EmStat4X™

POTENTIOSTAT | GALVANOSTAT | IMPEDANCE ANALYZER (optional)

PalmSens

Rev. 05-2024-010

Contents

› See for more information:
palmsens.com/emstat4x

High performance in a small footprint

The EmStat4X is a small battery-, and USB-powered Potentiostat, Galvanostat, and optional Frequency Response Analyser (FRA) for Electrochemical Impedance Spectroscopy (EIS).
The EmStat4X **Low Range (LR)** version is great for applications that require measuring low currents down to picoamps, like (bio)sensor research.

The **High Range (HR)** version is very suitable for applications that need a maximum current of up to 200 mA.

The EmStat4X LR and HR features include:

- **Fast EIS support:** for running fixed-frequency EIS measurements at a very low interval of around 1 ms.
- **Auxiliary Port:** for connecting to a MUX8-R2 multiplexer, temperature sensor, pH sensor, stirrer control, triggering and more.
- **iR compensation:** to compensate for the iR drop between the Reference electrode and the outside of the double layer of the electrochemical cell.
- **Wireless connectivity:** for a wireless connection to a PC, smartphone or tablet.
- **11.1 Wh battery:** for more than 8 hours of measurements (with the LR).
- **Small borderless display:** showing the state of the battery and connectivity.

Always a backup

This means all your measurements can be saved on-board as a backup. All internally stored measurements can be browsed and transferred back to the PC easily using PSTrace.

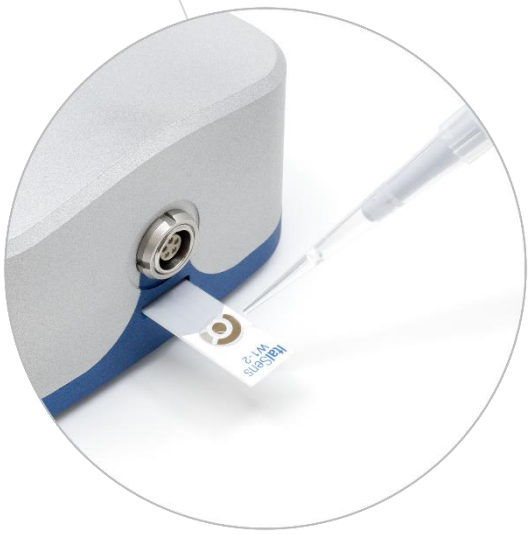
Your data is always with your instrument wherever you take it.

software for

Key specifications

	Low Range (LR)	High Range (HR)
▪ potential range	±3 V	±6 V
▪ max. compliance voltage	±5 V	±8 V
▪ current ranges	1 nA to 10 mA (8 ranges)	100 nA to 100 mA (7 ranges)
▪ max. current	±30 mA	±200 mA
▪ FRA/EIS (optional)	10 µHz to 200 kHz	
▪ electrode connections	WE, RE, CE, and ground, with 2 mm banana plugs And SPE connector	WE, RE, CE, S, and ground, with 2 mm banana plugs

See page 7 for all specifications.



Supported Techniques

The EmStat4X supports the following electrochemical techniques when used with PSTrace.

Voltammetric techniques

- Linear Sweep Voltammetry — LSV
- Cyclic Voltammetry — CV
- Fast Cyclic Voltammetry — FCV
- AC Voltammetry — ACV

Pulsed techniques

- Differential Pulse Voltammetry — DPV
- Square Wave Voltammetry — SWV
- Normal Pulse Voltammetry — NPV

These methods can all be used in their stripping modes which are applied for (ultra-) trace analysis.

Amperometric techniques

- Chronoamperometry — CA
- Zero Resistance Amperometry — ZRA
- Chronocoulometry — CC
- MultiStep Amperometry — MA
- Fast Amperometry — FAM
- Pulsed Amperometric Detection — PAD

Galvanostatic techniques

- Linear Sweep Potentiometry — LSP
- Chronopotentiometry — CP
- MultiStep Potentiometry — MP
- Open Circuit Potentiometry — OCP

Other

- Mixed Mode — MM
- Potentiostatic and Galvanostatic Impedance spectroscopy — EIS/GEIS
  at fixed frequency or frequency scan vs
  - fixed potential or fixed current
  - scanning potential or scanning current
  - time
- Fast EIS/GEIS — FEIS/FGEIS
  Very low interval fixed-frequency measurements

MethodSCRIPT™ allows for developing custom techniques. See page 15 for more information.

MethodSCRIPT™ by PalmSens

Measurement Specifications

The following table shows limits for some technique-specific parameters.

	Parameter	Min	Max
All techniques (unless otherwise specified)	▪ Conditioning time	0	4000 s
	▪ Deposition time	0	4000 s
	▪ Equilibration time	0	4000 s
	▪ Step potential	LR: 0.100 mV HR: 0.183 mV	250 mV
	▪ N data points	3	1 000 000
▪ NPV ▪ DPV	▪ Scan rate	LR: 0.1 mV/s (100 µV step) HR: 0.1 mV/s (183 µV step)	1 V/s (5 mV step)
	▪ Pulse time	0.4 ms	300 ms
▪ SWV	▪ Frequency	1 Hz	1250 Hz
▪ LSV ▪ CV	▪ Scan rate	LR: 0.01 mV/s (100 µV step) HR: 0.01 mV/s (183 µV step)	500 V/s (200 mV step)
▪ FCV	▪ Scan rate	LR: 0.1 mV/s (100 µV step) HR: 0.01 mV/s (183 µV step)	500 V/s (50 mV step)
	▪ N averaged scans	1	65535
	▪ N equil. scans	0	65535
▪ PAD	▪ Interval time	50 ms	4294 s
	▪ Pulse time	1 ms	1 s
	▪ N data points	3	1 000 000 (> 100 days at 10 s interval)
▪ CA ▪ CP ▪ OCP	▪ Interval time	0.4 ms	4294 s
	▪ Run time	1 ms	> year
▪ MM ▪ MA ▪ MP	▪ N cycles	1	20000
	▪ N levels	1	255
	▪ Level switching overhead time	~1 ms (typical)	-
	▪ Interval time	0.4 ms	4294 s
▪ FAM	▪ Interval time	1 µs	60 s
	▪ Run time	3 µs	34 days (60 s interval) 50 ms (1 µs interval)
	▪ N data points	3	50000
▪ Fast EIS	Interval time between points at fixed frequency	~1 ms (typical)	-

System Specifications

General		
	LR	HR
▪ dc-potential range	±3 V	±6 V
▪ compliance voltage	±5 V	±8 V
▪ maximum current	±30 mA	±200 mA
▪ max. data acquisition rate	1M samples/s	
▪ control loop bandwidth (stability setting)	320 Hz, 3.2 kHz, 30 kHz or 570 kHz	
▪ current follower bandwidth	23 Hz in 1 nA and 10 nA range 2.3 kHz in 100 nA and 1 uA range 230 kHz in 10 uA and 100 uA range > 500 kHz in ranges 1 mA and higher	

Potentiostat (controlled potential mode)		
	LR	HR
▪ applied potential resolution	100 µV	183 µV
▪ applied potential accuracy	≤ 0.2% ±1 mV offset	
▪ current ranges	1 nA to 10 mA (8 ranges)	100 nA to 100 mA (7 ranges)
▪ measured current resolution	0.009% of CR (92 fA on 1 nA range)	
▪ measured current accuracy	< 0.2% of current ±20 pA ±0.2% of range	< 0.2% of current ±0.2% of range

Galvanostat (controlled current mode)		
	LR	HR
▪ current ranges	10 nA, 1 uA, 100 uA, 10 mA (4 ranges)	1 uA, 100 uA, 10 mA, 100 mA (4 ranges)
▪ applied dc-current	±3 * CR (current range)	
▪ applied dc-current resolution	0.01% of CR	0.0183% of CR
▪ applied dc-current accuracy	< 0.4% of current ±20 pA ±0.2% of range	< 0.4% of current ±0.2% of range
▪ potential ranges	50 mV, 100 mV, 200 mV, 500 mV, 1 V	
▪ measured dc-potential resolution	96 µV at ±3 V (1 V range) 48 µV at ±1.5 V (500 mV) 19.2 µV at ±0.6 V (200 mV) 9.6 µV at ±0.3 V (100 mV) 4.8 µV at ±0.15 V (50 mV)	193 µV at ±6 V (1 V range) 96.5 µV at ±3 V (500 mV) 38.5 µV at ±1.2 V (200 mV) 19.3 µV at ±0.6 V (100 mV) 9.65 µV at ±0.3 V (50 mV)
▪ measured dc-potential accuracy	≤ 0.2% potential, ±1 mV offset	

FRA / EIS (impedance measurements)	
▪ frequency range	10 µHz to 200 kHz
▪ ac-amplitude range	1 mV to 900 mV rms, or 2.5 V p-p

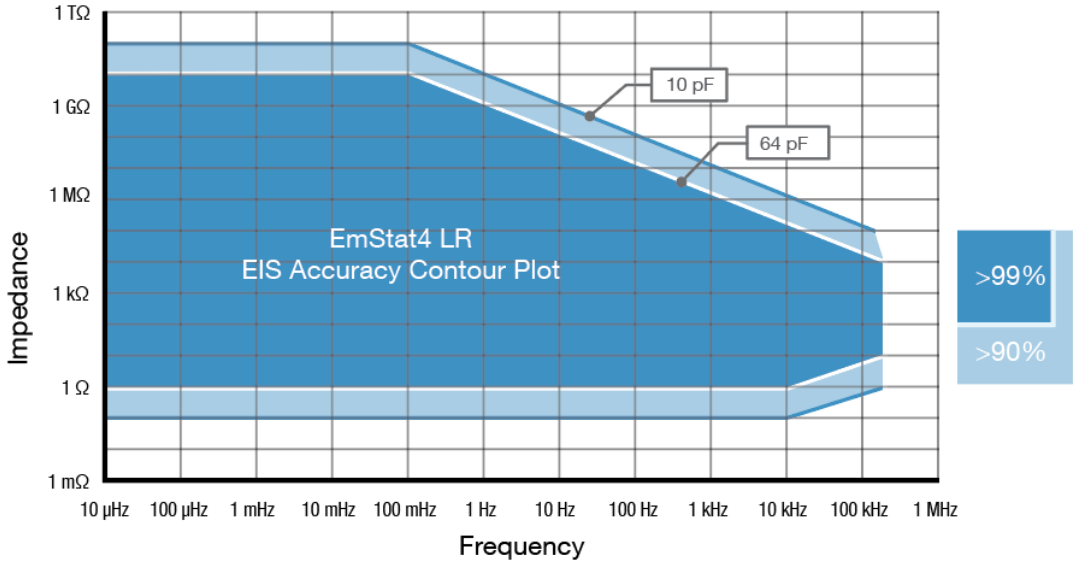
GEIS (galvanostatic impedance measurements)	
▪ frequency range	10 µHz to 100 kHz
▪ ac-amplitude range	0.9 * CR A rms

Electrometer	
▪ electrometer amplifier input	> 1 TΩ // 10 pF
▪ bandwidth	500 kHz

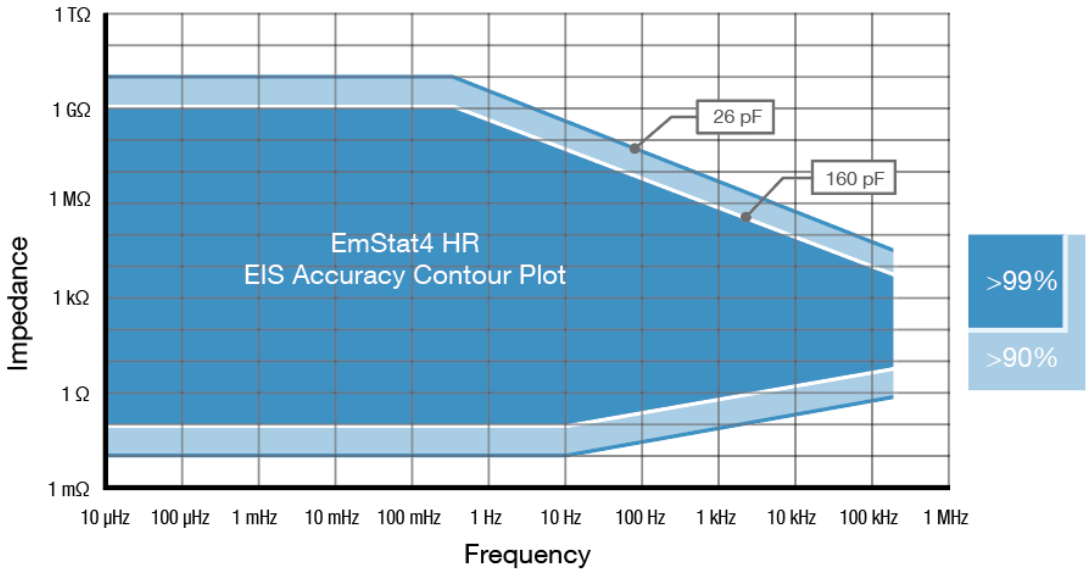
iR Compensation	
▪ method used for iR-drop compensation	Positive Feedback
▪ resolution of MDAC used for correcting potential	12-bit
▪ max. compensated resistance	1 MOhm

Other		
	LR	HR
▪ electrode connections	WE, RE, CE, and ground, with 2 mm banana plugs	WE, RE, CE, S, and ground, with 2 mm banana plugs
▪ power consumption	Typical: 1W (idle) Max: 1.6W (cell @ 30 mA)	Typical: 1.5W (idle) 1.6W (cell @ 10 mA) Max: 4.6W (cell @ 200 mA)
▪ battery	11.1 Wh capacity 80% charge in 2.5 hours, full charge in 3 hours	
▪ power source	USB-C or internal LiPo battery	
▪ communications	USB-C or wireless	
▪ housing	aluminium body: 11.4 x 8.0 x 4.5 cm	
▪ weight	~500 g	
▪ internal storage space	500 MB, equivalent to >15M datapoints or ~1000 measurement files (whichever comes first)	
▪ auxiliary port	▪ analog input ±10 V, 16-bit ▪ analog output 0-6 V, 12-bit ▪ digital I/O: - 4x digital output (3.3 V) - 1x digital input (3.3 V) ▪ i and E monitor (raw output of cell current and potential) ▪ power output (5 V, max. 300 mA)	

EmStat4X LR EIS Accuracy Contour Plot



EmStat4X HR EIS Accuracy Contour Plot



Note
The accuracy contour plots were determined with an ac-amplitude of ≤10 mV rms for all limits, except for the high impedance limit, which was determined using an ac-amplitude of 250 mV. The standard 1 meter cell cables were used. Please note that the true limits of an impedance measurement are influenced by all components in the system, e.g. connections, the environment, and the cell.

Standard EmStat4X Kit

A standard EmStat4X kit includes a rugged carrying case with:

- EmStat4X LR or HR
- USB-C - USB-C cable
- USB-C to USB-A adapter
- 1 meter cell cable with 2 mm banana pins
- 4 or 5 croc clips
- Dummy Cell

Also included:

- PSTrace software for Windows (on USB drive)
- Manual (hardcopy)
- Quick Start document
- Calibration Report

EmStat4X Accessories

MUX8-R2 or MUX16 multiplexer

The MUX8-R2 is an 8-channel multiplexer. It allows the EmStat4X to measure up to 8 cells, switching RE, CE, WE and Sense.

In 8-WE mode it can measure up to eight working electrodes on sensor arrays with shared reference and counter electrodes as well. The MUX8-R2 is stackable up to 128 channels.

Attention: The MUX8-R2 max. current with the EmStat4X HR is 70 mA.

Magnetic stirrer with Switchbox

The magnetic stirrer controlled by the instrument is ideal for stripping analysis applications. The stirrer is switched on during the conditioning and deposition stages by means of the Switchbox.

TMP36 temperature sensor

This temperature sensor allows for monitoring of temperature during an experiment.
The TMP36 provides accuracies of ±1°C at +25°C and ±2°C over the –40°C to +125°C temperature range.The supply current runs well below 50 µA, providing very low self-heating, less than 0.1°C in still air.

Differential Electrometer Amplifier (DEA)

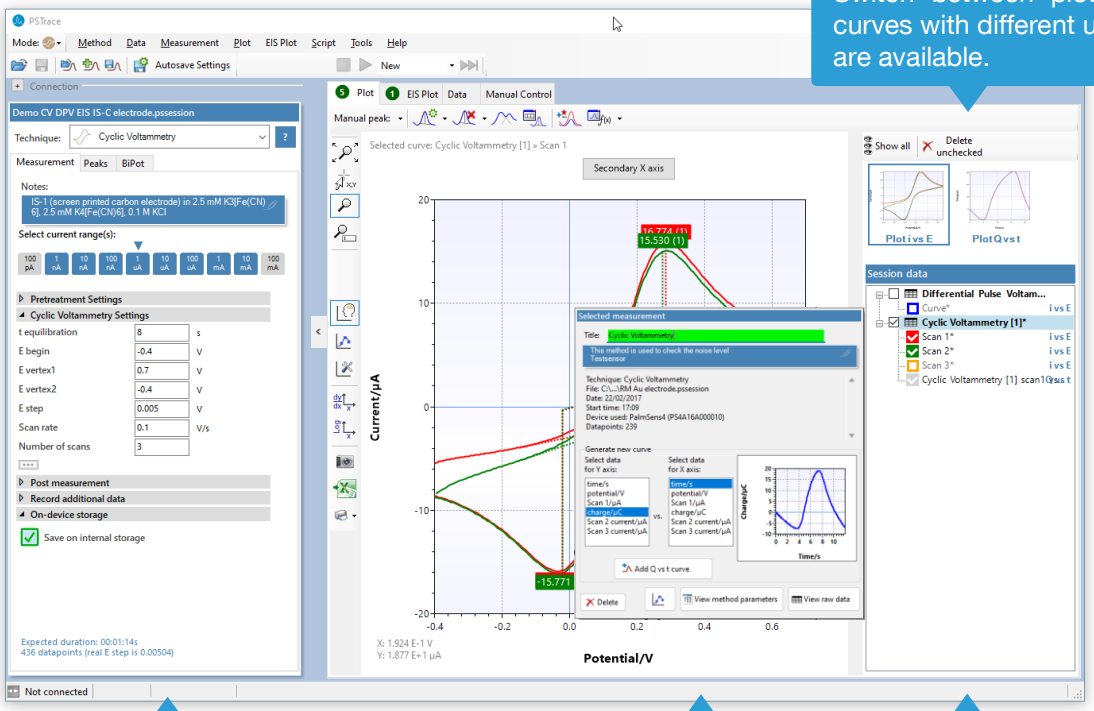
The Differential Electrometer Amplifier (DEA) is a high impedance input amplifier. It can be used as a high-precision floating voltage amplifier with differential input and single output to the auxiliary port of an EmStat4X.

Default range is -10V to 10V (1x gain). Possible gains are: 2x, 5x, 10x, 20x, 50x and 100x.

› See for more information:
palmsens.com/accessories

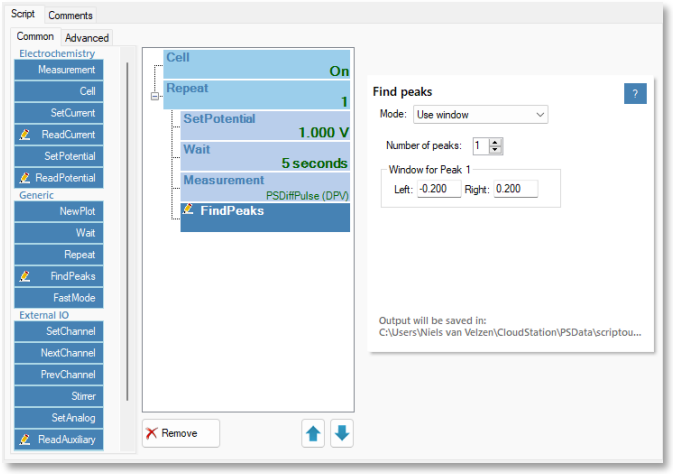
PSTrace: Software for Windows

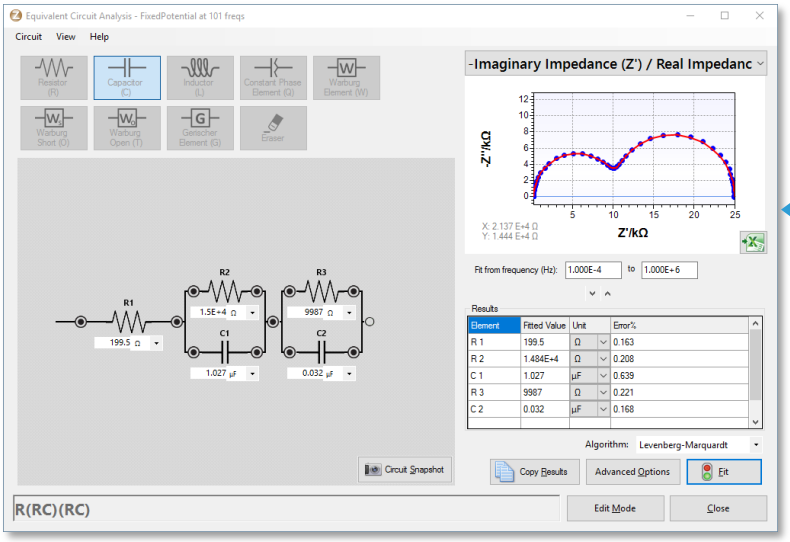
PSTrace is designed to get the most out of your instrument right after installation, without going through a long learning period. It has three modes: the Scientific mode which allows you to run all the techniques our instruments have to offer, and two dedicated modes for Corrosion analysis and the Analytical Mode. The Analytical Mode is designed for use with (bio)sensors and allows you to do concentration determinations. Extensive help files and prompts guide the user through a typical analysis.



Scripting

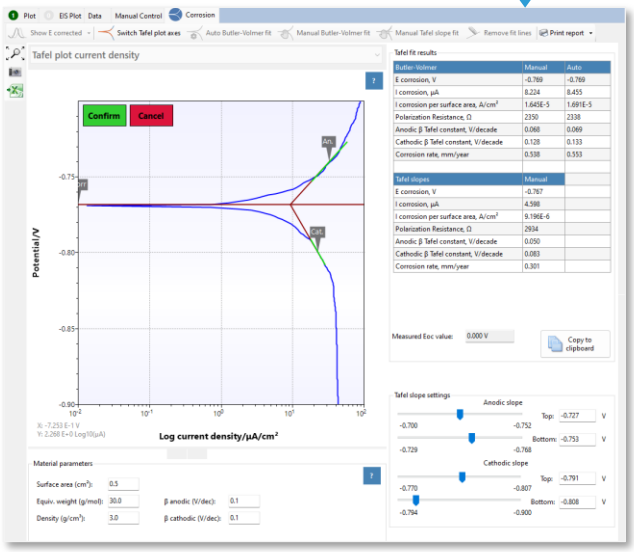
The intuitive script editor allows for easily creating a sequence of measurements or other tasks, by means of dragging and dropping actions in a list.





Use the graphical editor to draw the equivalent circuit or enter the CDC directly.

Corrosion mode for Tafel plot analysis and other corrosion data analysis.



Other functions in PSTrace

- Concentration determination
- Advanced peak search algorithms
- Open your data in Origin and Excel with one click of a button
- Save all available curves, measurement data and methods to a single file
- Load measurements from the internal storage
- Direct validation of method parameters
- Run custom MethodSCRIPT™

Integration with third-party software

- Excel
- Origin
- Matlab
- ZView

Minimum System Requirements

- Windows 7, 8, 10 or 11
- 1 GHz or faster 32-bit (x86) or 64-bit (x64) processor
- 2 GB RAM (32-bit) or 4 GB RAM (64-bit)
- Screen resolution of 1366 × 768 pixels

› See for more information:
palmsens.com/pstrace

EmStat4X works with MethodSCRIPT™

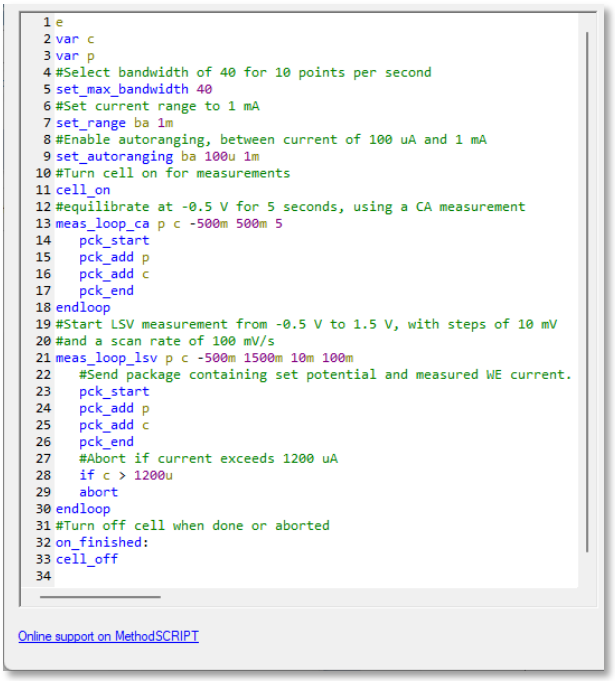
The MethodSCRIPT™ scripting language is designed to integrate our instruments and potentiostat (modules) effortlessly in your hardware setup, product, or experiment.

MethodSCRIPT™ gives you full control over your potentiostat. The simple script language is parsed on-board the instrument and allows for running all supported electrochemical techniques, making it easy to combine different measurements and other tasks.

MethodSCRIPT™ can be generated, edited, and executed in PSTrace.

MethodSCRIPT features include:

- Use of variables
- (Nested) loops and conditional logic support
- User code during a measurement iteration
- Exact timing control
- Simple math operations on variables (add, sub, mul, div)
- Digital I/O, for example for waiting for an external trigger
- Logging results to internal storage or external SD card
- Reading auxiliary values like pH or temperature
- and many more…



```
e
var c
var p
#Select bandwidth of 40 for 10 points per second
set_max_bandwidth 40
#Set current range to 1 mA
set_range ba 1m
#Enable autoranging, between current of 100 uA and 1 mA
set_autoranging ba 100u 1m
#Turn cell on for measurements
cell_on
#equilibrate at -0.5 V for 5 seconds, using a CA measurement
meas_loop_ca p c -500m 500m 5
   pck_start
   pck_add p
   pck_add c
   pck_end
endloop
#Start LSV measurement from -0.5 V to 1.5 V, with steps of 10 mV
#and a scan rate of 100 mV/s
meas_loop_lsv p c -500m 1500m 10m 100m
   #Send package containing set potential and measured WE current.
   pck_start
   pck_add p
   pck_add c
   pck_end
   #Abort if current exceeds 1200 uA
   if c > 1200u
   abort
endloop
#Turn off cell when done or aborted
on_finished:
cell_off

```

Online support on MethodSCRIPT

Write your own software and integrate (generated) MethodSCRIPTs. No libraries needed.

MethodSCRIPT is parsed on-board the instrument. No DLLs or other type of code libraries are required for using MethodSCRIPT™

MethodSCRIPT™

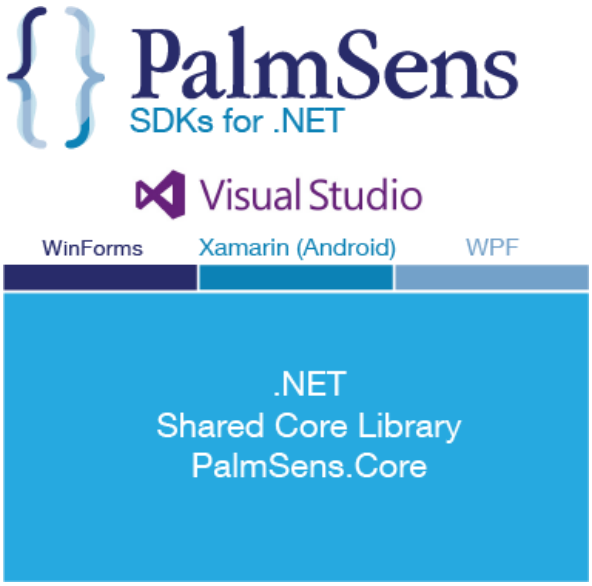
Code examples are available for:

C/C++ ARDUINO Swift Xamarin python Java

› See for more information:
palmsens.com/methodscript

Software Development Kits for .NET

Develop your own application in no time for use with any of our instruments or potentiostat module. Our SDKs are free of charge.



There are three PalmSens Software Development Kits (SDKs) for .NET. Each SDK can be used with any of our instruments or OEM potentiostat modules to develop your own software. The SDK's come with a set of examples that shows how to use the libraries. PalmSens SDKs with examples are available for the following .NET Frameworks:

- WinForms
- Xamarin (Android)
- WPF

Each SDK comes with code examples for:

- Connecting
- Running measurements and plotting data
- Manual control of the cell
- Accessing and processing measured data
- Analyzing and manipulating data
- Peak detection
- Equivalent Circuit Fitting on impedance data
- Saving and loading files

```
/// <summary>
/// Initializes the EIS method.
/// </summary>
1 reference
private void InitMethod()
{
    _methodEIS = new ImpedimetricMethod();
    _methodEIS.ScanType = ImpedimetricMethod.enumScanT
    _methodEIS.Potential = 0.0f; //0.0V DC potential
    _methodEIS.Eac = 0.01f; //0.01V RMS AC potential a
    _methodEIS.FreqType = ImpedimetricMethod.enumFrequ
    _methodEIS.MaxFrequency = 1e5f; //Max frequency is
    _methodEIS.MinFrequency = 10f; //Min frequency is
    _methodEIS.nFrequencies = 11; //Sample at 11 diffe

    _methodEIS.EquilibrationTime = 1f; //Equilabrates
    _methodEIS.Ranging.StartCurrentRange = new Current
    _methodEIS.Ranging.MinimumCurrentRange = new Curre
    _methodEIS.Ranging.MaximumCurrentRange = new Curre
}
```

› See for more information:
palmsens.com/sdk

PStouch: App for Android

PStouch

GET IT ON Google Play

PStouch is an app for Android devices compatible with all PalmSens, EmStat and Sensit potentiostats.

PStouch features:

- Setting up and running measurements
- Loading and saving measured curves
- Analyzing and manipulating peaks
- Sharing measurement data directly via any service like email or Dropbox
- Concentration determination by means of Standard Addition or Calibration Curve
- Support for PalmSens accessories such as a Multiplexer or Stirrer
- All method and curve files are fully compatible with PSTrace software for Windows.

› See for more information:
palmsens.com/pstouch

Please do not hesitate to contact PalmSens for more details: info@palmsens.com

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