EmStat4R™

POTENTIOSTAT / GALVANOSTAT /
IMPEDANCE ANALYZER (optional)

PalmSens

Rev. 11-2023-004

Contents

> See for more information:
www.palmsens.com/es4r

Desktop performance in a rugged enclosure

The EmStat4R is a portable USB-powered and wireless Potentiostat, Galvanostat, and optional Frequency Response Analyser (FRA) for Electrochemical Impedance Spectroscopy (EIS). The EmStat4R is great for (sensor) applications that require low currents, from 30 mA down to picoamps, such as sensor applications.

Ideal for sensor applications

The Connection Module can be exchanged by the user with a Connection Module suitable for using Screen Printed Electrodes (SPE). This allows for transforming your lab instrument with cable to a cable-less solution for use in the field.

Main Specifications	
▪ potential range	±3 V
▪ max. compliance voltage	±5 V
▪ current ranges	1 nA to 10 mA (8 ranges)
▪ max. current	±30 mA
▪ electrode connections (SNS module)	WE, RE, CE, and ground 2 mm banana pins

SPE Connection Module	
▪ sensor pitch	2.54 mm
▪ electrode connections	RE, WE, CE
▪ allowed sensor thickness	Between 0.1 mm and 0.8 mm
▪ maximum sensor width	11 mm

See section *System Specifications* on page 6 for more specifications.

Supported Techniques

The EmStat4R supports the following electrochemical techniques:

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**
▪ Multiple-Pulse Amperometric Detection	**MPAD ***

Galvanostatic techniques

▪ Linear Sweep Potentiometry	**LSP**
▪ Chronopotentiometry	**CP**
▪ MultiStep Potentiometry	**MP**
▪ Open Circuit Potentiometry	**OCP**
▪ Stripping Chronopotentiometry	**SCP or PSA ***

Other

▪ Mixed Mode	**MM**
▪ Potentiostatic and Galvanostatic Impedance spectroscopy at fixed frequency or frequency scan vs ○ fixed potential or fixed current ○ scanning potential or scanning current ○ time	**EIS/GEIS**

MethodSCRIPT™ allows for developing custom techniques. See page 13 for more information.

MethodSCRIPT™ by PalmSens

* This technique will be enabled with the release of PSTrace 5.10

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	0.100 mV	250 mV
	▪ N data points	3	1,000,000
▪ NPV ▪ DPV	▪ Scan rate	0.1 mV/s (100 µV step)	1 V/s (5 mV step)
	▪ Pulse time	0.4 ms	300 ms
▪ SWV	▪ Frequency	1 Hz	2500 Hz
▪ LSV ▪ CV	▪ Scan rate	0.01 mV/s (100 µV step)	500 V/s (200 mV step)
▪ PAD	▪ Interval time	50 ms	300 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	300 s
	▪ Run time	1 ms	> year
▪ MM ▪ MA ▪ MP	▪ N cycles	1	20,000
	▪ N levels	1	255
	▪ Level switching overhead time	+/-1 ms	
	▪ Interval time	50 ms	300 s

System Specifications

General	
▪ dc-potential range	±3 V
▪ compliance voltage	±5 V
▪ maximum current	±30 mA
▪ max. data acquisition rate	1M samples/s

Potentiostat (controlled potential mode)	
▪ applied potential resolution	100 µV
▪ applied potential accuracy	≤ 0.2% ±1 mV offset
▪ current ranges	1 nA to 10 mA 8 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
▪ bandwidth settings	320 Hz, 3.2 kHz, 30 kHz or 570 kHz

Galvanostat (controlled current mode)	
▪ current ranges	10 nA, 1 uA, 100 uA, 10 mA
▪ applied dc-current	±3 * CR (current range)
▪ applied dc-current resolution	0.01% of CR
▪ applied dc-current accuracy	< 0.4% of current ±20 pA ±0.2% of range
▪ potential ranges	50 mV, 100 mV, 200 mV, 500 mv, 1 V
▪ measured dc-potential resolution	96 µV (1 V) 48 µV (500 mV) 19.2 µV (200 mV) 9.6 µV (100 mV) 4.8 µV (50 mV)
▪ measured dc-potential accuracy	≤ 0.2% potential, ±1 mV offset
▪ bandwidth settings	320 Hz, 3.2 kHz, 30 kHz or 570 kHz

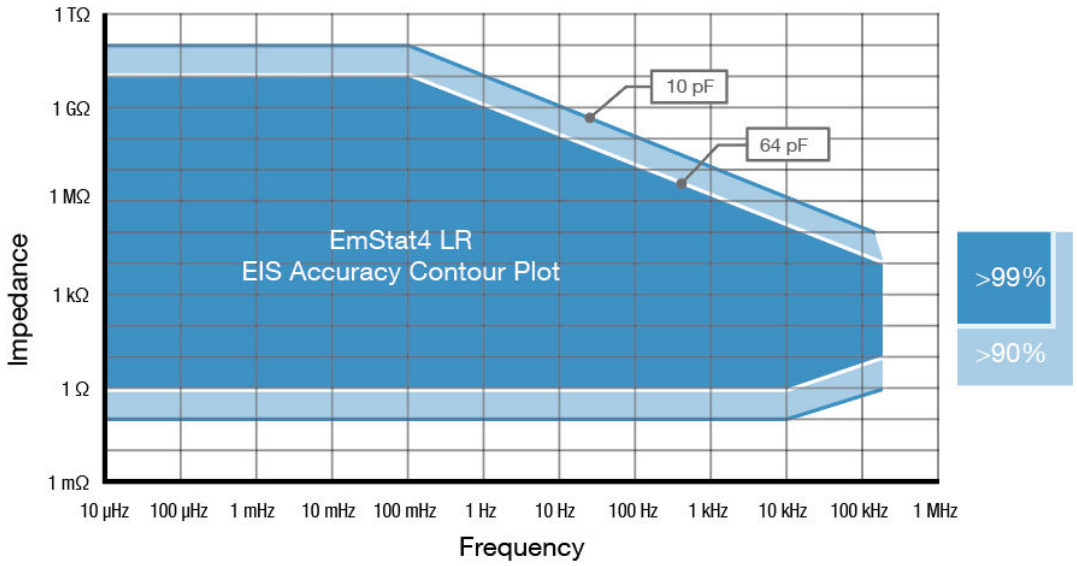
FRA / EIS (impedance measurements)	
▪ frequency range	10 µHz to 200 kHz
▪ ac-amplitude range	1 mV to 900 mV rms, or 2.5 V p-p

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	10 kHz or 500 kHz

Other	
▪ housing	▪ aluminum body only: 11.1 x 6.0 x 2.7 cm ▪ with rubber sleeve: 11.8 x 6.8 x 3.3 cm
▪ weight	~ 310 g
▪ power	USB-C port
▪ communication	USB-C or Bluetooth
▪ battery life	Connected via Bluetooth: ~3 hours with cell on at 10 mA current ~5 hours with cell off
▪ internal storage space	500 MB, equivalent to >15M datapoints

EmStat4R 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 EmStat4R Kit

A standard EmStat4R kit includes a rugged carrying case with:

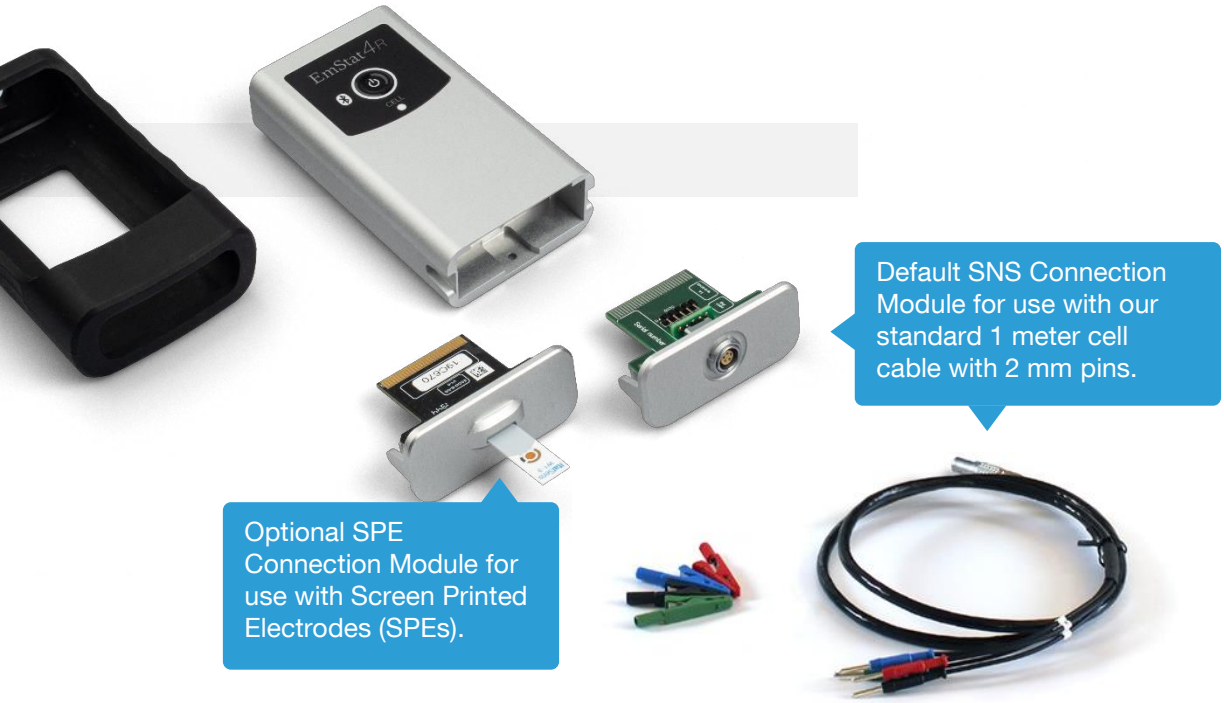
- EmStat4R instrument with
  SNS Connection Module (for use with 1 m cell cable)
  or SPE Connection Module (for use with Screen Printed Electrodes)
- USB-C cable
- 1 meter cell cable with 2 mm banana pins
- Dummy Cell

Optional:

- Optional additional SNS or SPE Connection Module

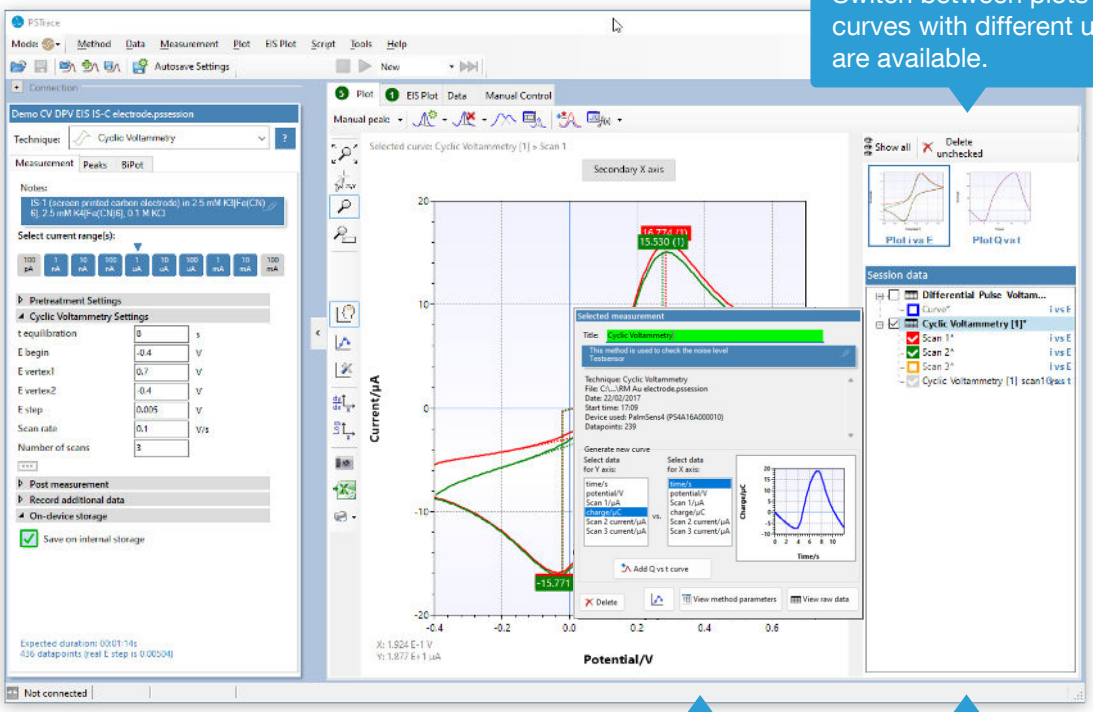
Also included:

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



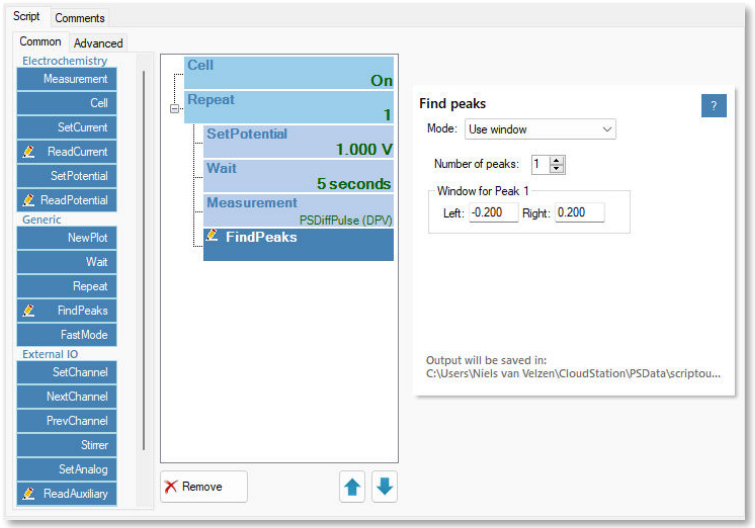
PSTrace: Software for Windows

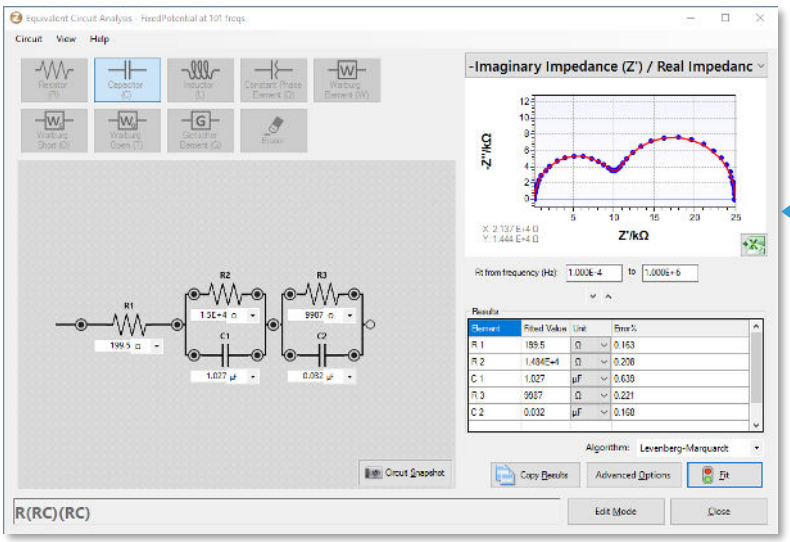
PSTrace is designed to get the most out of your instrument right after installation, without going through a long learning period. It has three modes; the Scientific mode which allows you to run all the techniques our instruments have to offer, and two dedicated modes for Corrosion analysis and the Analytical 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

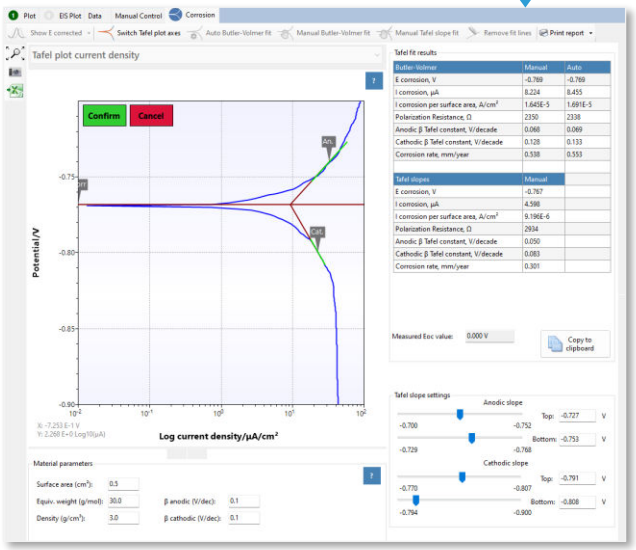
The intuitive script editor allows for easily creating a sequence of measurements or other tasks, by means of dragging and dropping actions in a list.





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 MethodSCRIPTS™

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 1280 x 800 pixels

› See for more information:
www.palmsens.com/pstrace

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.
Your smartphone or tablet connects with the EmStat4R via USB or wireless via Bluetooth.

PStouch features:

- Setting up and running measurements
- Loading and saving measured curves
- Analysing 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:
www.palmsens.com/pstouch

EmStat4R works with MethodSCRIPT™

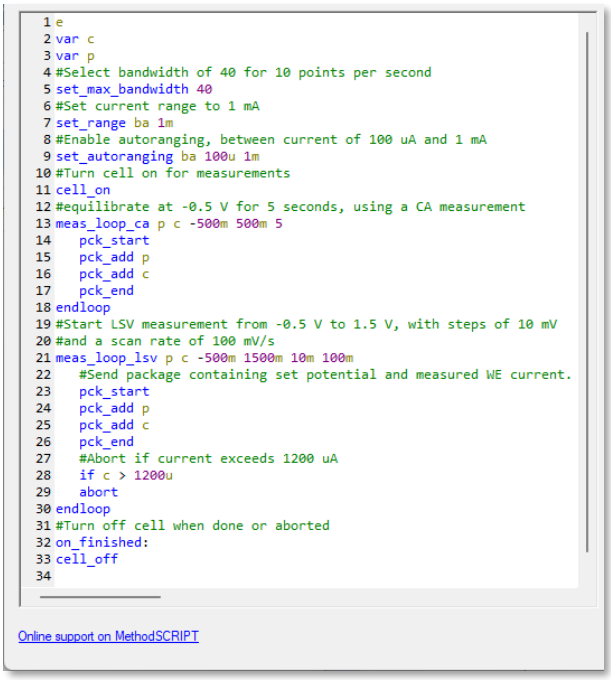
The MethodSCRIPT™ scripting language is designed to integrate our instruments and potentiostat (modules) effortlessly in your hardware setup, product, or experiment.

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™

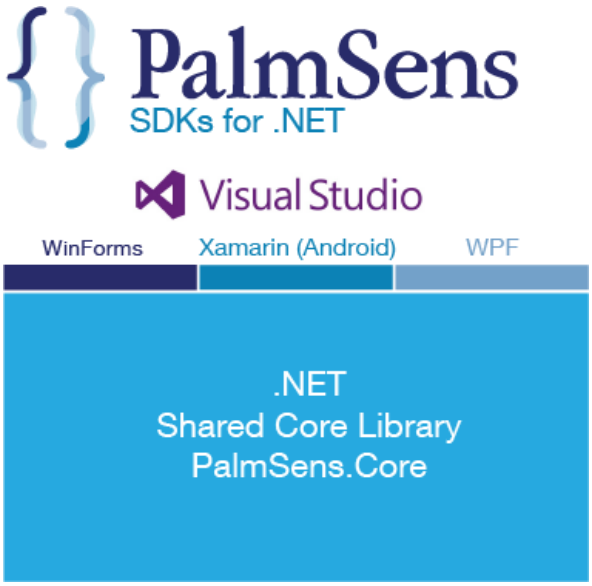
Code examples are available for:

C/C++ ARDUINO Swift Xamarin python Java

› See for more information:
www.palmsens.com/methodscript

Software Development Kits for .NET

Develop your own application in no time for use with any PalmSens instrument or potentiostat (module). Our SDKs are free of charge.

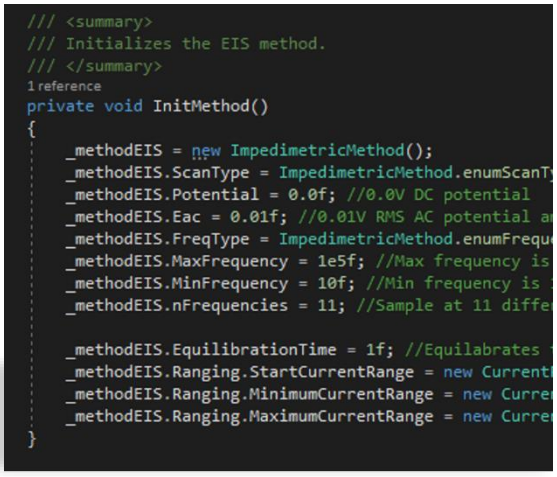


There are three PalmSens Software Development Kits (SDKs) for .NET. Each SDK can be used with any of our instruments or OEM potentiostat modules to develop your own software. The SDK's come with a set of examples that shows how to use the libraries. PalmSens SDKs with examples are available for the following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

EmStat4R can be re-branded for OEM purposes. Contact us about the possibilities.
See also: www.palmsens.com/go

Please do not hesitate to contact PalmSens for more details:
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