MultiEmStat4™

MULTI-CHANNEL POTENTIOSTAT / GALVANOSTAT /
IMPEDANCE ANALYZER

PalmSens

Rev. 11-2023-004

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;
the **Low Range** version which is great for applications that require measuring low currents down to picoamps, and 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:

	MultiEmStat4 LR™	MultiEmStat4 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 (per channel)	±30 mA	±200 mA
▪ electrode connections	WE, RE, CE, and ground, 2 mm banana plugs	WE, RE, CE, S(ense), and ground, 2 mm banana plugs
▪ hardware options	○ EIS up to 200 kHZ ○ Galvanic Isolation	○ EIS up to 200 kHZ ○ 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

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 ○ fixed potential or fixed current ○ scanning potential or scanning current ○ time	EIS/GEIS

MethodSCRIPT™ allows for developing custom techniques. See page 14 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	2500 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)
▪ 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 Channel Specifications

General		
model	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)		
model	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)		
model	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	

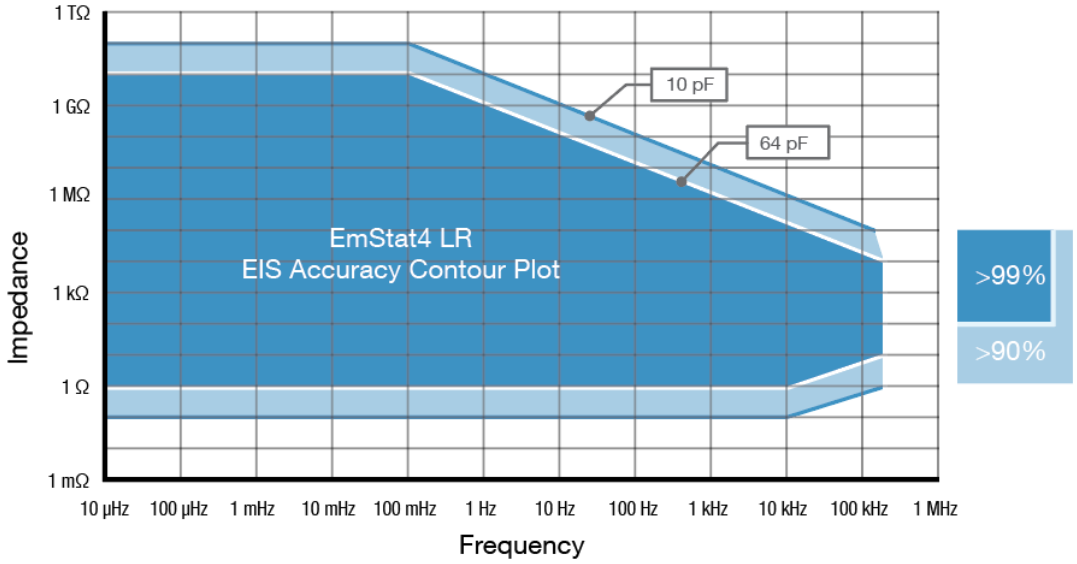
FRA / EIS (impedance measurements)	
▪ frequency range	10 µHz to 200 kHz
▪ ac-amplitude range	1 mV to 900 mV rms, or 2.5 V p-p

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

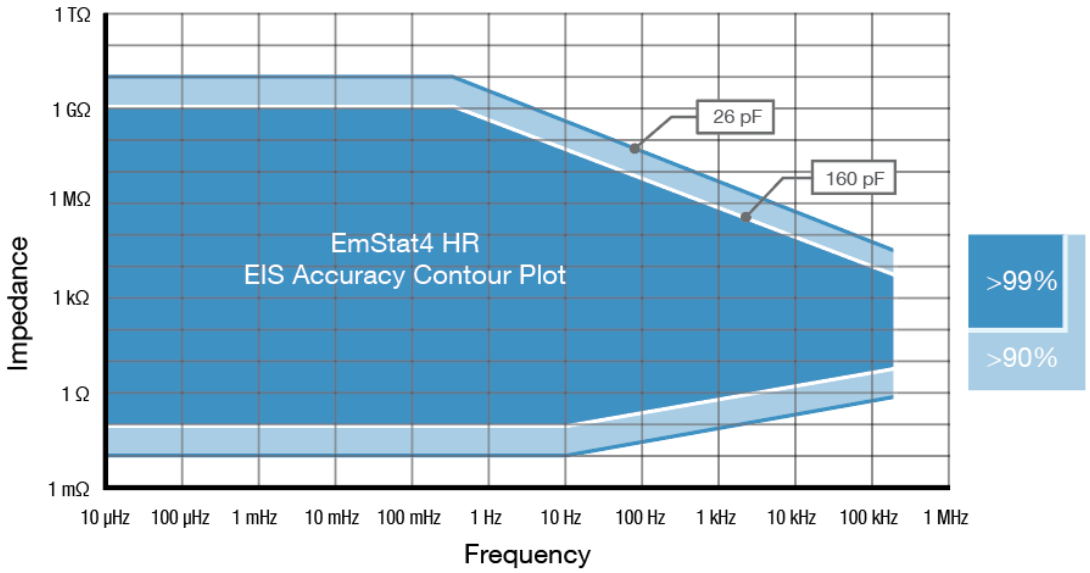
Electrometer	
▪ electrometer amplifier input	> 1 TΩ // 10 pF
▪ bandwidth	10 kHz or 500 kHz

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	aluminum body: 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:

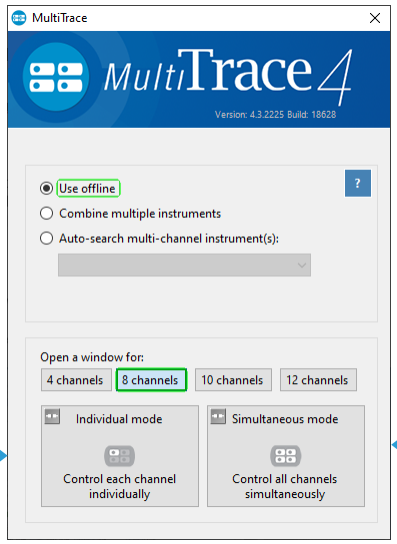
- MultiTrace software for Windows (on USB drive)
- Manual (hardcopy)
- Quick Start document
- Calibration report for each channel

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.

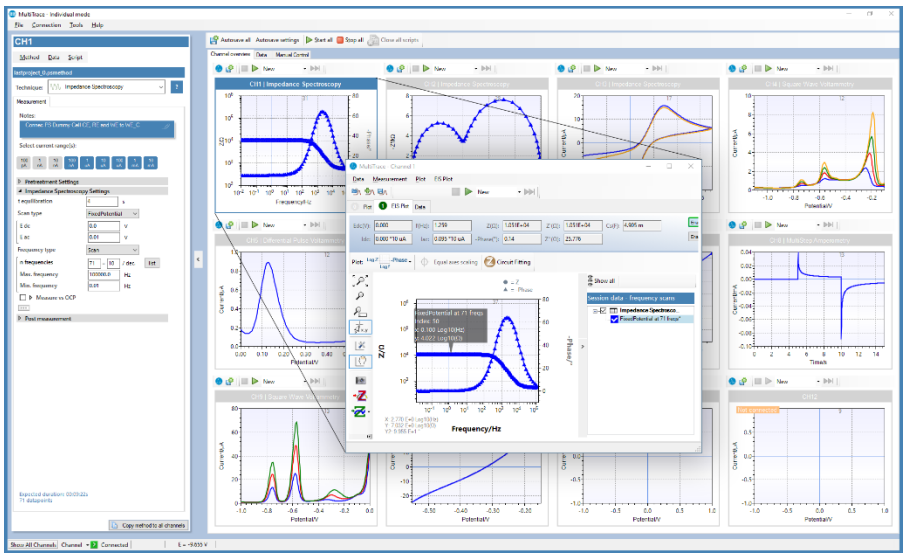


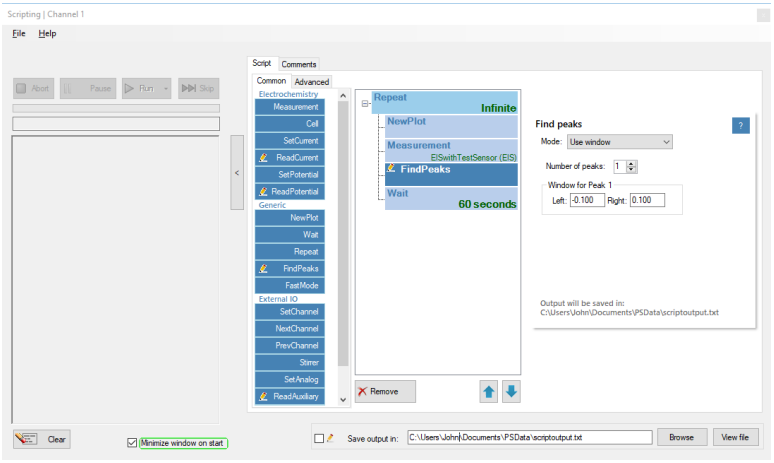
Simultaneous Mode: where all channels run the same measurement.

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.





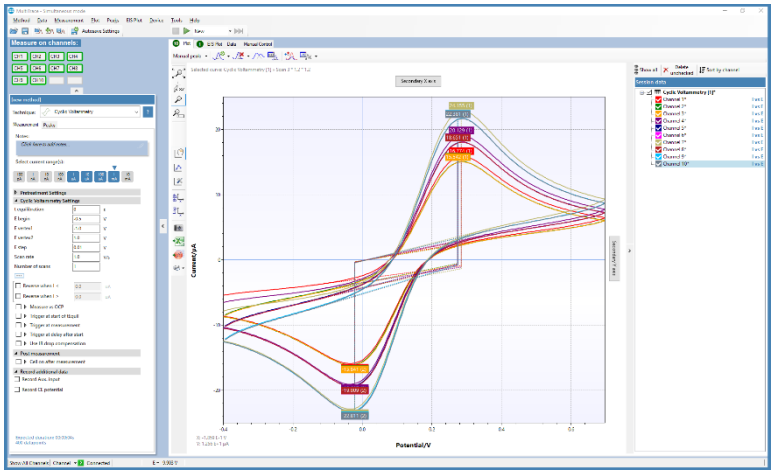
Scripting

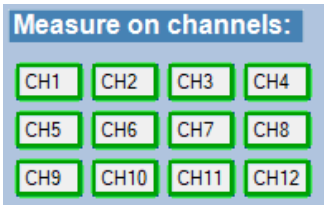
The Individual mode of MultiTrace also supports the option to run a sequence of measurements on a specific channel by using Scripting.
Such a sequence can include different techniques and provides control commands for manual cell control or digital input or output lines.

Simultaneous Mode

In the Simultaneous Mode the MultiEmStat4 works with all channels running the same measurement in parallel at the same time.

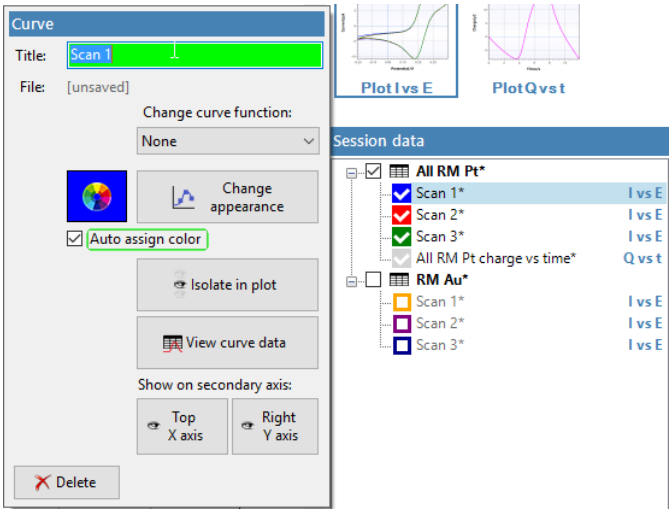
There is only one active method in the Method Editor which is started on all channels simultaneously upon start.
All results are presented as overlays in the same plot.

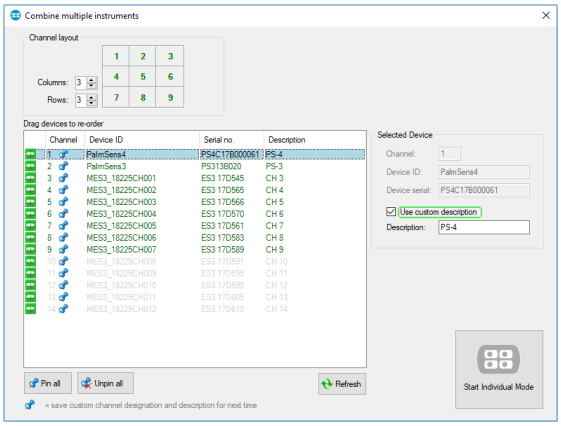




This panel in the main screen contains a toggle button for each channel determines which channels are participating in the measurement.

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



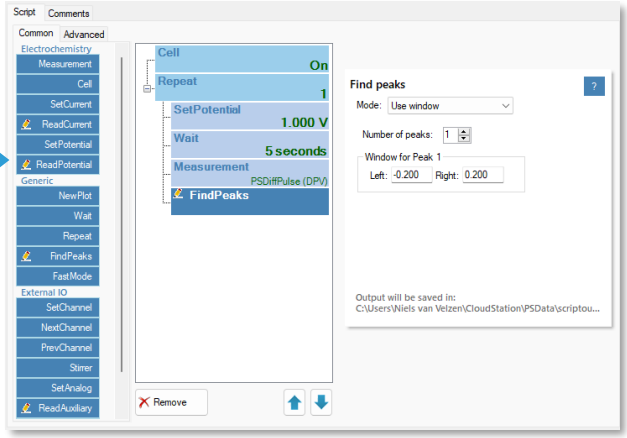


Combining different instruments

MultiTrace supports all instruments 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.

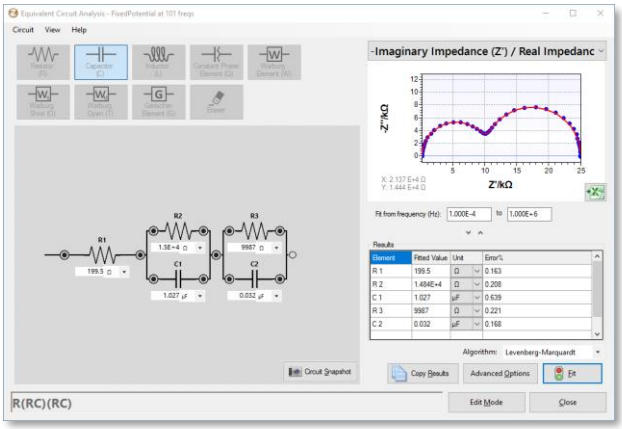
Scripting

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.



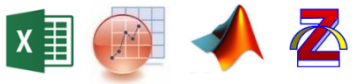
Other functions in MultiTrace

- 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



System requirements

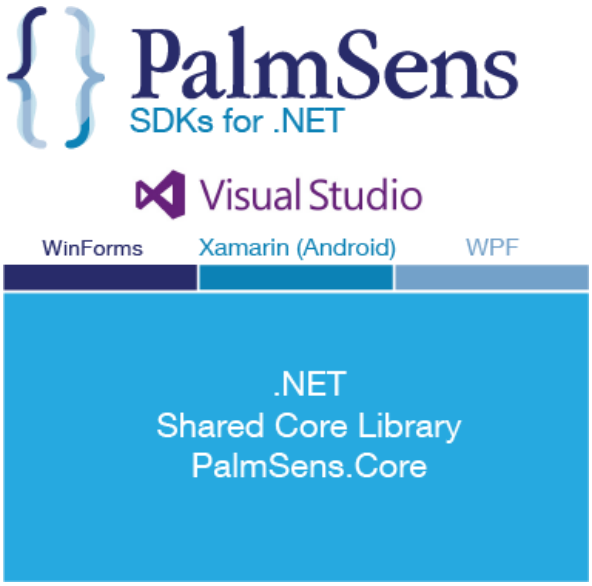
Minimum PC requirements are:

- Windows 7, 8, 10 or 11
- 1 GHz or faster 32-bit (x86) or 64-bit (x64) processor with at least 2 processor cores (4 or more cores recommended)
- 2 GB RAM (32-bit) or 4 GB RAM (64-bit)
- Screen resolution of at least 1280 x 768 pixels (higher is recommended)

› 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.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

MultiEmStat4 works with MethodSCRIPT™

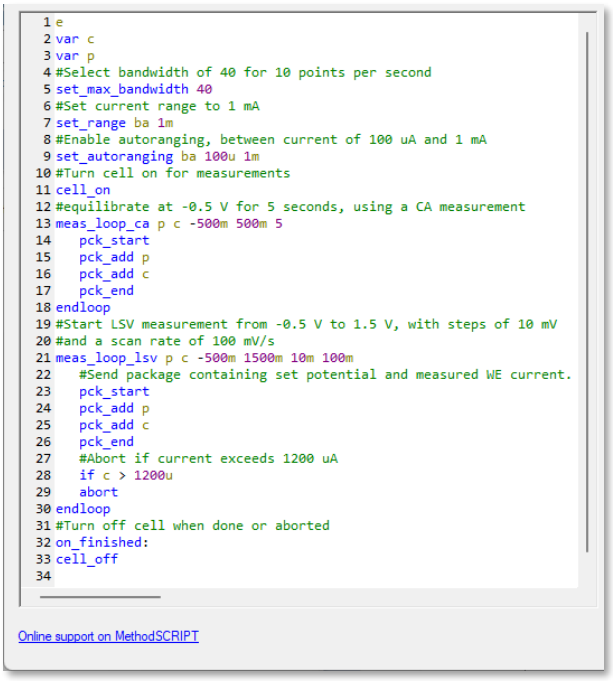
The MethodSCRIPT™ scripting language is designed to integrate our instruments and potentiostat (modules) effortlessly in your hardware setup, product, or experiment.

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..



```
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

Please do not hesitate to contact PalmSens for more details:
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