MultiPalmSens4™

multi-channel
POTENTIOSTAT / GALVANOSTAT / IMPEDANCE ANALYZER

PalmSens

Rev.06-2023-010

Contents

> See for more information:
> www.palmsens.com/mps4

MultiPalmSens4: Highly Configurable

The MultiPalmSens4 is a flexible multi-channel potentiostat, galvanostat and impedance analyzer which you can tailor to your requirements and budget.

Each channel can be configured with:

- ±5 V or ±10 V maximum potential range
- EIS/FRA with maximum frequency of 100 kHz or 1 MHz
- Bipotentiostat for second WE
- iR-Compensation
- Galvanic isolation

See page 10

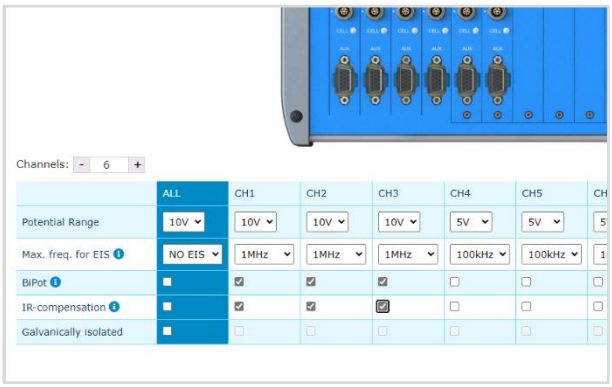
The MultiTrace software allows for using each channel individually or simultaneously or running a sequence of automated tasks on each channel. Each channel provides an additional auxiliary port for controlling peripherals or monitoring temperature or other analog signals.

Software for Windows

Always a backup

Every channel of the MultiPalmSens4 is equipped with internal storage of 8 GB. This means all your measurements[1] can automatically be saved on-board as backup. Measurements can be browsed and transferred to the PC easily using the MultiTrace software for Windows.

[1] Not supported for internal storage: EIS, MultiStep and MixedMode



› Configure your ideal MultiPalmSens4:
www.palmsens.com/mps4

Supported Techniques

The MultiPalmSens4 supports the following techniques.

Synchronising channels in Synched mode.

By enabling synchronization of channels and adjusting the setup of your cables, you can use the MultiPalmSens4 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 same measurement.

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

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/PSA** ⏱

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

System Channel Specifications

General		
config	PS4.F#.05	PS4.F#.10
▪ dc potential range	±5 V	±10 V
▪ compliance voltage	±10 V	
▪ maximum current	±30 mA (typical)	
▪ max. acquisition rate	150 000 points/s	

Potentiostat (controlled potential mode)	
▪ applied dc-potential resolution	76.3 µV (18-bit)
▪ applied potential accuracy	≤ 0.1% ±1 mV offset
▪ current ranges	100 pA to 10 mA (9 ranges)
▪ measured current accuracy	< 0.2% of current ±10 pA ±0.1% of range
▪ measured current resolution	0.005% of current range (18-bit, 5 fA on 100 pA range) 0.0025% of 10 mA range

Galvanostat (controlled current mode)	
▪ current ranges	1 nA to 10 mA (8 ranges)
▪ applied dc-current	±6 x applied current range
▪ applied dc-current resolution	0.0076% of applied range (<10 mA) 0.0038% of 10 mA range
▪ applied dc-current accuracy	< 0.2% of current ±10 pA ±0.1% of range
▪ potential ranges	10 mV, 100 mV, 1 V
▪ measured dc-potential resolution	78 µV at ±10 V (1 V range, 18-bit) 7.8 µV at ±1 V (100 mV range) 0.78 µV at ±0.1 V (10 mV range)
▪ measured dc-potential accuracy	≤ 0.05% or ±1 mV for |E| <9 V ≤ 0.2% for |E| ≥9 V

FRA / EIS (impedance measurements)		
config	PS4.F1.##	PS4.F2.##
▪ frequency range	10 µHz to 100 kHz	10 µHz to 1 MHz
▪ ac-amplitude range	1 mV to 0.25 V rms, or 0.7 V p-p	

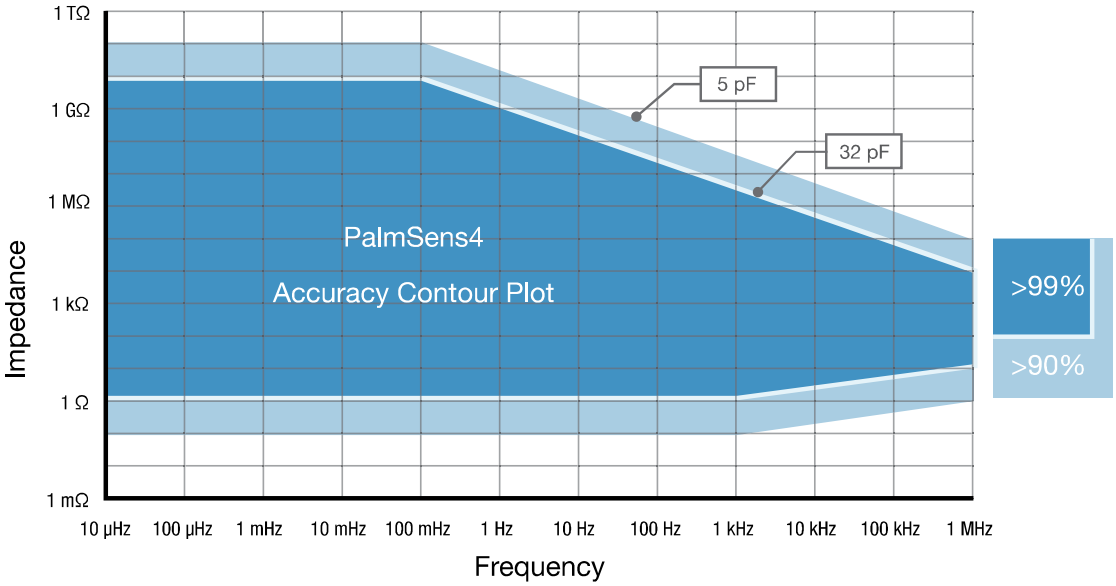
GEIS (galvanostatic impedance measurements)	
▪ frequency range	10 µHz to 100 kHz (all configurations)
▪ ac-amplitude range	0.001 * CR to 0.4 * CR rms (<10 mA) 0.001 * CR to 0.2 * CR rms (10 mA) (CR=current range)

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

Other	
▪ electrode connections	2 mm banana pins for RE, WE, CE and GND
▪ housing	15 x 25 x 25 cm^3
▪ weight	~4 kg
▪ temperature range	0 °C to + 50 °C
▪ power supply	external 12 V AC/DC adapter
▪ communication	USB-B
▪ internal storage space	8 GB per channel or +/- 800000 measurements incl. method info (assuming 200 data points per measurement)

Auxiliary port (D-Sub 15)	
▪ analog input	±10 V, 18-bit
▪ analog output	0-10 V, 12-bit (1 kOhm output impedance)
▪ digital I/O	4x digital output (5 V) 1x digital input (5 V)
▪ i-out and E-out	raw output of current and potential E-out ±10 V (1 kOhm output impedance) i-out ±6 V (1 kOhm output impedance)
▪ power	5 V-output (max. 150 mA)

EIS Contour Accuracy Plot



Note
The accuracy contour plot was determined under lab conditions using the standard 1 meter cell cable and should be used for reference purposes. Please note that the true limits of an impedance measurement are influenced by all components in the system, e.g. cables, the environment, and the cell.

Measurement Specifications

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

	Parameter	Min	Max
All techniques (unless otherwise specified)	▪ Conditioning time	0	1600 s
	▪ Deposition time	0	1600 s
	▪ Equilibration time	0	1600 s
	▪ Step potential	0.076 mV	250 mV
	▪ Pulse potential	0.076 mV	250 mV
	▪ N data points	3	1,000,000
▪ NPV ▪ DPV	▪ Scan rate	0.1 mV/s (76.3 µV step)	100 mV/s (5 mV step)
	▪ Pulse time	10 ms	300 ms
▪ SWV	▪ Frequency	1 Hz	1250 Hz
▪ ACV	▪ Frequency	1 Hz	2000 Hz
▪ LSV	▪ Scan rate	0.01 mV/s (76.3 µV step)	500 V/s (10 mV step)
▪ CV	▪ Scan rate	0.01 mV/s (76.3 µV step)	500 V/s (200 mV step)
▪ FCV	▪ Scan rate	400 mV/s (76.3 µV step)	500 V/s (10 mV step)
	▪ N averaged scans	2	255
	▪ N equilibration scans	1	255
▪ PAD	▪ Interval time	50 ms	300 s
	▪ Pulse time	1 ms	1 s
	▪ N data points		1,000,000 (> 100 days at 10 s interval)
▪ MPAD	▪ Pulse time	100 ms	2 s
	▪ Run time	1.2 s	100,000 s
	▪ N potential levels	3	3
▪ 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	~80 ms	
▪ FAM	▪ Interval time	0.02 ms	1 s
	▪ Run time	1 ms	30 s
	▪ N data points	3	4000 for interval time < 0.2 ms

Optional BiPot Specifications

Each channel of the MultiPalmSens4 can be extended in-factory with a BiPot module for use with a second Working Electrode.

BiPot specifications	
▪ dc-potential range	±5 V
▪ dc-potential resolution	153 µV (16-bit)
▪ dc-offset error	≤ 0.1%, ±1 mV offset
▪ accuracy	≤ 0.1%
▪ current ranges	100 pA to 10 mA (9 ranges)
▪ maximum measured current	i(WE1) + i(WE2) < 30 mA
▪ current resolution	0.005% of current range (5 fA on 100 pA range) 0.0025% of 10mA range
▪ current accuracy	≤ 0.1% current, ±0.2% range
▪ connection	comes with a cell cable with an additional (yellow) connector for WE2
▪ supported techniques	▪ Linear Sweep Voltammetry ▪ Cyclic Voltammetry ▪ Chronoamperometry ▪ Multistep Amperometry

Optional iR Compensation Module Specifications

Each channel of the MultiPalmSens4 can be extended in-factory with an iR Compensation add-on module.

iR Compensation module specifications	
▪ method used for iR-drop compensation	Positive Feedback
▪ resolution of MDAC used for correcting potential	16-bit
▪ max. compensated resistance	1 MOhm
▪ max. bandwidth with iR-drop compensation enabled	10 kHz

Standard MultiPalmSens4 Kit

A standard MultiPalmSens4 comes in a soft carrying case with:

- MultiPalmSens4
- 12V external power supply
- USB cable
- 1 meter cell cables with 2 mm banana pins
- 4 croc clips per cable
- PalmSens Dummy Cell

PalmSens Dummy Cell

Also included:

- MultiTrace software (on USB stick)
- Manual (hardcopy)
- Quick Start document
- Calibration reports

Each channel can be configured with the following options and corresponding product codes:

code:	MPS4.F#.05	MPS4.F#.10
Potential range	-5V to +5V	-10V to +10V

code:	MPS4.F0.##	MPS4.F1.##	MPS4.F2.##
EIS configuration	NO EIS	100 kHz	1 MHz

Optional:

- BiPot module
- iR Compensation module

For example, a single channel can have configuration *MPS4.F1.05* which means it will have max. 100 kHZ for EIS with ±5V potential range, or *MPS4.F2.10+BiPot* for max. 1 MHz EIS with ±10V and a BiPot module.

The MultiPalmSens4 can also be configured with **galvanically isolated** (floating) channels.

Soft carrying case

› Configure your ideal MultiPalmSens:
www.palmsens.com/mps4

MultiPalmSens4 Accessories

In-factory add-on modules

BiPot add-on module

The BiPot Module is an optional extension for the PalmSens4 and is for applications requiring control of two independent working electrodes. The module fits inside the PalmSens instrument. The PSTrace software supports this module for linear sweep, cyclic voltammetry and amperometric detection with two working electrodes.

See page 9 for BiPot specifications

iR Compensation add-on module

The iR Compensation module is an optional extension for the PalmSens4. The resistance between the reference electrode and the double layer of the specimen can cause a significant potential drop, decreasing the applied potential where it is required. The module provides positive feedback to compensate for the iR-drop between Reference electrode and the outside of the double layer of the electrochemical cell.

See page 9 for iR Compensation module specifications

Other accessories

MUX8-R2 or MUX16 multiplexer

The MUX8-R2 is an 8-channel multiplexer. It allows the PalmSens4 to measure up to 8 cells, switching RE, CE, WE1 and WE2 or 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.

The MUX16 is a 16-channel multiplexer. It allows the PalmSens4 to measure up to 16 working electrodes with shared counter and reference electrodes.

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.

LM35/TMP36 temperature sensor

This temperature sensor allows for monitoring of temperature during an experiment.
Two point calibration allows the user to precisely calibrate the sensor for the required temperature range. The calibration curve shows a linear slope of +10 mV/°C with 0.5°C Ensured Accuracy (at 25°C). It is rated for full 2°C to 150°C range (LM35) or -40°C to 125°C range (TMP36). The sensor has low self-heating (0.08°C in still air).

Differential Electrometer Amplifier (DEA)

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

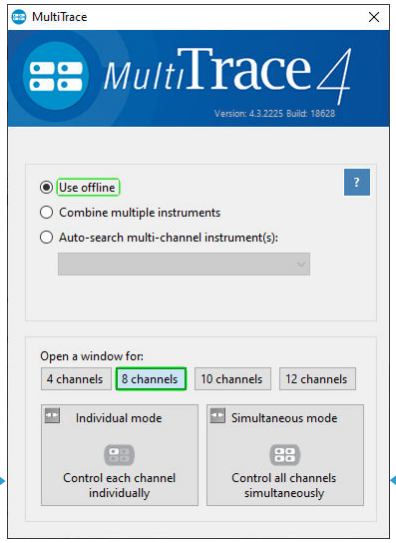
Default range is -10V to 10V (1x gain). Possible gains are: 2x, 5x, 10x, 20x, 50x and 100x.

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

MultiTrace: Software for Windows

The MultiPalmSens4 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 when in the opening screen of MultiTrace.

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

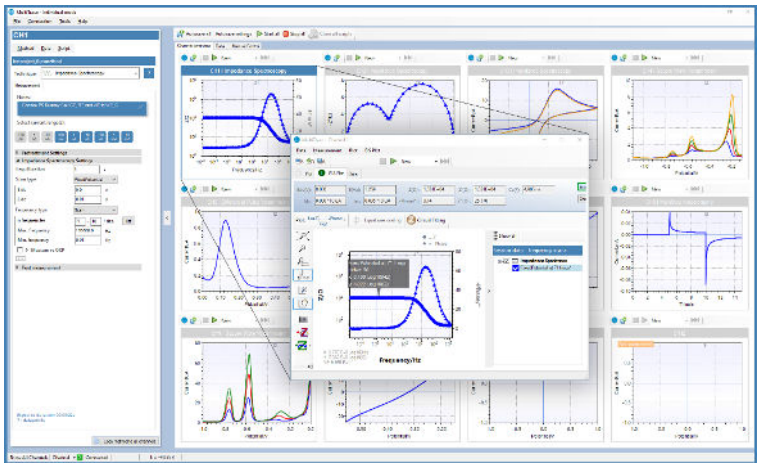


Simultaneous Mode: where all channels run the same measurement.

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.

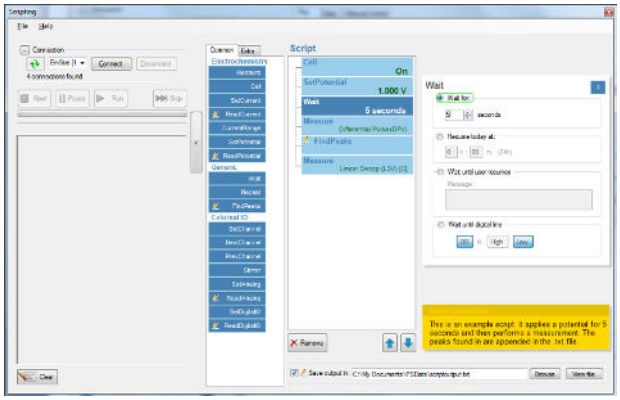
You can also run a script for a sequence of measurements and other actions on each channel.



Multiplexing each channel

Each MultiPalmSens4 channel can be extended with a MUX8-R2 multiplexer to connect eight individual cells (each with their own RE, CE and WE) to a single channel. This allows a fully equipped MultiPalmSens4 to work with 80 channels in total. You can stack multiple MUX8-R2 multiplexers for even more channels.
Each multiplexer connected to a channel of the MultiPalmSens4 is configurable in MultiTrace. See for more information:

www.palmsens.com/mux8-r2



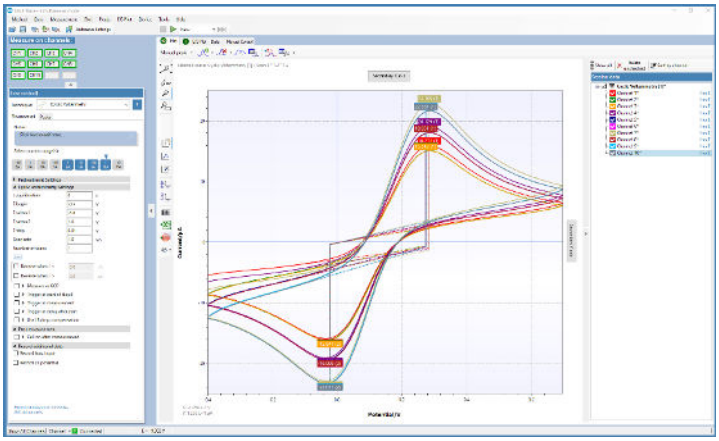
Scripting

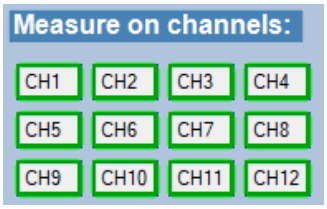
The individual mode also supports the option to run a sequence of measurements on a specific channel by using Scripting. Such a sequence can include different techniques and provides control commands for manual cell control or digital input or output lines.

Simultaneous Mode

In the Simultaneous Mode the MultiPalmSens4 works with all channels running the same measurement in parallel at the same time.

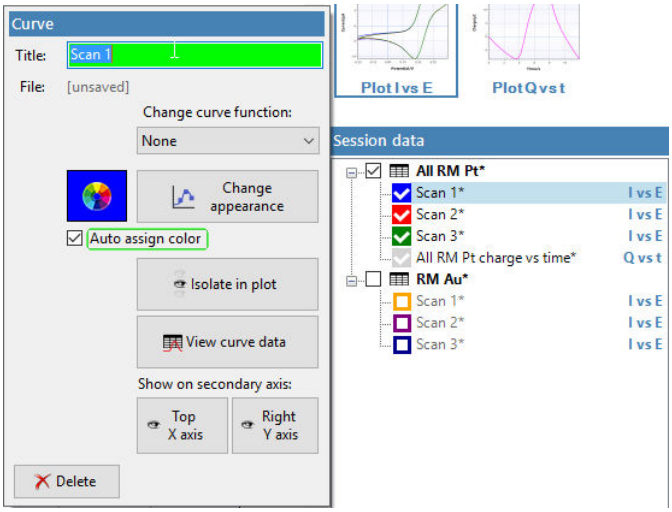
There is only one active method in the Method Editor which is started on all channels simultaneously upon start.
All results are presented as overlays in the same plot.

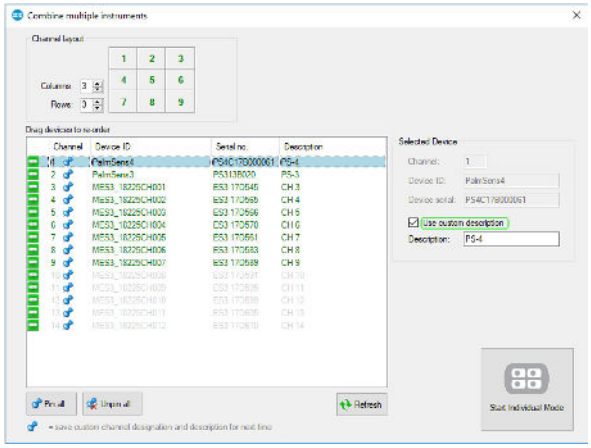




This panel in the main screen contains a toggle button for each channel determines which channels are participating in the measurement.

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



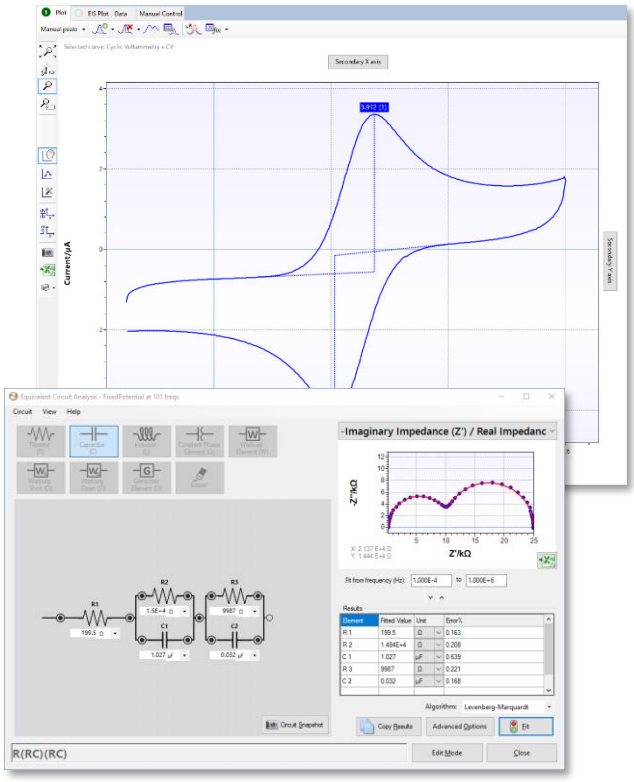


Combining different instruments

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.

Other functions in MultiTrace

- Equivalent Circuit Fitting
- Automatic peak search
- 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
- Browse measurements on MultiPalmSens4's internal storage
- Direct validation of method parameters



Integration with third party software:

- Excel
- Origin
- Matlab
- ZView

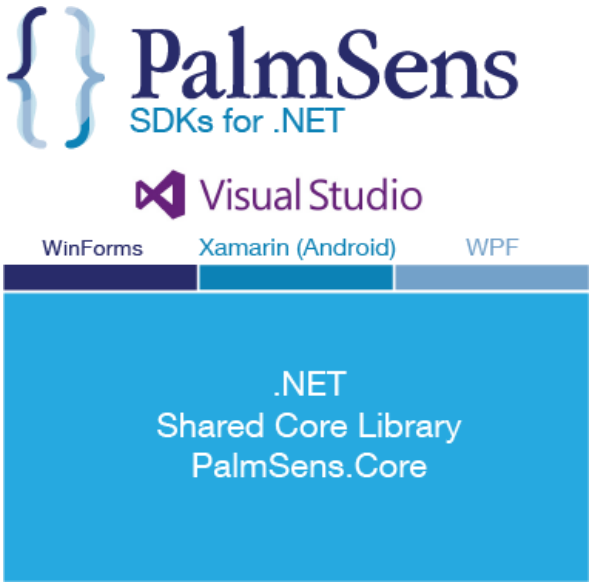
Minimum System Requirements

- Windows 7, 8, 10 or 11
- 1 GHz or faster 32-bit (x86) or 64-bit (x64) processor 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 1280 x 800 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.enumScanTy
    _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

Please don't hesitate to contact PalmSens for more details:
info@palmsens.com

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The Netherlands
www.palmsens.com