

EmStat4M™

ELECTROCHEMICAL INTERFACE MODULE
POTENTIOSTAT | GALVANOSTAT | IMPEDANCE ANALYZER (optional)



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➤ See for more information:
www.palmsens.com/emstat4m

Potentiostat module with desktop performance

The EmStat4M is a module (small PCB) of 62 x 40 mm functioning as Potentiostat, Galvanostat, and optional Frequency Response Analyser (FRA) for Electrochemical Impedance Spectroscopy (EIS).

It can be powered and communicate directly via its USB-C port, or it can be mounted on a carrier PCB using pin headers for communication, power and cell connections.

A high-end LEMO plug for using standard shielded sensor cables is standard available on the module.

Two versions for different applications

The EmStat4M Low Range version is ideal for applications that require a low current range down to 1 nA, whereas the High Range version is designed for applications that require a maximum current of up to 200 mA or higher potentials.

The following table shows the main differences:



EmStat4M LR

EmStat4M 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 μ Hz to 200 kHz	
▪ electrode connections	WE, RE, CE, and ground	WE, RE, CE, S, and ground

On-board mass storage



The EmStat4M is equipped with 500 MB internal storage memory for storing measurement data. Internally stored measurements can be browsed and transferred back to the PC easily using PStRace for Windows. Or you can write your own code to manage the internally stored measurements.

Communications protocol and Software Development Tools

The EmStat4M module works with the human-readable MethodSCRIPT protocol for direct serial (USB or UART) communication. This allows for connecting and using the module in a terminal window or with any microcontroller, PC, or operating system.

See page 13 for more information.



MethodSCRIPT™

Supported Techniques

The EmStat4M 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 |

Galvanostatic techniques

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

Other

- | | |
|---|------------|
| ▪ Mixed Mode | MM |
| ▪ Potentiostatic and Galvanostatic Impedance spectroscopy at fixed frequency or frequency scan vs | EIS/GEIS |
| ○ 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 13 for more information.



MethodSCRIPT™
by PalmSens

Measurement Specifications

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 μ V step) HR: 0.1 mV/s (183 μ V 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 μ V step) HR: 0.01 mV/s (183 μ V step)	500 V/s (200 mV step)
▪ FCV	▪ Scan rate	LR: 0.1 mV/s (100 μ V step) HR: 0.01 mV/s (183 μ V 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	50 ms	4294 s
▪ FAM	▪ Interval time	1 μ s	60 s
	▪ Run time	3 μ s	34 days (60 s interval) 50 ms (1 μ s interval)
	▪ N data points	3	50000
▪ Fast EIS	Interval time between points at fixed frequency	~1 ms (typical)	-

Module 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 ±0.150 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 μ Hz to 200 kHz
▪ ac-amplitude range	1 mV to 900 mV rms, or 2.5 V p-p

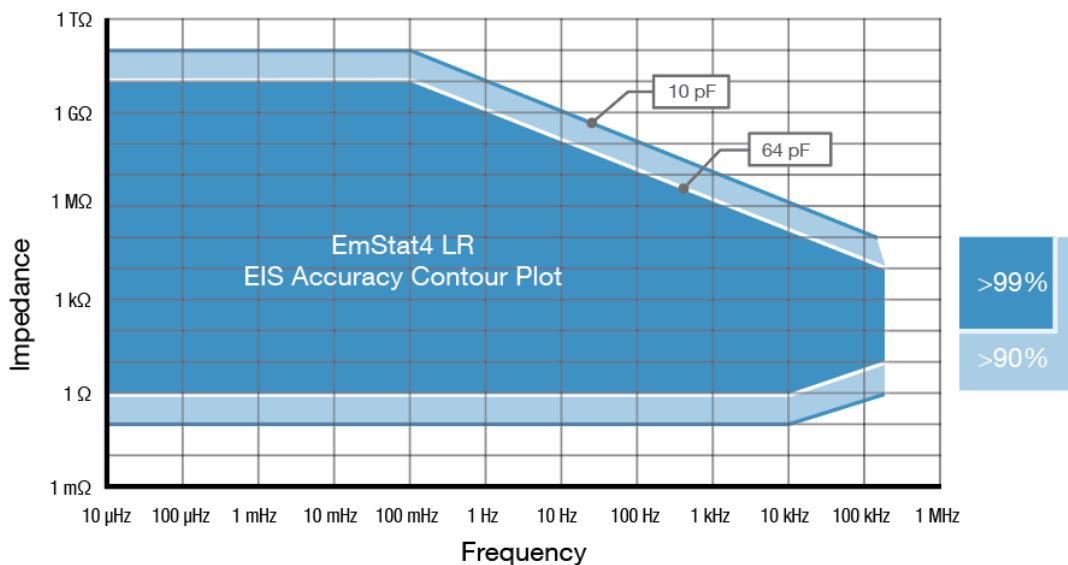
GEIS (galvanostatic impedance measurements)	
▪ frequency range	10 μ Hz to 100 kHz
▪ ac-amplitude range	0.9 * CR A rms

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

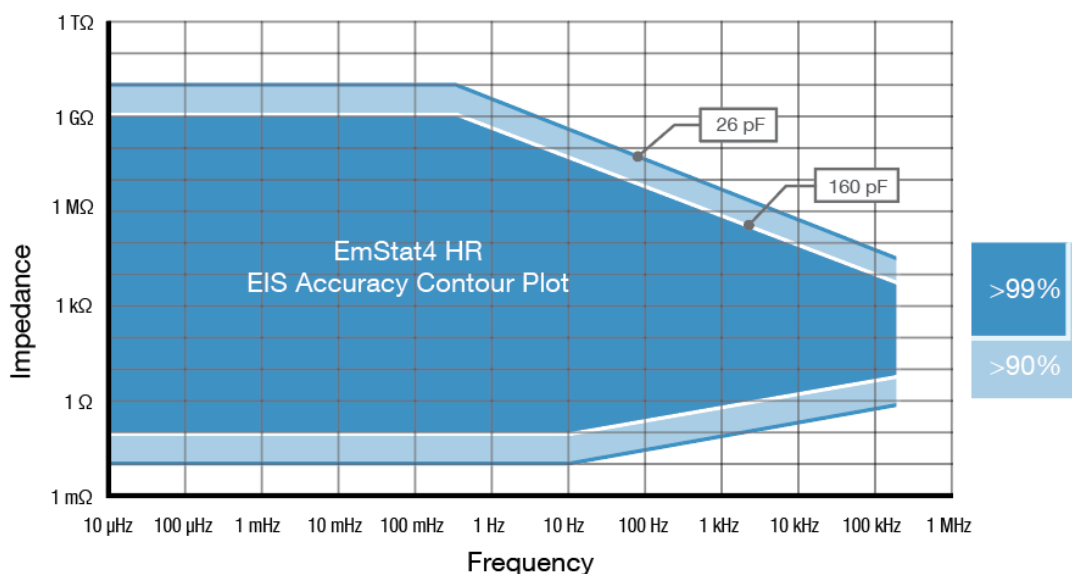
Other		
	LR	HR
▪ electrode connections	WE, RE, CE, and ground	WE, RE, CE, S and ground
▪ weight	~30 g	
▪ operating temperature	-40 °C to +85 °C. ¹	
▪ power + communication	USB-C	
▪ internal storage space	500 MB, equivalent to >15M datapoints or ~1000 measurement files (whichever comes first)	

¹ All the components of the EmStat4M are rated to the industrial standard of -40 °C to +85 °C. The EmStat4M is calibrated at 21 °C. The most sensitive components of the EmStat4M have a temperature drift of 50 ppm. At 1 °C or 41 °C, measurement drift of up to 0.1% may be experienced.

EmStat4M LR EIS Accuracy Contour Plot

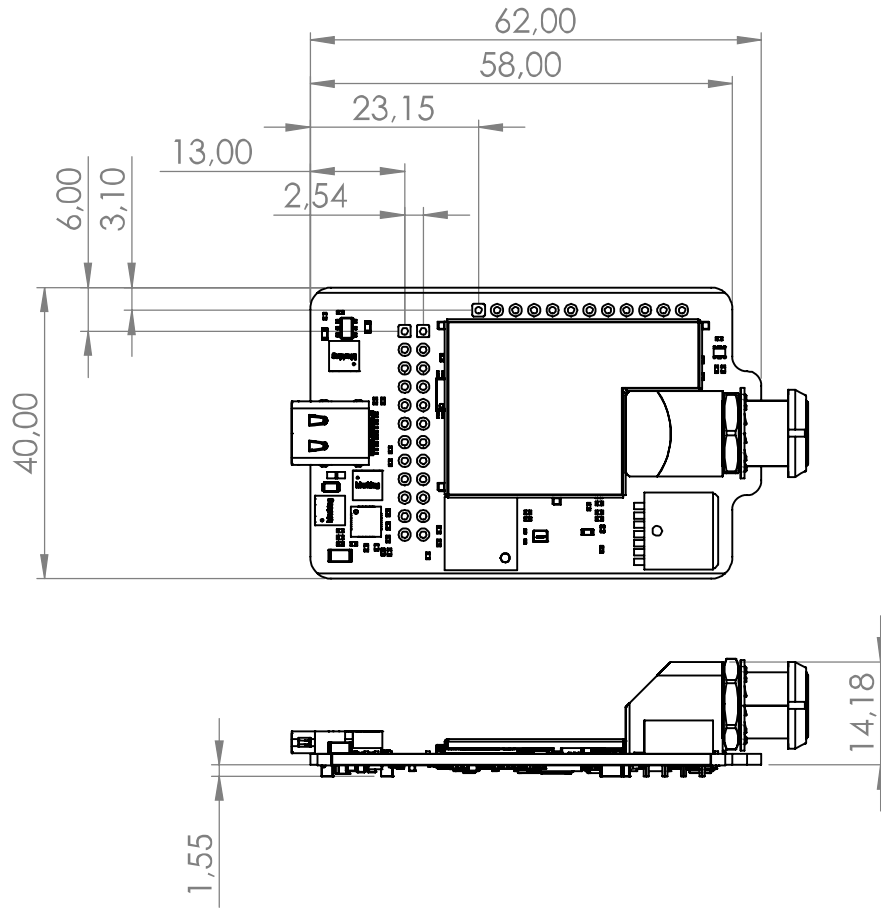


EmStat4M HR EIS Accuracy Contour Plot



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 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.



See document "EmStat4M Data Sheet" for pin-out and more technical details.

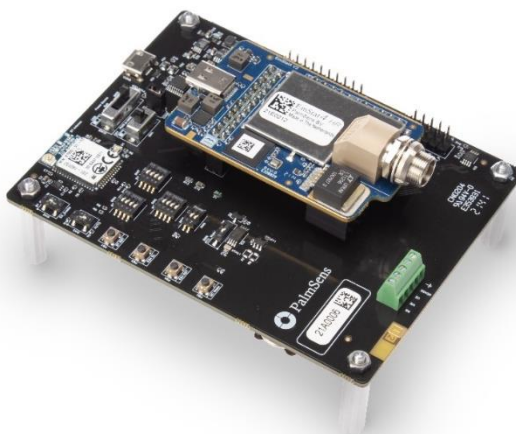
EmStat4M Starter and Development Kit

The EmStat4M module can be ordered as a bare module or as part of a kit. We offer two kits; the Starter Kit and the Development Kit with the additional Development Board (PCB) which offers extra peripherals including:

- Bluetooth module,
- Support for a LiPo battery, incl. charging,
- Pin headers for an MKR-series Arduino,
- Break-out EmStat4M GPIO pins,
- Screw-terminals for easy wire connections,
- RTC for real-time clock,
- and push buttons for triggering / testing.

	Module only	Starter Kit	Development Kit
▪ EmStat4M LR or HR module	✓ *	✓	✓
▪ Development Board	-	-	✓
▪ USB-C cable	-	✓	✓
▪ USB-C splitter cable for extra power (EmStat4M HR only)	-	✓	✓
▪ Sensor cable (1 meter with 2 mm pins)	-	✓	✓
▪ 4 or 5 croc clips	-	✓	✓
▪ Dummy Cell	-	✓	✓
▪ USB drive with PSTrace software for Windows and documentation	-	✓	✓
▪ Quick Start document	-	✓	✓
			More information

* with optional LEMO sensor connector



EmStat4M Development Board

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.

Switch between plots if curves with different units are available.

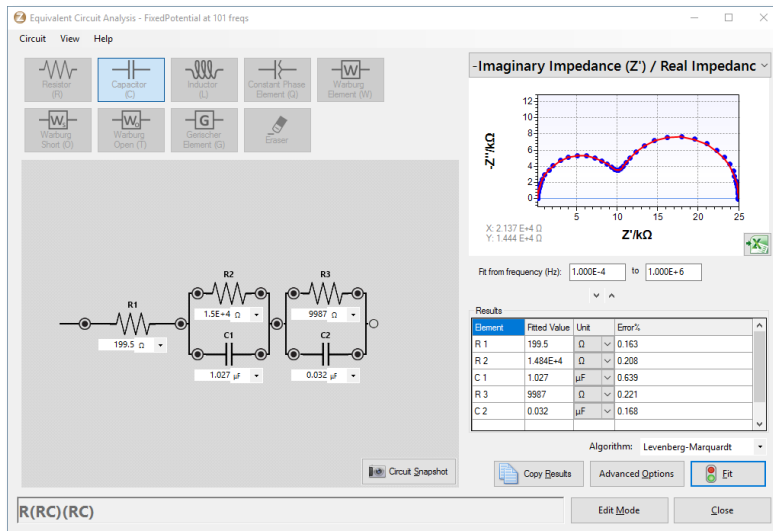
Setup your measurement easily and get immediate feedback on validity of parameters.

Click on a measurement for detailed information or generating new curves.

Quickly toggle the visibility of curves or groups of curves.

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.

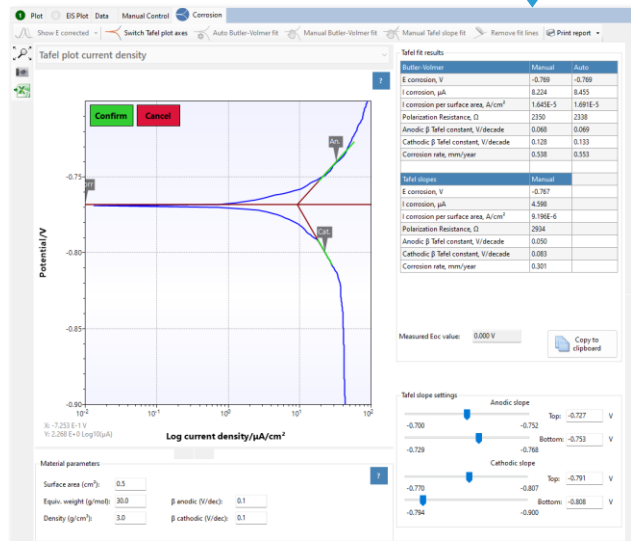


Use the graphical editor to draw the equivalent circuit or enter the CDC directly.

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

EmStat4M 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 PStace.

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 c
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™


MethodSCRIPT™
Code examples are available for:



➤ 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>
/// </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; //Equilibrates
    _methodEIS.Ranging.StartCurrentRange = new Current
    _methodEIS.Ranging.MinimumCurrentRange = new Curre
    _methodEIS.Ranging.MaximumCurrentRange = new Curre
}
```

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

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

PalmSens BV
The Netherlands
www.palsens.com

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