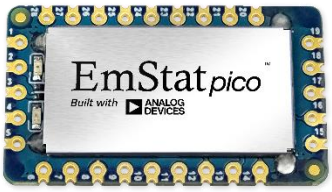
EmStat*pico*™

Built with ANALOG DEVICES

ELECTROCHEMICAL INTERFACE MODULE



PalmSens

Rev.9-2022-017

Contents

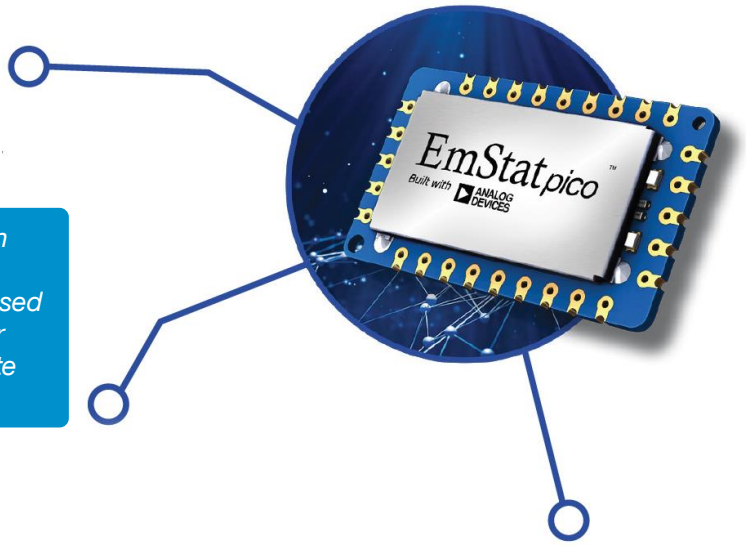
› See for more information:
www.palmsens.com/pico

EmStat Pico: Electrochemical Interface Module

The EmStat Pico is a joint development by PalmSens BV and Analog Devices Inc. PalmSens BV is known for introducing the first commercially available handheld potentiostat. Over the last decade these have evolved to become smaller and more versatile. Together with Analog Devices, PalmSens now proudly presents the world smallest potentiostat module available on the market.

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

With a footprint of just 18x30 mm and a height of 3 mm the EmStat Pico can be embedded into virtually any design.



Different power modes and an ultra-low power sleep mode allow the EmStat Pico to be used in wearable applications or for long term monitoring at remote sites.

The EmStat Pico supports the new MethodSCRIPT™, a scripting language that allows you to let the EmStat Pico do what you want without the hassle of reading into spec sheets.

Supported Techniques

The following electrochemical techniques are supported by the EmStat Pico module.

Voltammetric techniques:

▪ Linear Sweep Voltammetry	LSV
▪ Cyclic Voltammetry	CV
▪ Square Wave Voltammetry	SWV
▪ Differential Pulse Voltammetry	DPV
▪ Normal Pulse Voltammetry	NPV

The above techniques can also be used for stripping voltammetry

Techniques as a function of time:

▪ Chronoamperometry	CA
▪ Pulsed Amperometric Detection	PAD
▪ Open Circuit Potentiometry	OCP
▪ MultiStep Amperometry	MA

Electrochemical Impedance Spectroscopy

▪ Scanning or fixed frequency mode	EIS

MethodSCRIPT™ allows for developing custom techniques. See page 9 for more information.

MethodSCRIPT™ by PalmSens

Dual-channel and Bipotentiostat functionality

The second channel of the EmStat Pico can be used for running sequential measurements on two different cells each with their own Reference, Counter and Working electrodes. The second channel can also be used in Bipotentiostat mode, functioning as second Working Electrode versus the Reference and Counter electrode of channel 1. Both channels are recorded simultaneously in the Bipotentiostat mode.

The second Working Electrode (WE2) can either be set at a potential offset with respect to WE1 or at a fixed potential with respect to RE1.

The Bipotentiostat mode is supported in Low Speed mode (see table below) for all techniques, excluding EIS and OCP.

Main Specifications

The module works in three different modes;

Low Speed mode: for scan rates up to 1 V/s or a bandwidth of 100 Hz.
High Speed mode: for high scan rates and frequencies.
Max Range mode: a combination of the Low and High Speed modes for optimal dynamic dc-potential range

General	Low Speed mode	High Speed mode	Max Range mode
▪ Full dc-potential range	-1.2 to +2 V	-1.7 to +2 V	-1.7 to +2 V
▪ Dynamic dc-potential range [1]	2.2 V	1.2 V	2.6 V
▪ Compliance voltage		-2.0 to +2.3 V [2]	
▪ Maximum current		±3 mA	
▪ Max. acquisition rate (datapoints/s)	100	1000	100
▪ Supports FRA/EIS	NO	YES	NO
Potentiostat (controlled potential mode)	Low Speed mode	High Speed mode	Max Range mode
▪ Channels	2 (2x WE, 2x RE and 2x CE)		
▪ Applied dc-potential resolution	537 µV	395 µV	932 µV
▪ Applied potential accuracy	< 0.2%	< 0.5%	< 0.5%
▪ Available current ranges	100 nA, 2 uA, 4 uA, 8 uA, 16 uA, 32 uA, 63 uA, 125 uA, 250 uA, 500 uA, 1 mA, 5 mA	100 nA, 1 uA, 6 uA, 13 uA, 25 uA, 50 uA, 100 uA, 200 uA, 1 mA, 5 mA	100 nA, 1 uA, 6 uA, 13 uA, 25 uA, 50 uA, 100 uA, 200 uA, 1 mA, 5 mA

1 The dynamic range is the range that can be covered during a single scan within the full potential range. For example; a linear scan can start at -1.5 V and end at 1.1 V or vice versa, covering 2.6 V dynamic range.
2 The compliance voltage is the maximum potential between Working and Counter electrode and depends on the selected mode.

Potentiostat (controlled potential mode)	Low Speed mode	High Speed mode	Max Range mode
▪ Current accuracy	< 0.5% of current ±0.1% of range	< 1% of current ±0.1% of range [3]	
▪ Measured current resolution	0.006% of range (5.5 pA on 100 nA range)		
▪ Measured potential resolution (for OCP)	56 µV		

FRA / EIS (impedance measurements) in High Speed Mode only	
▪ Frequency range	0.016 Hz to 200 kHz
▪ Ac-amplitude range	1 mV to 0.25 V rms, or 0.708 V peak-peak

Bipotentiostat	
▪ Modes	1. WE2 at fixed potential (E offset vs RE1) 2. WE2 scanning (E offset vs WE1)
▪ Max. potential WE2	ΔE(WE1) + ΔE(WE2) < 1.6 V [4]

Electrometer	
▪ Electrometer amplifier input	> 1 TΩ // 10 pF
▪ Bandwidth	250 kHz

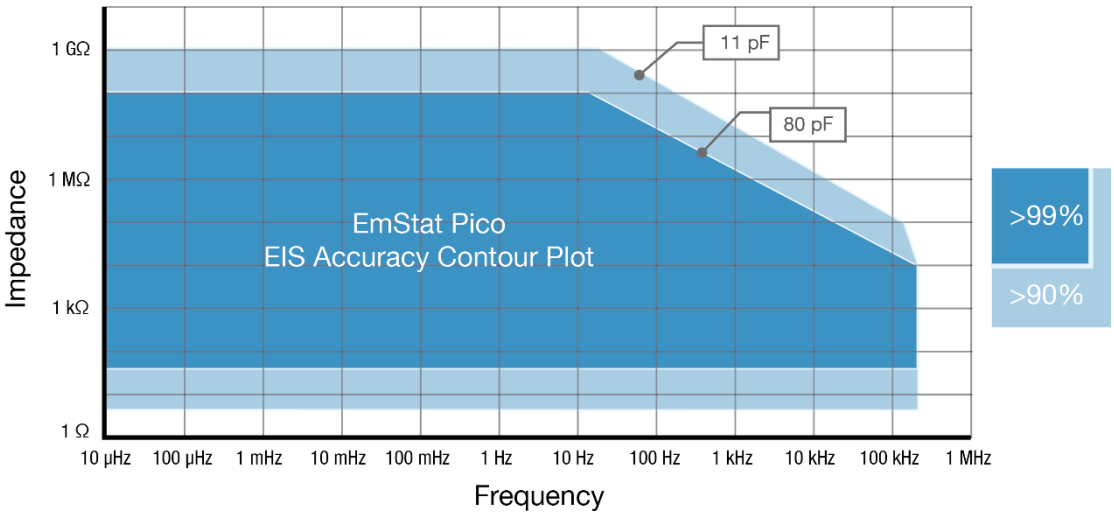
Communications and peripherals	
▪ Module communications	UART
▪ Communication with external peripherals	SPI and I^2C
▪ Analog I/O	3 analog input pins
▪ Digital I/O	7 general-purpose I/O pins 1 wake-up pin
▪ Optional on-board temperature sensor[5]	±0.25 °C

[3] Channel 2 has an uncompensated series resistor (typical 110 Ω) in series with the WE2 signal. This additional resistance must be taken into account.
[4] If your main WE1 is scanning from -0.5V to +0.5V, the WE2 can only have a maximum offset of 0.6V.
[5] The high accurate on-board temperature sensor is standard available on modules that come with the EmStat Pico Development Kit. For separate EmStat Pico modules the temperature sensor is optional.

Other

▪ **Storage**	4000 datapoints on-board (optional external SD card can directly be connected to Pico for mass storage)
▪ **Mounting**	Surface mounted with castellated pads Through hole pins (2.54 mm pitch)
▪ **Dimensions**	18 x 30 x 2.6 mm
▪ **Operation temperature range**	-40 °C to +85 °C

EIS Accuracy Contour Plot

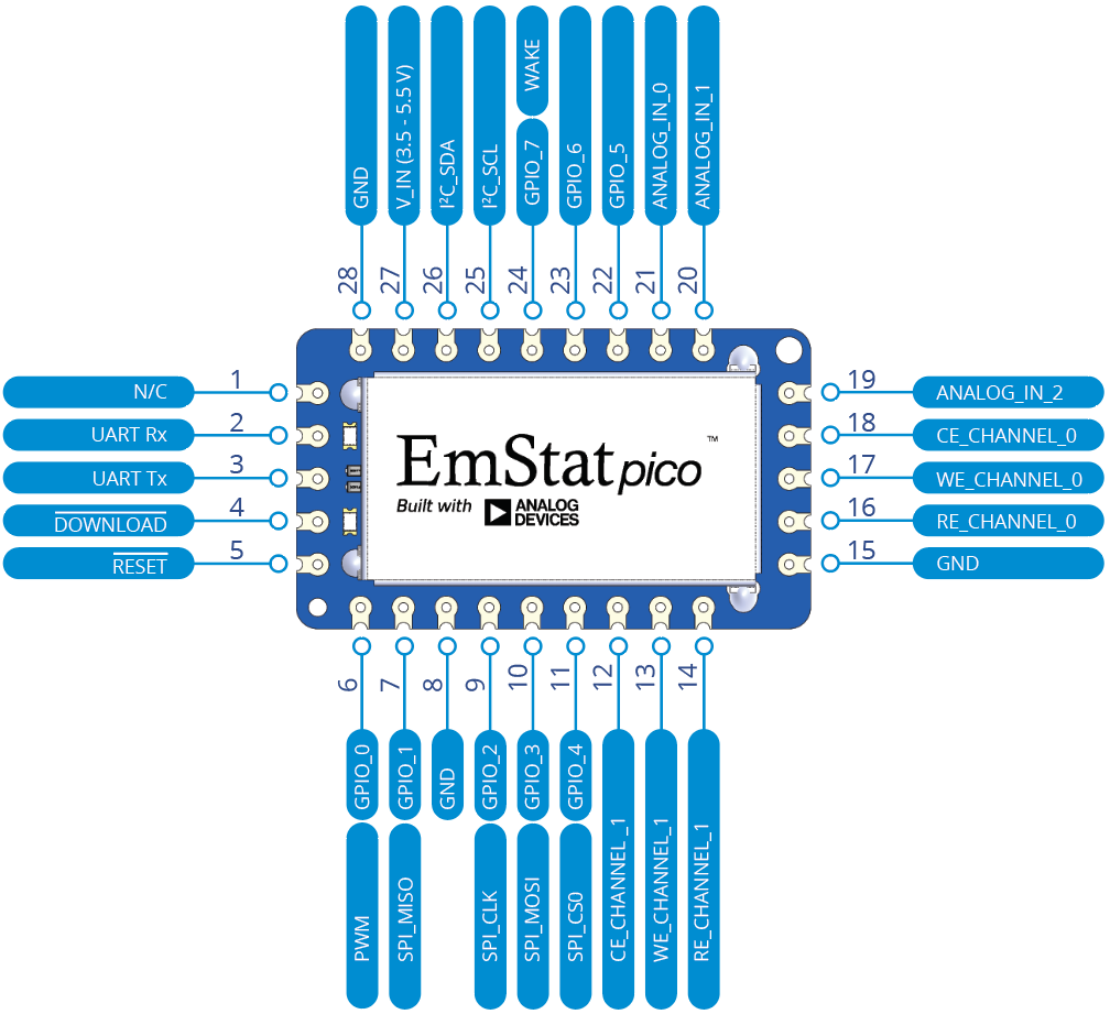


Note
The accuracy contour plot was determined under lab conditions and should be used for reference purposes. Please note that the true limits of an impedance measurement are influenced by all components in the system, e.g. cables, the environment, and the cell.

Limits of some technique specific parameters for EmStat Pico

Normal Pulse and Differential Pulse Voltammetry	Scan rate: Pulse time:	0.02 mV/s (0.280 mV step) to 5 V/s (10 mV step) 1ms to 300ms
Square Wave Voltammetry	Frequency:	1 Hz to 500 Hz
Linear Sweep and Cyclic Voltammetry	Scan rate:	0.02 mV/s (0.280 mV step) to 5 V/s (10 mV step)
Pulsed Amperometric Detection	Interval time: Pulse time: Maximum run time:	1 ms to 10 s 1 ms to 1 s 1000000 s
ChronoAmperometry and Open Circuit Potentiometry	Interval time: Maximum run time:	1 ms to 300 s 1000000 s (> 10 days at 300 s interval)
Multistep Amperometry,	Interval time: Level switching overhead time: Number of levels: Number of cycles: Maximum run time:	1 ms to 300 s ±10 ms 1 to 255 1 to 20000 1000000 s per level

Module pin-out



All logic levels at 3.3V

MethodSCRIPT™: EmStat Pico Scripting Language

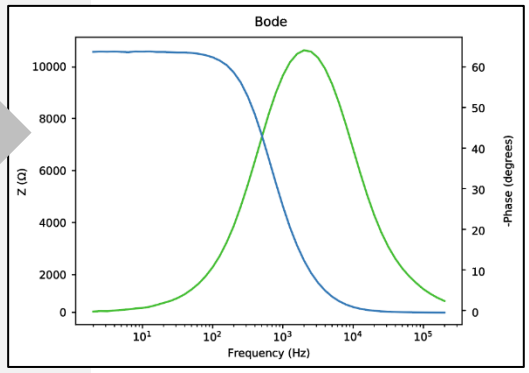
The EmStat Pico potentiostat module works with the new MethodSCRIPT™ scripting language. This language allows developers to program a human-readable script directly into the Pico module by means of a serial (TTL) connection. The simple script language allows for running electrochemical techniques supported by EmStat Pico and makes it easy to combine different measurements and other tasks.

Example MethodSCRIPT for EIS measurement on a test circuit

```
e
#Declare variables
var h
var r
var j
#Initialize device
set_pgstat_mode 3
#Set starting current range
set_cr 1m
#Turn cell on for measurement
cell_on
#Start EIS scan from 200kHz to 2 Hz in 41 steps
meas_loop_eis h r j 10m 200k 2 41 0
   #Send results of measurement loop step
   pck_start
   #Send frequency
   pck_add h
   #Send Z real
   pck_add r
   #Send Z imaginary
   pck_add j
   pck_end
   #Continue with next step of EIS scan
endloop
#Turn cell off after measurement
cell_off
```

Scripts can easily be generated and executed in PSTrace for Windows.

See page 12.



Actual measured result on dummy cell ran in Python

MethodSCRIPT is parsed on-board the instrument. No DLLs or other type of code libraries are required for using MethodSCRIPT™

MethodSCRIPT features include:

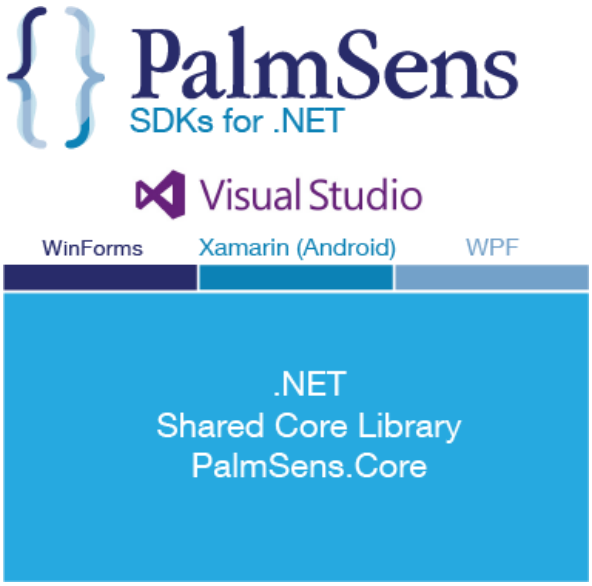
- Use of variables
- (Nested) loops and conditional logic support
- User code during a measurement iteration
- Exact timing control
- Simple math operations on variables (add, sub, mul, div)
- Digital I/O, for example for waiting for an external trigger
- Logging results to internal storage or external SD card
- Reading auxiliary values like pH or temperature
- and many more..

MethodSCRIPT™

› See for more information, tutorials and documentation:
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 or for the EmStat Pico Core.

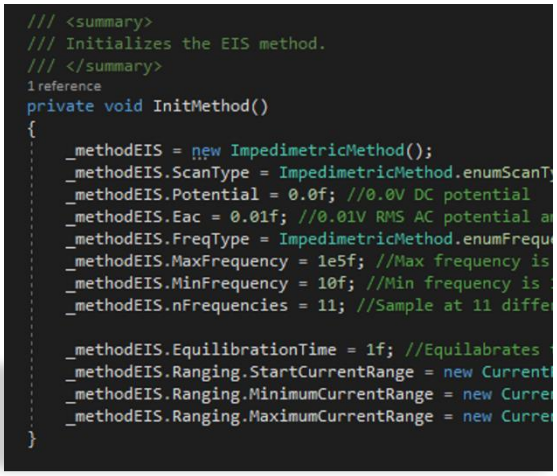


There are three PalmSens Software Development Kits (SDKs) for .NET. Each SDK can be used with any of our instruments or OEM potentiostat modules to develop your own software. The SDK's come with a set of examples that shows how to use the libraries. PalmSens SDKs with examples are available for the following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

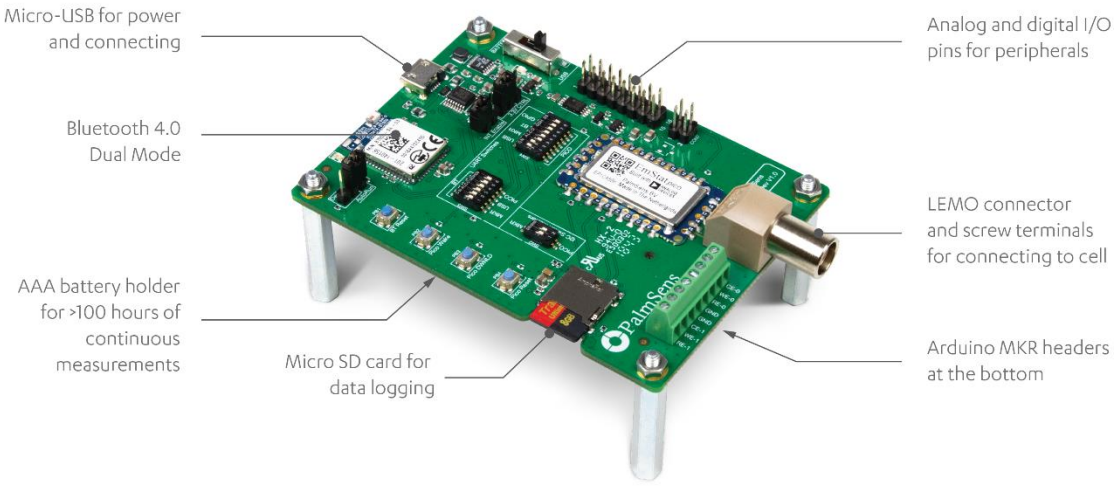


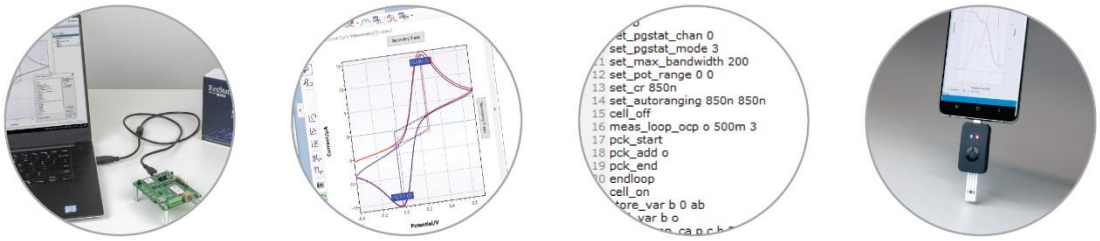
```
/// <summary>
/// Initializes the EIS method.
/// </summary>
1 reference
private void InitMethod()
{
    _methodEIS = new ImpedimetricMethod();
    _methodEIS.ScanType = ImpedimetricMethod.enumScanT
    _methodEIS.Potential = 0.0f; //0.0V DC potential
    _methodEIS.Eac = 0.01f; //0.01V RMS AC potential 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

EmStat Pico Development Board

The EmStat Pico Development board allows to run your experiments conveniently in our PSTrace software for electrochemistry.





STEP 1

Connect the EmStat Pico Development Board to a PC running PSTrace

STEP 2

Fine-tune your electrochemistry for optimal use of the EmStat Pico module

STEP 3

Generate the MethodSCRIPT™ snippet for running your measurement on the EmStat Pico

STEP 4

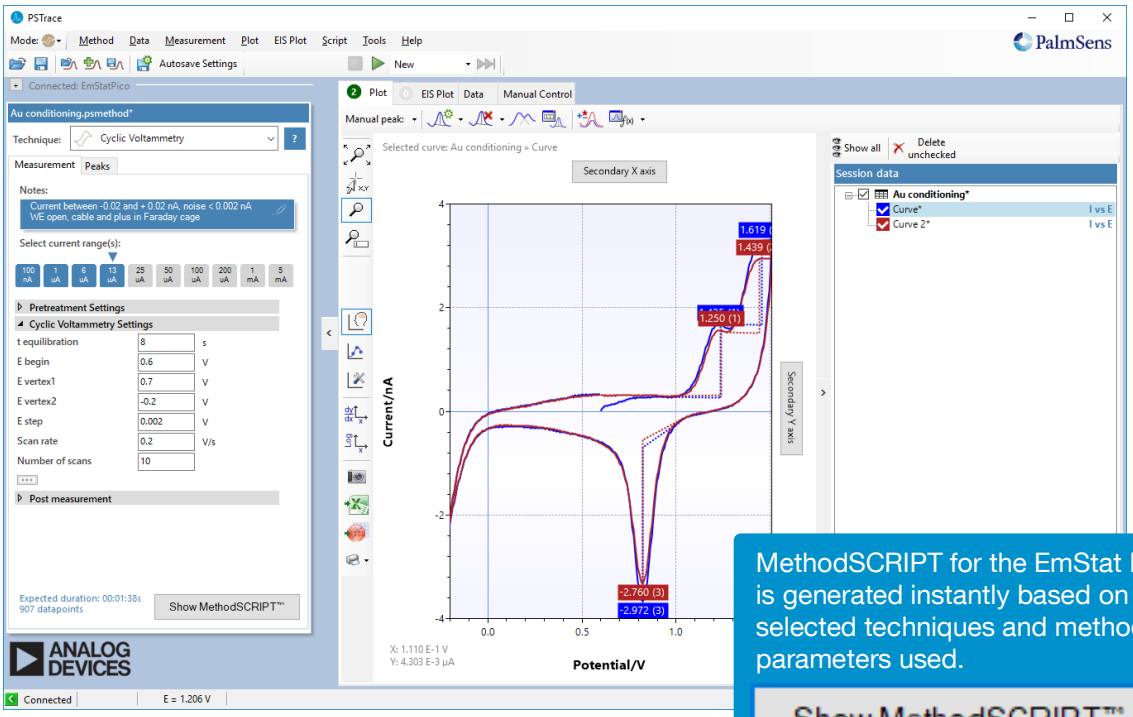
Use the MethodSCRIPT™ snippet to run the exact same measurement on the embedded EmStat Pico in your product

Comes with code examples for: iOS

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

PSTrace: research software for Windows

The EmStat Pico Development Board can be used directly with the PSTrace software for Windows. PSTrace automatically sets the EmStat Pico in the optimal mode based on the user specified method parameters.

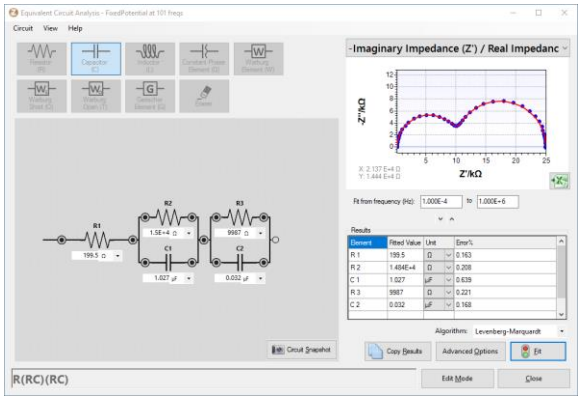


MethodSCRIPT for the EmStat Pico is generated instantly based on the selected techniques and method parameters used.

Show MethodSCRIPT™

Other functions in PSTrace 5

- Method validation
- Automatic peak search
- Equivalent Circuit Fitting
- 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
- Dynamic feedback on 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/pstrace

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

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www.palmsens.com

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