. It has a max applied current of ± 1 A, maximum applied potential of ± 12 V and EIS ranging from 10 μHz to 20 kHz. It can operate as a single-channel potentiostat, bipotentiostat, or multichannel-potentiostat but it cannot be used in multiplexing.

The **Interface 1010T** is an entry-level potentiostat designed for undergraduate and graduate teaching labs. It provides all of the capabilities needed for getting students introduced to physical and analytical electrochemistry. It is a potentiostat, galvanostat, ZRA and Floating (Isolated from earth ground). It supports methods such as EIS, CV, CA, CP, NPV, SWV. It is a portable device weighing only 2 kg with a size of 24 cm × 6 cm × 27 cm. It has a max applied current of ± 100 mA, maximum applied potential of ± 5 V and EIS ranging from 10 μHz to 20 kHz. It can only operate as a single-channel potentiostat and it cannot be used in multiplexing.

The **Interface 5000P/E** are fully-featured potentiostats/galvanostats for battery testing. They are also ideally designed for testing of fuel cells and supercapacitors, cell-level testing of various energy storage and conversion devices and include capabilities for monitoring both half-cell voltages in addition to the whole cell voltage during an experiment due to having a dual electrometer, which allows for monitoring both the anode and cathode in addition to the entire cell in charge/discharge experiments and EIS experiments. They both can operate as a potentiostat, galvanostat or ZRA, supporting methods such as EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel. They operate using eChemDC Toolkit and eChemAC software and are portable devices as they only weigh around 3 kg with a size of 24 cm × 6 cm × 27 cm. They both have dual electrometer, a max applied current of ± 5 A, maximum applied potential of ± 6 V and EIS ranging from 10 μHz to 2 MHz for the **5000E** and from 10 μHz to 20 kHz for the **5000P**. They can operate as a multichannel-potentiostat with up to eight potentiostats in a single chassis and they are also compatible with Gamry ECM8 Electrochemical Multiplexer.

The Reference family

The **Reference 620** is a high-performance, research-grade potentiostat / galvanostat / ZRA designed for fast, low-current measurements. It can be used in a variety of applications such as physical electrochemistry (especially at microelectrodes), fast cyclic voltammetry, electrochemical corrosion, electrochemical noise measurements, paints and coatings, and sensors. It has a number of auxiliary input and outputs designed to help interfacing with other equipment. It also has a thermocouple input for temperature measurements. It can operate as a potentiostat, galvanostat, Zero Resistance Ammeter (ZRA) and it is Floating (Isolated from Earth Ground). It supports methods such as EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel. It operates using eChemDC Toolkit and eChemAC software. It is a portable device as it only weighs around 3 kg with a size of 19 cm × 9 cm × 27 cm. It has a max applied current of ± 600 mA, maximum applied potential of ± 11 V and EIS ranging from 10 μHz to 5 MHz. It can operate as a single-channel potentiostat or as a bipotentiostat. It is also compatible with Gamry ECM8 electrochemical multiplexer.

The **Reference 3000** is a high-performance potentiostat / galvanostat / ZRA that is very useful for battery, capacitor, or fuel cell development, as well as general electrochemical measurements requiring higher currents. It can operate as a potentiostat, galvanostat, zero resistance ammeter (ZRA) and it is Floating (isolated from earth ground). It supports the same methods as the Reference 620, namely, EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel. It operates using eChemDC Toolkit and eChemAC software. It is not considered as a portable device as, although it is light at 7 kg with a size of 20 cm × 23 cm × 30 cm, it requires a computer and an external power supply which makes it more suitable for laboratory use than field work. It has a max applied current of ± 3 A at 15V or ± 1.5 A at 32V, maximum applied potential of ± 32 V and EIS ranging from 10 μ Hz to 1 MHz. It can operate as a single-channel potentiostat, bipotentiostat, or multichannel-potentiostat. It is also compatible with Gamry ECM8 Electrochemical Multiplexer.

The **Reference 3000AE with Auxiliary Electrometer** is a high-performance potentiostat / galvanostat / ZRA just like the Reference 3000 but the Reference 3000 AE features eight additional electrometers and is ideal for battery, capacitor, and fuel cell development. It features eight additional voltage measurements which makes it ideal for testing of multiple cells within a stack or measuring auxiliary voltages from devices such as pressure gauges or pH meters. It can operate as a potentiostat, galvanostat, zero resistance ammeter (ZRA) and it is Floating (isolated from earth ground). It supports the same methods as the Reference 620 and Reference 3000, namely, EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel. It operates using eChemDC Toolkit and eChemAC software. Although it is not overly heavy and with a size of 20 cm × 23 cm × 30 cm it is not considered as a portable device. as it requires a computer and an external power supply which makes it more suitable for laboratory use than field work. It has a max applied current of ± 3 A at 15V or ± 1.5 A at 32V, maximum applied potential of ± 32 V and EIS ranging from 10 μ Hz to 1 MHz. It can operate as multichannel-potentiostat using the eight additional voltage measurements. It is also compatible with Gamry ECM8 Electrochemical Multiplexer.

The GAMRY PAL

The **GAMRY PAL** is compact potentiostat made with portability and utility in mind as it has the size of a USB flash drive measuring only 29 mm in length. It's powerful enough for teaching voltammetry in a hands-on classroom with screen-printed electrodes. It is also capable of performing lightweight laboratory testing using the optional cell cable. The required software Gamry Pal Suite is included. It supports methods such as CV, CA, CP, NPV, LSV, CYP, SWV, OCP. It has a max applied current of 30 mA at ± 1.5 V or 20 mA at ± 2.5 V, maximum applied potential of ± 2.5 V and EIS ranging from 100 mHz to 100 kHz. It can only operate as a single-channel potentiostat and it cannot be used in multiplexing.



Figure 7. Main electrochemical workstations supplied by GAMRY instruments (potentiostats/galvanostats).

Table 7. Main electrochemical instruments supplied by GAMRY instruments: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Instrument Type	Software	Supported methods	Specifications	Portable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Limitations	Price range
GAMRY Instruments (USA)	Interface 1010E	Potentiostat, galvanostat, ZRA	Virtual Front Panel™ and eChem Toolkits™	EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel	Max Applied Current - ±1 A Maximum Applied Potential - ±12 V EIS 10 µHz - 2 MHz	Yes	24 × 6 × 27 cm	single-channel potentiostat, bipotentiostat, or multichannel-potentiostat	ECM8 Multiplexer compatible	High cost for each module	~\$11,000
	Interface 1010B	Potentiostat, galvanostat, ZRA	eChem Toolkits™	EIS, CV, CA, CP, CC, NPV, CYP, SWV, EFM	Max Applied Current - ±1 A Maximum Applied Potential - ±12 V EIS 10 µHz - 20 kHz	Yes	24 × 6 × 27 cm	single-channel potentiostat, bipotentiostat, or multichannel-potentiostat	No		~\$6500
	Interface 1010T	Potentiostat	No	EIS, CV, CA, CP, NPV, SWV	Max Applied Current - ±100 mA Maximum Applied Potential - ±5 V EIS 10 µHz - 20 kHz	Yes	24 × 6 × 27 cm	No	No	Designed for undergraduate and graduate teaching labs	~\$2500
	Interface 5000E/P	Potentiostat, galvanostat, ZRA	eChemD C Toolkit and eChemA C	EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel	Max Applied Current - ±5A Maximum Applied Potential - ±6 V EIS 10 µHz - 1 MHz/20kHz	Yes	24 × 6 × 27 cm	Yes. Up to eight potentiostats in a single chassis	ECM8 Multiplexer compatible	Potential issues with low impedance battery measurements due to contact resistance	~\$7000
	Reference 620	Potentiostat, galvanostat, ZRA	eChemD C Toolkit and eChemA C	EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel	Max Applied Current - ±600 mA Maximum Applied Potential - ±11 V EIS 10 µHz - 5 MHz	Yes	9 × 19 × 27 cm	single-channel potentiostat, bipotentiostat	ECM8 Multiplexer compatible	cell resistance, and external interference can impact measurement accuracy in the low current regime	~\$
	Reference 3000	Potentiostat, galvanostat, ZRA	eChemD C Toolkit and eChemA C	EIS, CV, CA, CP, NPV, CYP, SWV, EFM	±3 A@15V or ±1.5A@32V Maximum Applied	Yes	20 × 23 × 30 cm	Single-channel potentiostat, bipotentiostat, or	ECM8 Multiplexer compatible	limitations in its lowest measurable impedance and phase noise,	~\$10,000

		CPT, Tafel	Potential - ± 32 V EIS 10 μ Hz - 1 MHz			multichannel-potentiostat	particularly when combined with the ECM8 multiplexer	
Reference 3000 with Auxiliary Electrometer (w/AE)	Potentiostat, ZRA	eChemD C Toolkit and eChemA C	EIS, CV, CA, CP, NPV, CYP, SWV, EFM, CPT, Tafel	± 3 A@15V or ± 1.5 A@32V Maximum Applied Potential - ± 32 V EIS 10 μ Hz - 1 MHz	Yes	20 $\times$ 23 $\times$ 30 cm	Eight additional voltage measurements w/AE	ECM8 Multiplexer compatible
				30 mA at ± 1.5 V or 20 mA at ± 2.5 V				
Gamry PAL	Compact Potentiostat	Gamry Pal Suite	CV, CA, CP, NPV, LSV, CYP, SWV, OCP	Maximum Applied Potential - ± 2.5 V EIS 100 mHz - 100 kHz	Yes	USB-like, Length 29 mm	No	No
							Limitations in voltage and current ranges	~\$

• **AMETEK Scientific Instruments via Princeton Applied Research and Solatran**

AMETEK Scientific Instruments, headquartered in the United States, engineers high-performance potentiostats and potentiostat/galvanostats tailored for a broad spectrum of electrochemical research (Figure 8), from corrosion and sensor development to energy storage and battery science (Table 8). All devices operate with the company’s VersaStudio or PowerSuite software and connect via wired USB or ethernet; none are battery-powered or Bluetooth-enabled. Here’s a clear, narrative summary of their key instruments [39]:

﷥ **VersaSTAT3A**

The VersaSTAT3A is a compact, single-channel potentiostat/galvanostat (24 $\times$ 17 $\times$ 8 cm) with ± 12 V compliance and a current range spanning 2 pA to 2 A. It covers core electrochemical methods such as: LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM and includes EIS. It connects via cable, is strictly bench-top, and does not support multiplexing.

﷥ **VersaSTAT3**

The VersaSTAT3 offers the same capabilities but has a slightly narrower current range, starting at 100 pA. Like its sibling, it remains a non-portable, single-channel instrument without multiplexing.

﷥ **VersaSTAT3F**

Designed for high sensitivity, the VersaSTAT3F pushes the lower current limit to 400 fA while maintaining the broader ± 12 V range and rich method support including EIS. It remains a mono-channel bench-top instrument without multiplexing options.

﷥ **VersaSTAT4A and VersaSTAT4**

Stepping up the performance, both the VersaSTAT4A and VersaSTAT4 extend the compliance to ± 20 V and handle currents from 4 fA to 4 A in a slightly larger 27 $\times$ 22 $\times$ 10 cm frame. The “A” model features enhanced electronics for improved stability and broader dynamic range. Both maintain full method versatility (including EIS), function as single-channel units, and do not support multiplexing.

﷥ **PARSTAT 3000A and PARSTAT 4000A**

For higher-power applications, the PARSTAT 3000A delivers ± 30 V compliance and up to 20 A of current in a desktop unit (30 $\times$ 25 $\times$ 12 cm). It supports all listed electrochemical methods including

EIS but remains a single-channel, cable-powered instrument with no multiplexing capability. Its counterpart, the PARSTAT 4000A, provides similar voltages with a current limit of 4 A.

❧ **1287A**

The 1287A is well known for its low-noise precision performance. It operates up to ± 20 V (or ± 14.5 V in certain configurations) and supports 100 pA to 2 A current. Like the others, it remains a bench-top, single-channel device without multiplexing support.

❧ **EnergyLab XM, EchemLab XM, and ModuLab XM ECS**

EnergyLab XM, EchemLab XM, and ModuLab XM ECS models are configurable electrochemical workstations that can be scaled to multiple channels. These systems support up to ± 20 V and currents from femtoamperes to amperes per channel, with full method support including EIS. Users can incorporate a MUX-12 multiplexer to run multiple working electrodes. These are entirely bench-top and must be custom-configured at installation.

❧ **CellTest multichannel potentiostat**

The CellTest Multichannel Potentiostat is purpose-built for high-throughput battery testing. With a flexible channel count (typically several units in a rack), it delivers independent control of voltage and current across each cell and supports methods such as CV, EIS, CA, CP, and OCV. It uses wired connections and is fully modular in design.

❧ **PARSTAT MC**

The PARSTAT MC is a multi-channel setup capable of housing up to 16 independently operated potentiostat/galvanostat modules. Each module supports the full method suite and EIS, connecting via cables and managed through PowerSuite software. No multiplexing is required, as each channel is truly independent.

❧ **PARSTAT 3000A-DX**

The PARSTAT 3000A-DX expands on the standard 3000A by adding front-end modularity and advanced signal management. It maintains all supported techniques, including EIS, and is engineered for applications where signal clarity and configurability are key. Though each module is single-channel, the system's overall architecture allows for considerable scalability.

In summary, AMETEK's electrochemical instruments provide a wide spectrum of solutions, from basic single-channel potentiostats to complex, multi-channel modular systems meeting the demands of both routine analysis and advanced research.



Figure 8. Main electrochemical workstations supplied by AMETEK Scientific Instruments via Princeton Applied Research and Solatron (potentiostats/galvanostats).

Table 8. Main electrochemical instruments supplied by AMETEK Scientific Instruments via Princeton Applied Research and Solatron: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Instrument Name	Supported Methods	Specifications (Ranges)	Portable	Size (cm)	Channels (Number)	Multiplexing (Multiplexer Name)	Limitations	Price Range (USD)
VersaSTAT3 A	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±12 V; Potential Range: ±10 V; Current Range: 2 pA to 2 A	No	24 x 17 x 8	Mono-channel (1)	Not supported	No internal battery; not portable	\$15,000 – \$20,000
VersaSTAT3 ZRA	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±12 V; Potential Range: ±10 V; Current Range: 100 pA to 2 A	No	24 x 17 x 8	Mono-channel (1)	Not supported	No internal battery; not portable	\$13,000 – \$18,000
VersaSTAT3 F	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±12 V; Potential Range: ±10 V; Current Range: 400 fA to 2 A	No	24 x 17 x 8	Mono-channel (1)	Not supported	No internal battery; not portable	\$15,000 – \$20,000
VersaSTAT4 A	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD,	Compliance Voltage: ±20 V; Potential Range: ±20 V;	No	27 x 22 x 10	Mono-channel (1)	Not supported	No internal battery; not portable	\$22,000 – \$28,000

	LCP, CP, MP, OCP, MM, EIS	Current Range: 4 fA to 4 A							
VersaSTAT4	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±20 V; Potential Range: ±20 V; Current Range: 4 fA to 4 A	No	27 x 22 x 10	Mono-channel (1)	Not supported	No internal battery; not portable	\$22,000 – \$28,000	
PARSTAT 3000A	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±30 V; Potential Range: ±30 V; Current Range: 4 fA to 20 A	No	30 x 25 x 12	Mono-channel (1)	Not supported	No internal battery; not portable	\$30,000 – \$40,000	
PARSTAT 4000A	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±30 V; Potential Range: ±30 V; Current Range: 4 fA to 4 A	No	30 x 25 x 12	Mono-channel (1)	Not supported	No internal battery; not portable	\$30,000 – \$40,000	
1287A	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±14.5 V or ±20 V; Potential Range: 100 µV to 14.5 V/ 20 V ; Current Range: 100 pA to 2 A	No	26 x 17 x 10	Mono-channel (1)	Not supported	No internal battery; not portable	\$18,000 – \$25,000	
EnergyLab XM	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Modular system; Potential: up to ±20 V; Current: fA to A (user configurable)	No	Modular system (varies)	Mono-channelsupportin g multiplexer	Yes (Multiplexer: MUX-12)	Requires configuration; not portable	\$50,000 – \$80,000	
EchemLab XM	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Modular system; Potential: up to ±20 V; Current: fA to A (user configurable)	No	Modular system (varies)	Mono-channelsupportin g multiplexer	Yes (Multiplexer: MUX-12)	Requires configuration; not portable	\$50,000 – \$80,000	
ModuLab XM ECS	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, FAM, PAD, LCP, CP, MP, OCP, MM, EIS	Compliance Voltage: ±20 V; Potential Range: ±20 V; Current: fA to A (configurable)	No	Modular system (varies)	Mono-channelsupportin g multiplexer	Yes (Multiplexer: MUX-12)	Requires configuration; not portable	\$60,000 – \$90,000	
CellTest Multichannel	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, PAD, LCP, CP, MP, OCP, MM, EIS	Modular; ±20 V; Current range: fA to A (per channel, user configurable)	No	Modular system (varies)	Multi-channel (up to 16)	Yes (MUX-12 or custom options)	Requires configuration; not portable	\$80,000 – \$150,000	
PARSTAT MC	LSV, CV, DPV, SWV, NPV, CA, ZRA, CC, MA, PAD, LCP, CP, MP, OCP, MM, EIS	±20 V; Current range: fA to 2 A (user selectable per channel); EIS on all channels	No	45 × 40 × 20 (per unit)	Multi-channel (up to 16)	Yes (MUX-12 or MUX-16)	Requires configuration; not portable	\$100,000 – \$160,000	

PARSTAT 3000A-DX	LSV, CV,							
	DPV, SWV,	±30 V						
	NPV, CA,	compliance;						
	ZRA, CC, MA,	Current range:	No	35 × 30 × 15	two-channel (2)	Not supported	No internal battery; not portable	\$40,000 – \$60,000
	PAD, LCP,	4 nA to 2 A;						
	CP, MP, OCP,	High-speed EIS						
	MM, EIS							

• **Phadke Instruments**

Phadke Instruments Pvt. Ltd. is an Indian company, based in Mumbai, that was established in 2005 [40]. They specialize in the supply and distribution of analytical and research instruments by providing equipment for electrochemistry, spectroscopy, and materials science, with a strong emphasis on serving research, academia, and industry sectors. Their range of products covers electrochemistry equipment, water and soil testing tools, energy-related instruments, sample preparation devices, and spectroscopy equipment (Figure 9).

Phadke represents several leading international manufacturers and commercializes and resells their high end potentiostats, galvanostats and Zero Resistance Ammeters (ZRAs) like the Zennium range (Zhanner, Germany), the Squidstat range (Admiral Industries, USA), AMEL’s range of multichannel potentiostats (AMEL, Italy) and the Galvanoplot range of compact potentiostats (SolarBiotec, Turkey).

Phadke Instruments manufactures its own, relatively low-cost, family of **PhadkeSTAT 20** potentiostats. They can mainly be used for basic electrochemical research, biosensor research, corrosion inhibitor research, photoelectrochemistry research, electrochemical deposition, trace analysis, and teaching (Table 9).

As shown in the Table below, all 5 variations of **PhadkeSTAT 20** potentiostats are portables as they share the same small physical size (105mm x 132mm x 55mm) and weigh only 400 g each. The current ranges between 200 nA and 20 mA, the voltage has a range of ± 2 V but they do not support EIS measurements. They all use the EC-Prayog software for their operation which is a Windows-based software that allows for communication between the potentiostat and the computer. They are all single channels and do not support multiplexing. The difference between them lies only in the methods and applications they support, as follows:

- PhadkeSTAT 20 Corr**
OCP, Tafel
- PhadkeSTAT 20 CV**
OCP, CV, LSV
- PhadkeSTAT 20 Basic**
OCP, Tafel, CV, LSV
- PhadkeSTAT 20 Standard**
OCP, Tafel, CV, LSV, CA
- PhadkeSTAT 20 Advanced**
OCP, Tafel, CV, LSV, CA, CC, NPV, SWV, DPV

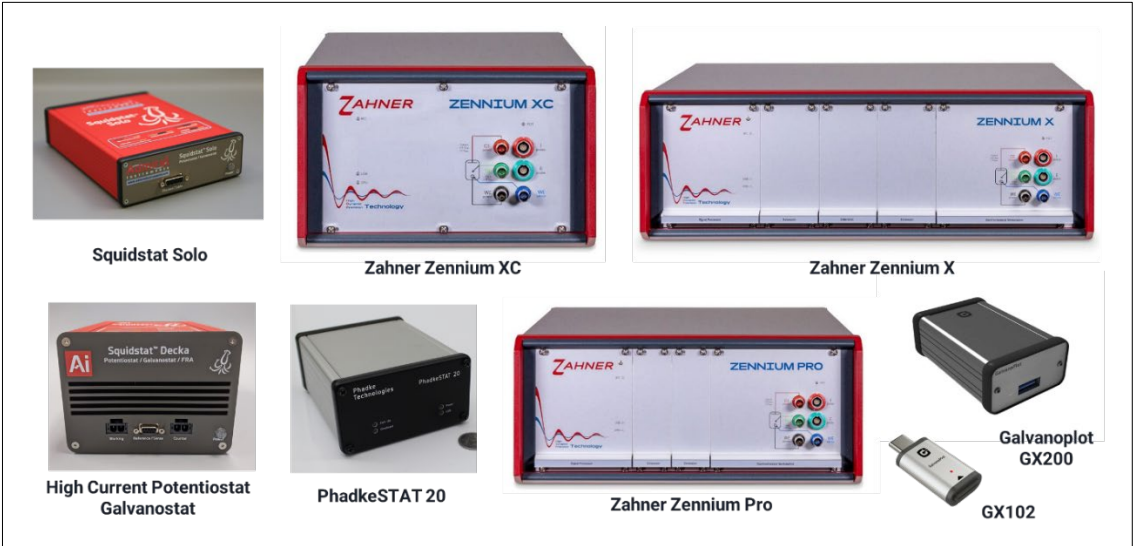


Figure 9. Main electrochemical workstations supplied by Phadke instruments (potentiostats/galvanostats).

Table 9. Main electrochemical instruments supplied by Phadke instruments: name, characteristics, specifications, supported methods, size, number of channels, and limitations.

Supplier	Instrument name	Instrument Type	Software	Supported methods	Specifications	Portable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Limitations	Price range
Phadke Instruments (India)	PhadkeSTAT 20 Corr	Potentiostat	No	OCP, Tafel	• ±2 V • Current 200 nA to 20 mA	Yes	105mm x 132mm x 55mm	Mono	No	Limited Voltage and current ranges. No EIS	~\$2300
	PhadkeSTAT 20 CV	Potentiostat	No	OCP, CV, LSV	• ±2 V • Current 200 nA to 20 mA	Yes	105mm x 132mm x 55mm	Mono	No	As above	~\$2300
	PhadkeSTAT 20 Basic	Potentiostat	No	OCP, Tafel, CV, LSV	• ±2 V • Current 200 nA to 20 mA	Yes	105mm x 132mm x 55mm	Mono	No	As above	~\$2300
	PhadkeSTAT 20 Standard	Potentiostat	No	OCP, Tafel, CV, LSV, CA	• ±2 V • Current 200 nA to 20 mA	Yes	105mm x 132mm x 55mm	Mono	No	As above	~\$2500
	PhadkeSTAT 20 Advanced	Potentiostat	No	OCP, Tafel, CV, LSV, CA, CC, NPV, SWV, DPV	• ±2 V • Current 200 nA to 20 mA	Yes	105mm x 132mm x 55mm	Mono	No	As above	~\$2500

• **Electrochemical Instruments Ltd.**

Electrochemical Instruments (Elins) is a Russian company that manufactures and sells instruments for electrochemical research [41]. The products provided by Elins include (Figure 10): potentiostats-galvanostats, impedance meters, multichannel potentiostats, and electrochemical cells. Five different models (P-2X, P-20X, P-40X, P-150X, P-45X) of single channel potentiostats-galvanostats and two Multichannel potentiostats, (P-2X8 and P-20X8) are provided by this company (Table 10). The five single channel instruments can work with different voltage ranges and current ranges depending on the different models. Two of these devices (P-40X and P-45X) can be equipped with electrochemical impedance measurement module FRA-24M to perform EIS measurements at

different frequencies. The Multichannel potentiostat, galvanostat P-20X8 has 8 independent channel-potentiostats. It can work with 5 current ranges per channel and 1 potential range (± 6 V). The minimum recommended operating current is 10 mA and the maximum current is equal to 2 A per channel. The Multichannel potentiostat, galvanostat P-2X8 has 8 independent channel-potentiostats also, but it can work with 7 current ranges per channel and 1 potential range (± 5 V). The minimum recommended operating current is 10 nA and the maximum current is equal to 0.1 A per channel.

Elins instruments were designed in 2015-2017. All the instruments can be used according to 2, 3, 4 electrode connection schemes, they have built-in non-volatile memory for all experimental data, and built-in functions and self-diagnostic units. Elins instruments operate under ES-8 control software which does not support English language. It should be noted that these instruments cannot work with Smartsoft software. Elins instruments have a certain set of characteristics and capabilities for the best cost solution for almost any task in a variety of areas of electrochemical measurements. They are designed as high-quality modern equipment and are characterized by high stability and accuracy. The following measurements can be supported by these instruments: OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR, EIS.

The main features of all the potentiostats-galvanostats manufactured by Elins including the specifications, size of the instrument, limitations and supported methods of each instrument are summarized in the table below:

Table 10. Main electrochemical instruments supplied by Electrochemical Instruments Ltd. (Elins): name, characteristics, specifications, supported methods, size, number of channels, and limitations.

, Supplier	Instrument name	Supported methods	Specifications	Maximum voltage and current	Sweep and Registration speed	Potable	Size of the instrument	Mono- or Multi-channels	Multiplexing	Limitations	Price range
Electrochemical Instruments Ltd. (Russia)	Potentiostat-galvanostat, P-2X	OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	± 5 V 6 current ranges, with minimal recommended operating current 10 nA.	- M - Maximum voltage: 12 V - M - Maximum current: 0.2 A	- Sweep speed: up to 10 V/s - Registration speed: up to 200 points/s	No	253×175×52 mm ³	mono	No	Absence of any languages in software and documentation but Russian	85000 rub
	Potentiostat-galvanostat, P-20X	OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	± 2 V and ± 15 V 8 current ranges, with minimal recommended operating current 1 nA.	- M - Maximum voltage: 17 V - M - Maximum current: 1.5 A	- Sweep speed: up to 20 V/s - Registration speed: up to 200 points/s	No	253×175×52 mm ³	mono	No	Absence of any languages in software and documentation but Russian	219000 rub
	Potentiostat-galvanostat, P-40X	OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	± 2 V and ± 5 V 8 current ranges, with minimal recommended operating current 1 nA.	- M - Maximum voltage: 17 V - M - Maximum current: 3 A	- Sweep speed: up to 50 V/s - Registration speed: up to 1000 points/s	No	361×233×101 mm ³	mono	No	Absence of any languages in software and documentation but Russian	276000 rub
	Potentiostat-galvanostat, P-150X	OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV	± 2 V and ± 9 V 4 current ranges, with	- M - Maximum voltage: 10 V	Sweep speed: up to 20 V/s	No	361×233×101 mm ³	mono	No	Absence of any languages in software	289000 rub

	CCD, GCD, minimal PCD, ESR	recommended operating current 50 μ A.	•	Maximum current: 15 A	Registration speed: up to 200 points/s							and documentation but Russian
Potentiostat - galvanostat, P-45X	OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	• ± 1 V, ± 2 V, ± 5 V and ± 12 V • 9 current ranges, with minimal recommended operating current 100 pA.	•	Maximum voltage: 17 V Maximum current: 3 A	• Sweep speed: up to 50 V/s • Registration speed: up to 1000 points/s	No	361×233×101 mm ³	mono	No			Absence of any languages in software and documentation but Russian 377000 rub
Potentiostat P-40X with electrochemical impedance measurement module FRA-24M	EIS, OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	• ± 2 V and ± 5 V • 8 current ranges, with minimal recommended operating current 1 nA. • EIS frequency from 10 μ Hz to 1 MHz.	•	Maximum voltage: 17 V Maximum current: 3 A	• Sweep speed: up to 50 V/s • Registration speed: up to 1000 points/s	No	361×233×101 mm ³	mono	No			Absence of any languages in software and documentation but Russian 460000 rub
Potentiostat P-45X with electrochemical impedance measurement module FRA-24M	EIS, OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	• ± 1 V, ± 2 V, ± 5 V and ± 12 V • 9 current ranges, with minimal recommended operating current 100 pA. • EIS frequency from 100 μ Hz to 1 MHz.	•	Maximum voltage: 17 V Maximum current: 3 A	• Sweep speed: up to 50 V/s • Registration speed: up to 1000 points/s	No	361×233×101 mm ³	mono	No			Absence of any languages in software and documentation but Russian 659000 rub
Multichannel potentiostat, P-20X8	EIS, OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	• ± 6 V • 5 current ranges per channel, with minimal recommended operating current 10 μ A.	•	Maximum voltage: 10 V Maximum current of each channel is 2 A	• Sweep speed: up to 10 V/s • Registration speed: up to 200 points/s	No	484×288×93 mm ³	8 independent channels-potentiostats	No			Absence of any languages in software and documentation but Russian 627000 rub
Multichannel potentiostat, P-2X8	EIS, OCP, POT, BE, CP, CC, CA, CR, LSV, CV, ASV, CSV, CCD, GCD, PCD, ESR	• ± 5 V • 7 current ranges per channel, with minimal recommended operating	•	Maximum voltage: 10 V Maximum current of each	• Sweep speed: up to 10 V/s • Registration speed: up to 200 points/s	No	484×288×48 mm ³	8 independent channels-potentiostats	No			Absence of any languages in software and documentation but Russian 289000 rub

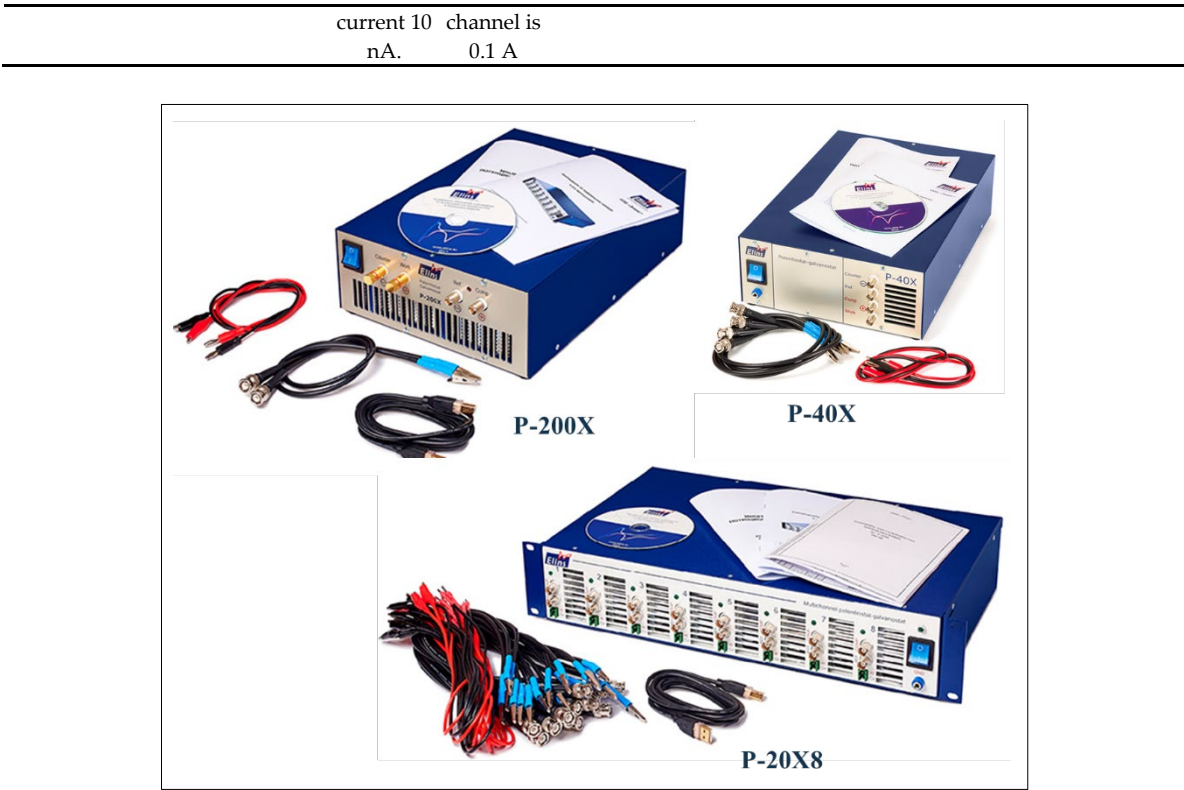


Figure 10. Main electrochemical workstations supplied by Electrochemical Instruments Ltd. (Elins) (potentiostats/galvanostats).

• **TEXAS Instruments**

Texas Instruments (TI) is an American company that design and manufacture analog and embedded semiconductors that are the essential components of electronic systems [42]. Texas Instruments (TI) does not manufacture full potentiostat-galvanostat instruments like those sold by other specialized electrochemical equipment companies (e.g., Gamry, BioLogic, Metrohm, Phadke, ECI, etc...). However, TI sells analog front-end components that can be used to build potentiostat-galvanostat systems, particularly portable or integrated systems like wearable biosensors or low-power lab devices. In particular, TI provides two analog front-end (AFE) Potentiostats: LMP91000 and LMP91002 (Table 11).

LMP91000 and LMP91002 Sensor AFE Systems: Configurable AFE Potentiostat for Low-Power Chemical Sensing Applications.

Each of LMP91000 and LM91002 is a programmable analog front-end (AFE) to be used in micro-power electrochemical sensing applications. It provides a complete signal path solution between a sensor and a microcontroller that generates an output voltage proportional to the cell current. They mainly work in three-electrode configuration where each contains a working electrode (WE) where the redox reaction occurs, a reference electrode (RE) that maintains a stable potential and a counter electrode (CE) which balances current flow.

These devices function as a miniaturized potentiostat designed for low-power, portable electrochemical sensing. While it does not replace a full lab-grade potentiostat-galvanostat, it implements the essential potentiostat function: maintaining a fixed potential between a working and reference electrode and measuring current at the working electrode. AFE potentiostats are used as integrated potentiostat, they can't perform cyclic voltammetry or advanced scans, and are not suitable for real-time sweeping of voltage like in EIS. They are ideal for applications like gas detection (e.g., CO, NO₂), biosensors, and low-power field sensors.

The adjustable cell bias and transimpedance amplifier (TIA) gain of these devices are programmable through the I²C interface, which can also be used for sensor diagnostics. An integrated temperature sensor can be read by the user through the VOUT pin and used to provide additional

signal correction in the μC or monitored to verify temperature conditions at the sensor. The LMP91000 is optimized for micro-power applications and operates over a voltage range of + 2.7 to + 5.25 V while the LMP91002 operates over a range of + 2.7 to + 3.6 V. The total current consumption can be less than 10 μA for both devices.

The main characteristics of LMP91000 and LMP91002 are summarized in the table below:

Table 11. Main electrochemical instruments supplied by TEXAS Instruments (TI): name, characteristics, specifications, supported methods, number of channels, applications, and limitations.

Feature	LMP91000	LMP91002
Typical Values	$T_A = 25\text{ }^{\circ}\text{C}$	$T_A = 25\text{ }^{\circ}\text{C}$
Supply voltage	2.7 V to 5.25 V	2.7 V to 3.6 V
Supply Current (Average Over Time)	< 10 μA	< 10 μA
Cell Conditioning Current	Up to 10 mA	Up to 10 mA
Reference Electrode Bias Current (85 $^{\circ}\text{C}$)	900 pA (max)	900pA (max)
Output Drive Current	750 μA	750 μA
Complete Potentiostat Circuit-to-Interface to	Most Chemical Cells	Most Non-Biased Gas Sensors
Voltage Drift	Low-Bias	Low-Bias
Programmable TIA gain	2.75 k Ω to 350 k Ω	2.75 k Ω to 350 k Ω
Compatible Digital Interface	I ² C	I ² C
Ambient Operating Temperature	-40 $^{\circ}\text{C}$ to 85 $^{\circ}\text{C}$	-40 $^{\circ}\text{C}$ to 85 $^{\circ}\text{C}$
Package	14-Pin WSON	14-Pin WSON
Applications	• Chemical Species Identification • Amperometric Applications • Electrochemical Blood Glucose Meter	• Gas Detectors • Amperometric Applications • Electrochemical Blood Glucose Meter

Conclusion

The selection of electrochemical instruments, more specifically, potentiostats and/or galvanostats is a time-consuming process. This process requires prior knowledge of the key-parameters to consider when performing electrochemical experiments. Many students, junior researchers, industrial workers, and startups, especially from a non-electrochemistry field, face lack of comprehension of these parameters which often requires external intervention or needs help in choosing the best instrument that fits the intended application. In this paper, we summarized most of the commercial electrochemical workstations (potentiostats and/or galvanostats) available on the market worldwide. For each instrument, we listed the supported methods, the current and potential ranges, a key-parameter to select the electrochemical instruments, characteristics (portability, size, multichannel and/or multiplexing support) in addition to an estimated price for each instrument in the country of manufacture, which may vary according to the applicable taxes in each country for the instrumentation category. Finally, in addition to the presented document, many consulting companies may assist users in selecting the most suitable instrument for their intended application such as Electrochemistry Consulting and Services (E2CS), ElectroSeek, Metrohm, Electrochemeia, Electrosynthesis, ACM instruments, Catalyze Group, Hazen Research, Bio Nano consulting, Electrode Solutions and many others, helping saving both time and budget.

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Conflicts of Interest Declaration: The authors declare no conflict of interest.

Abbreviations

ASV: Anodic Stripping Voltammetry
BE: Bulk Electrolysis
CA: Chronoamperometry
CC: Chronocoulometry
CD: Charge-Discharge Cycling
CP: Chronopotentiometry
CPT: Critical Pitting Temperature
CSV: Cathodic Stripping Voltammetry
CV: Cyclic Voltammetry
CVC: Current voltage curve
CYP: Cyclic Polarization
DNPV: Differential Normal Pulse Voltammetry
DPV: Differential Pulse Voltammetry
EFM: Electrochemical Frequency Modulation
EIS: Electrochemical Impedance Spectroscopy
FAM: Fast Amperometry
FCV: Fast Cyclic Voltammetry
FEIS: Fast Electrochemical Impedance Spectroscopy
FGEIS: Fast Galvanostatic Impedance Spectroscopy
FRA: Frequency Response Analyzer
GCD: Galvanostatic Charge-Discharge
GEIS: Galvanostatic Impedance Spectroscopy
I-V Plot: Current Voltage Plot
LCP: Linear Current Potential
LP: Linear Polarization
LSA: Linear Sweep Amperometry
LSV: Linear Sweep Voltammetry
MA: MultiStep Amperometry
MM: Mixed Mode
MP: MultiStep Potentiometry
MPA: Multiple Pulse Amperometry
MPAD: Multiple Pulse Amperometric Detection
NPV: Normal Pulse Voltammetry
OCP: Open Circuit Potential
PAD: Pulsed Amperometric Detection
PCD: Potentiostatic Charge-Discharge
PDEIS: Potentiodynamic Electrochemical Impedance Spectroscopy
SCP: Stripping Chronopotentiometry
SWV: Square Wave Voltammetry
ZRA: Zero resistance Amperometry

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