# MultiEmStat4 ™

MULTI-CHANNEL POTENTIOSTAT / GALVANOSTAT / IMPEDANCE ANALYZER



**PalmSens**

## Contents

❯ See for more information:
www.palmsens.com/mes4

## No Compromises on Productivity and Performance

The MultiEmStat4 is a compact Potentiostat, Galvanostat, and optional Frequency Response Analyser (FRA) for Electrochemical Impedance Spectroscopy (EIS) with 4, 8 or 12 channels. The MultiEmStat4 comes in two versions:

1. the **Low Range** version which is great for applications that require measuring low currents down to picoamps,
2. the **High Range version**, which is very suitable for applications that need a maximum current of up to 200 mA.

The following table shows the main differences:

|  | *Multi* EmStat *4 LR* ™ | *Multi* EmStat *4 HR* ™ |
|---|---|---|
| • potential range | ±3 V | ±6 V |
| • max. compliance | ±5 V | ±8 V |
| • current ranges | 1 nA to 10 mA (8 ranges) | 100 nA to 100 mA (7 ranges) |
| • max. current (per channel) | ±30 mA | ±200 mA |
| • electrodes | WE, RE, CE, and ground, 2 mm banana plugs | WE, RE, CE, S(ense), and ground, 2 mm banana plugs |
| • hardware options | o  EIS up to 200 kHZ<br>o  Galvanic Isolation | o  EIS up to 200 kHZ<br>o  Galvanic Isolation |

### Always a Backup

The MultiEmStat4 is equipped with 500 MB internal storage memory on each channel for storing your measurements as a backup. All internally stored measurements can be browsed and transferred back to the PC easily using the MultiTrace software.

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

❯ Configure your ideal MultiEmStat:
www.palmsens.com/**mes4**

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## Supported Techniques

The MultiEmStat4 supports the following electrochemical techniques.

### Synchronizing Channels

By enabling synchronization of channels and adjusting the setup of your cables, you can use the MultiEmStat4 as a polypotentiostat. This means you can use multiple working electrodes, one counter and one reference electrode in the same cell at the same time. Your working electrodes all perform the exact same measurement.

Techniques marked with an ⏱ can be used in Synched mode.

### Voltammetric techniques

| | | | |
|---|---|---|---|
| ▪ Linear Sweep Voltammetry | **LSV** | ⏱ |
| ▪ Cyclic Voltammetry | **CV** | ⏱ |

### 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** | ⏱ |
| ▪ Pulsed Amperometric Detection | **PAD** | ⏱ |

### Galvanostatic techniques

| | | | |
|---|---|---|---|
| ▪ Linear Sweep Potentiometry | **LSP** | ⏱ |
| ▪ Chronopotentiometry | **CP** | ⏱ |
| ▪ MultiStep Potentiometry | **MP** | ⏱ |
| ▪ Open Circuit Potentiometry | **OCP** | ⏱ |

### Other

| | | | |
|---|---|---|---|
| ▪ Mixed Mode | MM | ⏱ |
| ▪ Potentiostatic/Galvanostatic Impedance spectroscopy at fixed frequency or frequency scan vs | EIS/GEIS | |

- o fixed potential or fixed current
- o scanning potential or scanning current
- o time

MethodSCRIPT™ allows for developing custom techniques. See page 14 for more information.

## 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<br>HR: 0.183 mV | 250 mV |
| | ▪ N data points | 3 | 1,000,000 |
| ▪ NPV<br>▪ DPV | ▪ Scan rate | LR: 0.1 mV/s (100 µV step)<br>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 | 2500 Hz |
| ▪ LSV<br>▪ CV | ▪ Scan rate | LR: 0.01 mV/s (100 µV step)<br>HR: 0.01 mV/s (183 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<br>(> 100 days at 10 s interval) |
| ▪ CA<br>▪ CP<br>▪ OCP | ▪ Interval time | 0.4 ms | 300 s |
| | ▪ Run time | 1 ms | > year |
| ▪ MM<br>▪ MA<br>▪ MP | ▪ N cycles | 1 | 20,000 |
| | ▪ N levels | 1 | 255 |
| | ▪ Level switching overhead time | ~1 ms | |
| | ▪ Interval time | 0.4 ms | 300 s |

## System Channel 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 | |

| 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 |
| ▪ bandwidth settings | 320 Hz, 3.2 kHz, 30 kHz or 570 kHz | |

| 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 (1 V) 48 µV (500 mV) 19.2 µV (200 mV) 9.6 µV (100 mV) 4.8 µV (50 mV) | 193 µV (1 V) 96.5 µV (500 mV) 38.5 µV (200 mV) 19.3 µV (100 mV) 9.65 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 | | |
|---|---|---|
| model | 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 |
| ▪ housing | aluminium housing: 21.2 x 22.1 x 7.7 cm | |
| ▪ weight | ~3 kg | |
| ▪ communication | USB (type B) | |
| ▪ power | external 12 V AC/DC adapter | |
| ▪ internal storage space on each channel | 500 MB, equivalent to >15M datapoints | |

## MultiEmStat4 LR EIS Accuracy Contour Plot
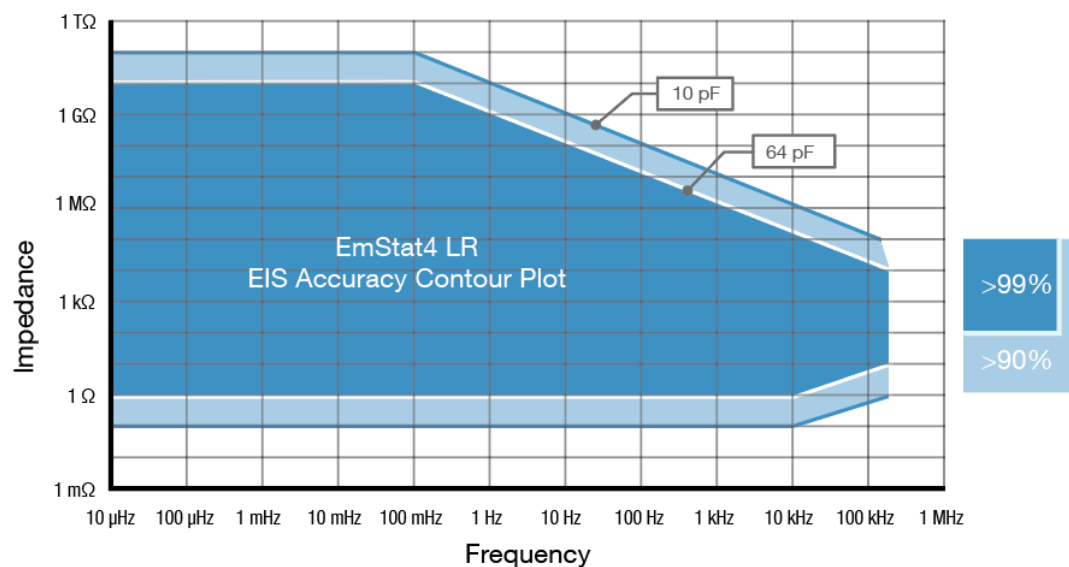


## MultiEmStat4 HR EIS Accuracy Contour Plot
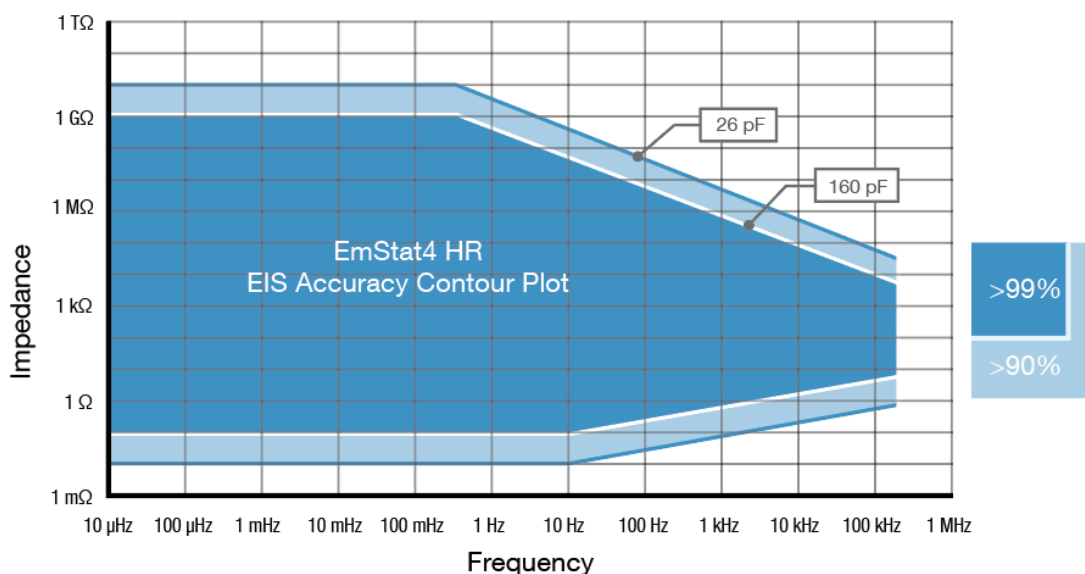


**Note**

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 MultiEmStat4 Kit

A standard MultiEmStat4 comes in a soft case with:
- MultiEmStat4 LR or HR
- 12V external power supply
- USB cable
- 1 meter cell cable with 2 mm banana pins
- 4 or 5 croc clips per cable
- 1x Dummy Cell

Also included:
- MultiTrace software for Windows (on USB drive)
- Manual (hardcopy)
- Quick Start document
- Calibration report for each channel



*The MultiEmStat4 comes
standard in a soft carrying case.*

## MultiTrace: Software for Windows

The MultiEmStat4 comes with MultiTrace for Windows. MultiTrace allows the instrument to be controlled in two different modes: Individual and Simultaneous channel control mode.
This mode can be selected in the start-up window of MultiTrace.
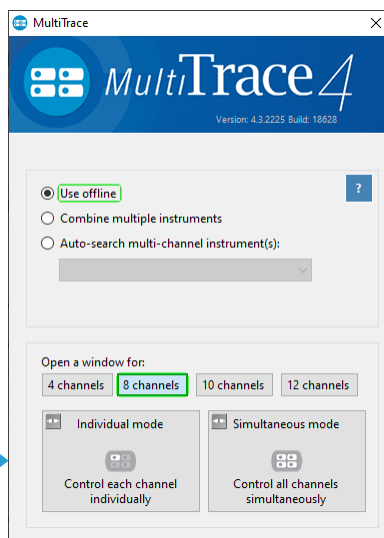


**Individual Mode:**
where each channel can run a measurement or script independently from the other channels.
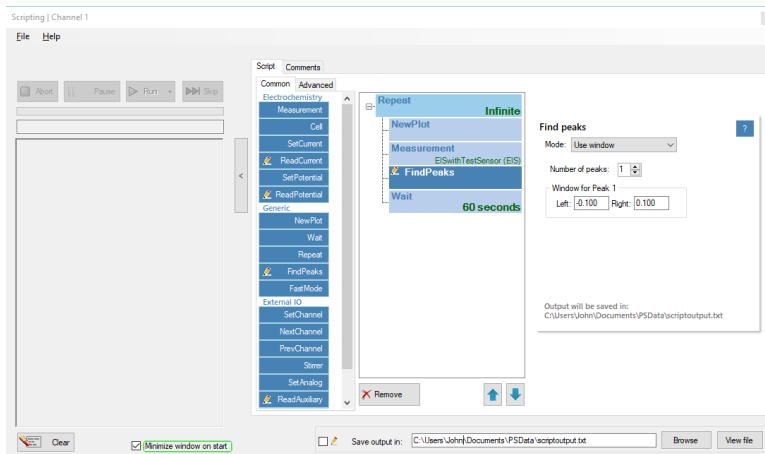
**Simultaneous Mode:**
where all channels run the same measurement.

## Individual Mode

The individual mode gives an overview of all channels. Each channel can be selected separately and can run a measurement independently in parallel with other channels.

You can also run a script for a sequence of measurements and other actions on each channel.
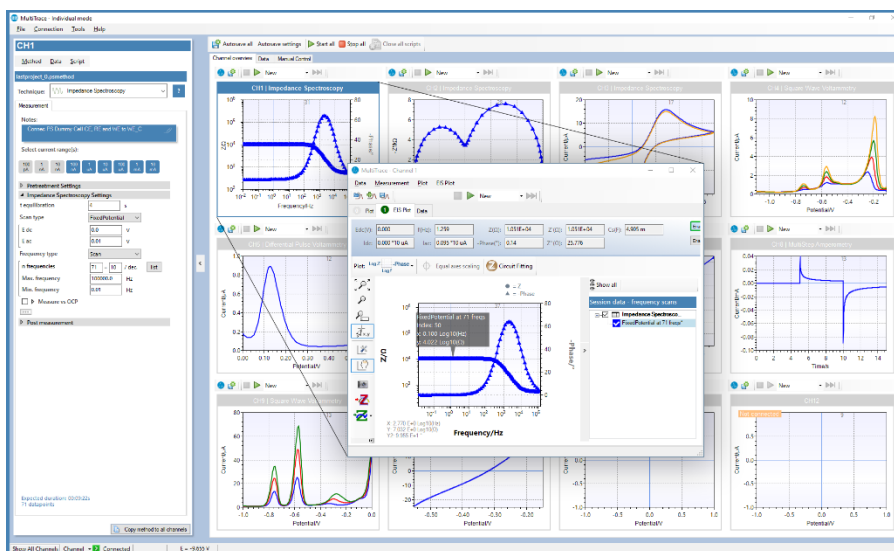
## Scripting

The Individual mode of MultiTrace also supports the option to run a sequence of measurements on a specific channel by using Scripting.

Such a sequence can include different techniques and provides control commands for manual cell control or digital input or output lines.
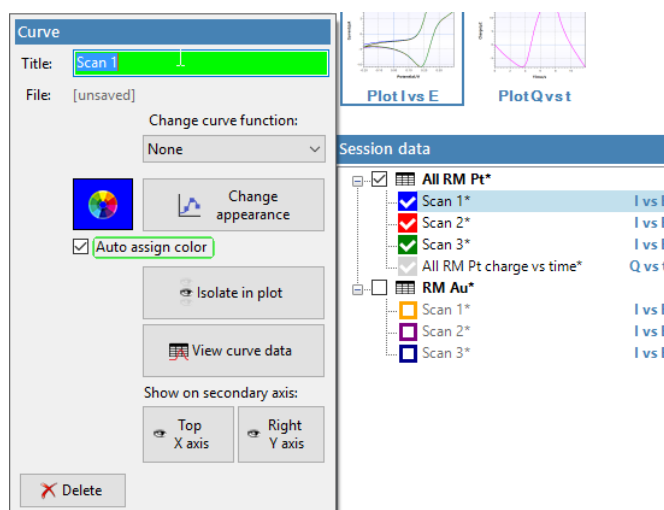
## Simultaneous Mode

In the Simultaneous Mode the MultiEmStat4 works with all channels running the same measurement in parallel at the same time.
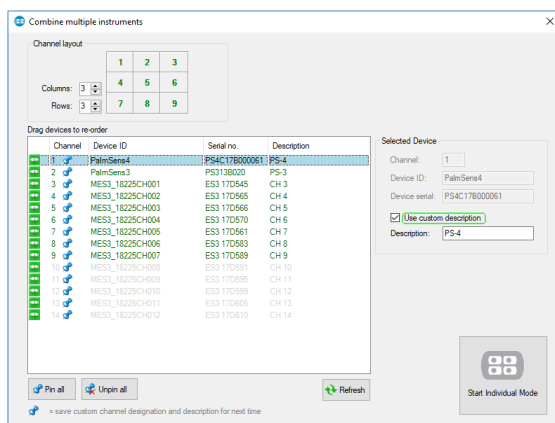
There is only one active method in the Method Editor which is started on all channels simultaneously upon start.
All results are presented as overlays in the same plot.
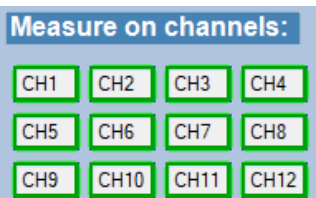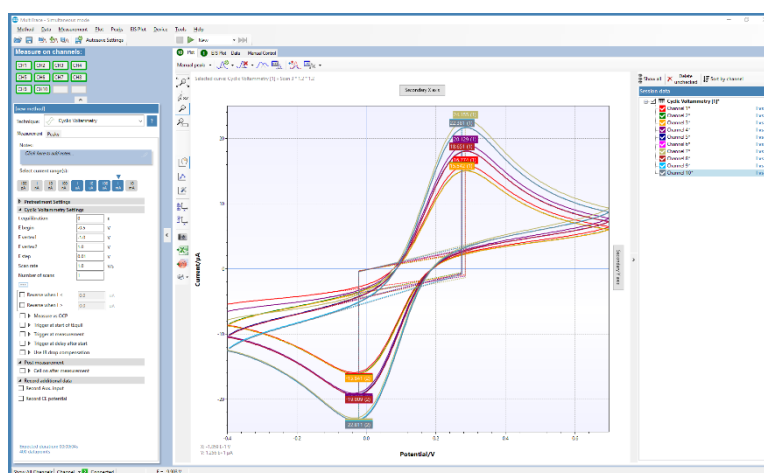




This panel in the main screen contains a toggle button for each channel determines which channels are participating in the measurement.

Pop-up window shown when clicking a Curve in the legend.

## Combining different instruments

MultiTrace supports all instrument models provided by PalmSens BV. A collection of different instruments can be combined for control by MultiTrace in both Individual and Simultaneous mode. Either multiple multi-channel or single-channel instruments can be combined.

## 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.
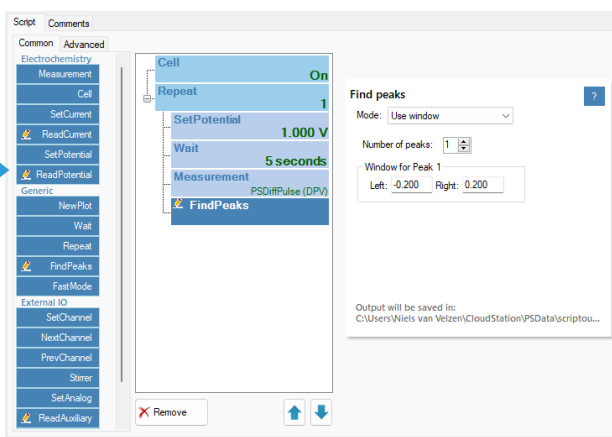


## Other functions in MultiTrace

- Equivalent Circuit Fitting
- Advanced peak search algorithms
- Scripting (on each channel)
- Automatic data saving
- 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
- Direct feedback on validity of method parameters
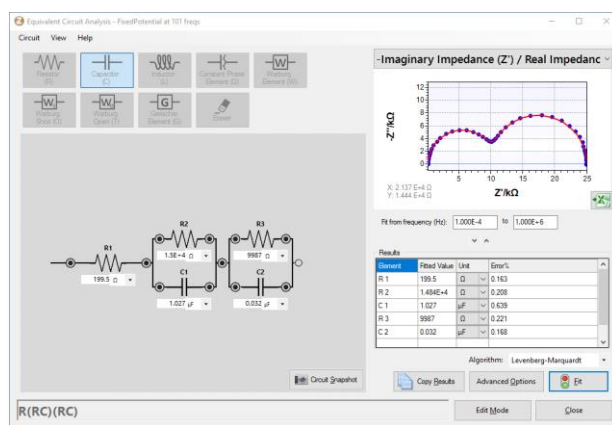


## Integration with third party software:
- Excel
- Origin
- Matlab
- ZView



## 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/multitrace

## 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.enumFreq
    _methodEIS.MaxFrequency = 1e5f; //Max frequency is
    _methodEIS.MinFrequency = 10f; //Min frequency is
    _methodEIS.nFrequencies = 11; //Sample at 11 diffe

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

❯ See for more information:
www.palmsens.com/sdk

## MultiEmStat4 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..

```
1  e
2  var c
3  var p
4  #Select bandwidth of 40 for 10 points per second
5  set_max_bandwidth 40
6  #Set current range to 1 mA
7  set_range ba 1m
8  #Enable autoranging, between current of 100 uA and 1 mA
9  set_autoranging ba 100u 1m
10 #Turn cell on for measurements
11 cell_on
12 #equilibrate at -0.5 V for 5 seconds, using a CA measurement
13 meas_loop_ca p c -500m 500m 5
14    pck_start
15    pck_add p
16    pck_add c
17    pck_end
18 endloop
19 #Start LSV measurement from -0.5 V to 1.5 V, with steps of 10 mV
20 #and a scan rate of 100 mV/s
21 meas_loop_lsv p c -500m 1500m 10m 100m
22    #Send package containing set potential and measured WE current.
23    pck_start
24    pck_add p
25    pck_add c
26    pck_end
27    #Abort if current exceeds 1200 uA
28    if c > 1200u
29    abort
30 endloop
31 #Turn off cell when done or aborted
32 on_finished:
33 cell_off
34
```

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™

**Code examples are available for:** C#, C/C++, ARDUINO, Swift, Xamarin, python, Java

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

**PalmSens**

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

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The Netherlands
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