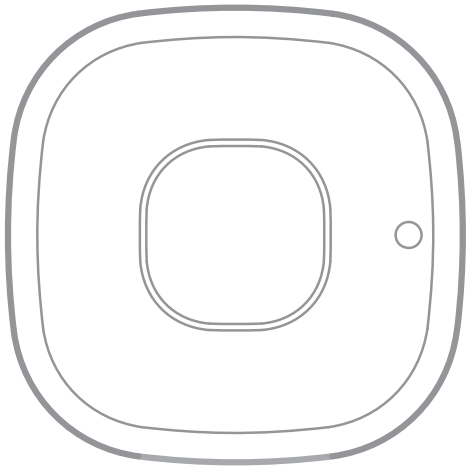
SENSIT WEARABLE™

Potentiostat / impedance analyzer
for wearable electrochemical biosensors



PalmSens

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™
ALLIANCES

Rev. 11-2024-008

Contents

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

Your shortcut to next-gen, non-invasive electrochemical sensors

The Sensit Wearable is a groundbreaking device designed to enhance the research, development, and validation of wearable biosensors. This lightweight instrument, weighing just 10 grams, is battery-powered, wireless, and fully programmable.

Supported Techniques

The Sensit Wearable supports the following electrochemical techniques:

- Linear Sweep Voltammetry **LSV**
- Cyclic Voltammetry **CV**
- Differential Pulse Voltammetry **DPV**
- Square Wave Voltammetry **SWV**
- Normal Pulse Voltammetry **NPV**
- Chronoamperometry **CA**
- MultiStep Amperometry **MA**
- Pulsed Amp. Detection **PAD**
- Mixed Mode **MM**
- Open Circuit Potentiometry **OCP**
- Impedance spectroscopy **EIS**
  at fixed frequency or frequency scan vs
  - fixed potential
  - scanning potential
  - time

Sensit Wearable with mounting bracket

Connecting to your sensor or cell

The Development Kit comes with accessories that allows you to attach the Sensit Wearable to any electrochemical (bio)sensor that works with one or two Working Electrodes, a Reference Electrode (RE) and Counter Electrode (CE).
The RE and CE can also be combined in a 2-electrode configuration.

See page 5 for an overview of available adapters and options to make a connection to your sensor, skin patch or electrochemical cell.

Key specifications	
▪ dc-potential range	-1.2 V to +2 V
▪ compliance voltage	-2.0 V to +2.3 V
▪ maximum current	±3 mA
▪ current resolution	0.006% of range (5.5 pA on 100 nA range)
▪ potentiostat interface	2x WE, 1x CE, 1x RE
▪ ac-amplitude range	1 mV to 0.25 V rms, or 0.708 V p-p
▪ EIS frequency range	0.016 Hz to 200 kHz
▪ communication	USB-C and Bluetooth 5.0 Low Energy
▪ charging	USB-C and wireless
▪ battery life	multiple days depending on script
▪ internal storage	14 MB, equivalent to >450k datapoints

See page 9 for more detailed specifications.

Programming the Sensit Wearable

The Sensit Wearable can be used directly with our PSTrace software for research, and controlled like any other lab potentiostat.

No programming skills are required to start running measurements.

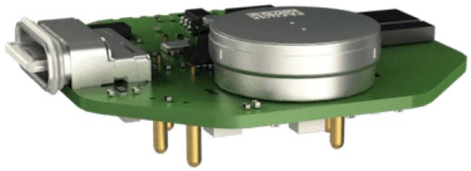
MethodSCRIPT™ by PalmSens

MethodSCRIPT™

The powerful and versatile MethodSCRIPT communications protocol allows for writing scripts to run measurements over a longer period and go in to a deep-sleep state when the instrument is idle.
The raw or processed data can be stored on the internal mass storage and be retrieved via USB or Bluetooth for further analysis.
See page 7 for more information.

Battery life

The internal re-chargeable 50 mAh battery allows for 2 hours of continuous measurements. Using its deep-sleep mode in a script, its battery life can be extended to days or even weeks.
The Sensit Wearable can be programmed to wake up and run a measurement at certain intervals, or when tapping it.
See page 11 for more information about the battery.



Bipotentiostat functionality

The second working electrode (WE2) functions as a Bipotentiostat, where the potential of the second working electrode is biased versus the first working electrode (WE1) or at a fixed potential. Both working electrodes are recorded simultaneously in the Bipotentiostat mode.

The Bipotentiostat mode is supported for all techniques, excluding EIS and OCP.

Sensit Wearable Development Kit

The Development Kit includes:

- Sensit Wearable
- Sensit Wearable Development Board
- Velcro Strap with mounting bracket and universal connector
- 2 Sensit Wearable mounting brackets
- USB-C cable
- 1 m cell cable with 2 mm banana pins
- Set of 5 croc clips
- Dummy Cell
- Connectors for screen-printed electrodes (SPE)

Also in the box:

- USB stick with PSTrace software for Windows (see page 11)
- Manual (hardcopy)
- Example skin patches

The example patches from our partners Lohmann and Screentec illustrate how the Sensit Wearable can be integrated in a bespoke skin patch design.

Two example mounting brackets for integration with your patch design. Also available as 3D STEP files.

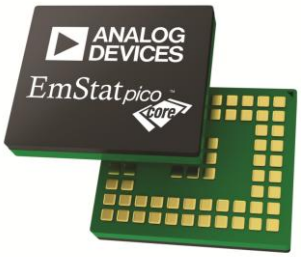
Development board for easy connecting to Sensit Wearable pogo pins

Velcro strap with mounting bracket and universal connector

1 meter cell cable with croc clips

Sensit Wearable is powered by the EmStat Pico Core chip

At the heart of the Sensit Wearable is our EmStat Pico Core potentiostat chip.



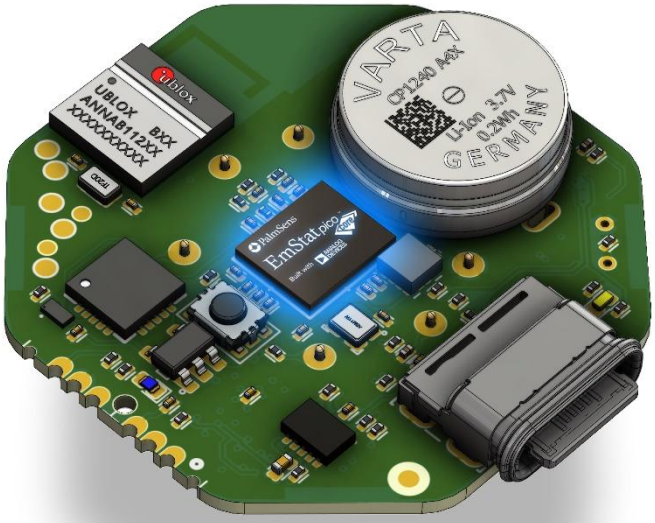
The EmStat Pico Core is a joint development by PalmSens BV and Analog Devices Inc., based on the ADuCM356 and powered by the MethodSCRIPT™ protocol from PalmSens.

The ADuCM356 is an ultralow power, mixed-signal microcontroller based on the Arm® Cortex™-M3 processor. The device features current, voltage, and impedance measurement capability.

The on-board MethodSCRIPT parser on the EmStat Pico Core allows for using the AduCM356 as a generic potentiostat for use with any type of electrochemical sensor or biosensor. MethodSCRIPT allows you to use the full potential of the AduCM356 without reading its datasheets or touching a compiler. The human-readable MethodSCRIPT can be generated with PSTrace for Windows. You can also make use of the extensive MethodSCRIPT documentation with many code examples available.

More information:

- EmStat Pico Core - PalmSens
- PSTrace - PalmSens
- ADuCM356 - Analog Devices Inc.



AHEAD OF WHAT'S POSSIBLE™

The Sensit Wearable 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™ by PalmSens

MethodSCRIPT can be generated, edited, and executed in PSTrace.

MethodSCRIPT features include:

- Use of variables
- (Nested) loops and conditional logic support
- Entering deep-sleep mode
- Configuring wake-up triggers
- User code during a measurement iteration
- Exact timing control
- Simple math operations on variables (add, sub, mul, div)
- Logging results to internal storage
- 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™

Measurement Specifications

The following table shows Sensit Wearable limits for some technique-specific parameters, when using PSTrace for Windows. Some of these limits can be exceeded when using a customized MethodSCRIPT.

	Parameter	Min	Max
All techniques (unless otherwise specified)	▪ Conditioning time	0	4000 s
	▪ Deposition time	0	4000 s
	▪ Equilibration time	0	4000 s
	▪ N data points	3	1 000 000 (> 100 days at 10 s interval)
▪ NPV ▪ DPV	▪ Scan rate	0.02 mV/s (0.280 mV step)	5 V/s (10 mV step)
	▪ Pulse time	1 ms	300 ms
▪ SWV	▪ Frequency	1 Hz	500 Hz
▪ LSV ▪ CV	▪ Scan rate	0.02 mV/s (0.280 mV step)	5 V/s (10 mV step)
▪ PAD	▪ Interval time	1 ms	10 s
	▪ Pulse time	1 ms	1 s
	▪ N data points	3	1 000 000 (> 100 days at 10 s interval)
▪ CA ▪ OCP	▪ Interval time	1 ms	10 s
	▪ Run time	1 ms	> 10 days
▪ MM ▪ MA	▪ N cycles	1	20000
	▪ N levels	1	255
	▪ Level switching overhead time	~10 ms (typical)	-
	▪ Interval time	1 ms	300 s
Note	Running measurements directly via Bluetooth LE limits the maximum data rate to 100 datapoints per second.		

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

Potentiostat Specifications

General	
▪ dc-potential range	-1.2 V to +2 V
▪ compliance voltage	-2.0 V to +2.3 V
▪ maximum current	±3 mA
▪ max. data acquisition rate	1000 samples/s

Potentiostat (controlled potential mode)	
▪ applied potential resolution	395 µV
▪ applied potential accuracy	≤ 0.2% ±1 mV offset
▪ current ranges	100 nA, 1 uA, 6 uA, 13 uA, 25 uA, 50 uA, 100 uA, 200 uA, 1 mA, 5 mA
▪ measured current resolution	0.006% of CR (5.5 pA on 100 nA range)
▪ measured current accuracy	< 0.5% of current ±0.1% of range

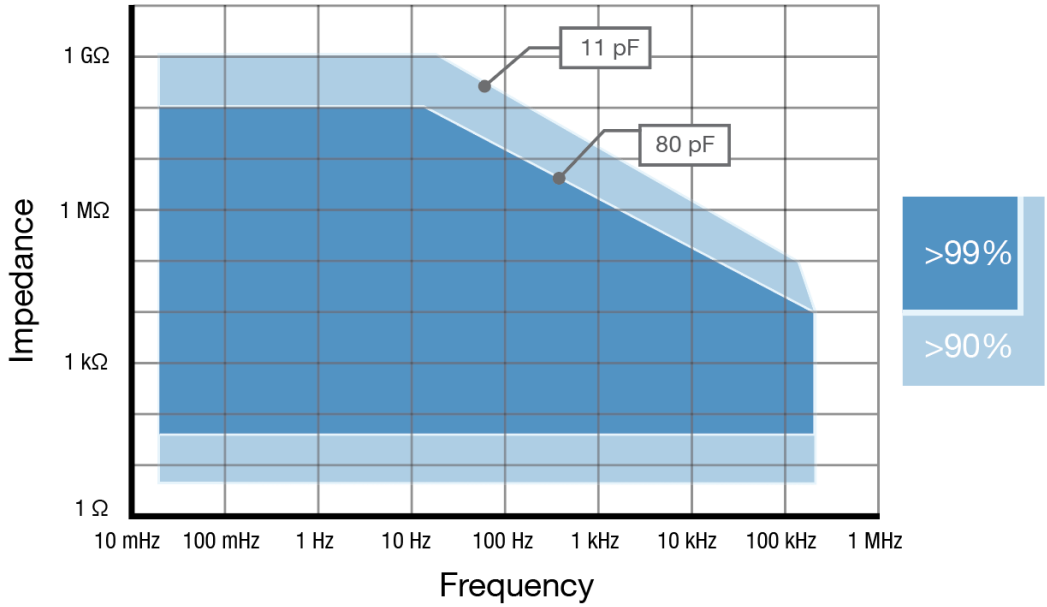
FRA / EIS (impedance measurements)	
▪ frequency range	16 mHz to 200 kHz
▪ ac-amplitude range	1 mV to 250 mV rms, or 708 mV p-p

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

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 [1]

[1] If your main WE1 is scanning from -0.5V to +0.5V, the WE2 can only have a maximum offset of 0.6V.

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.

Other Specifications

Other			
▪ housing	35 x 35 x 12 mm (including mounting bracket)		
▪ weight	~10 g		
▪ electrode connections	6 pogo pins for: WE1, WE2, RE, CE, AUX, and ground		
▪ battery	Varta CP 1240 A4 UN 38.3 passed relevant tests acc. IEC 62133 passed		
▪ battery power capacity	50 mAh (at 0.2C from 4.2 V to 3.0 V at 20 °C) or 0.2 Wh		
▪ power consumption	off:	0.1 mW	(75 days)
	idle or measuring:	92 mW	(2 hours)
	sleep with Bluetooth connected:	1 mW	(7.5 days)
	sleep without Bluetooth connection:	0.3 mW	(25 days)
	sleep with 10 mV bias potential applied on WE1:	4.44 mW	(40 hours)
▪ communication	USB-C and Bluetooth 5.0 low energy		
▪ charging	USB-C or wireless ~2 hours for a full charge		
▪ internal storage space	14 MB, equivalent to >450k datapoints		
▪ indicators	▪ status indicator (blue) ▪ charge indicator (orange)		

Battery life for a common use case scenario

In this situation the Sensit Wearable is programmed to sample current every 10 minutes for 500 ms, store the data and go back to sleep mode. The battery life for this scenario is:

(599.5/600 * 0.3 mW) +
(0.5/600 * 92 mW) = 0.38 mW

Battery life = 180 mWh / 0.38 mW = 470 h
or ~20 days

PSTrace software

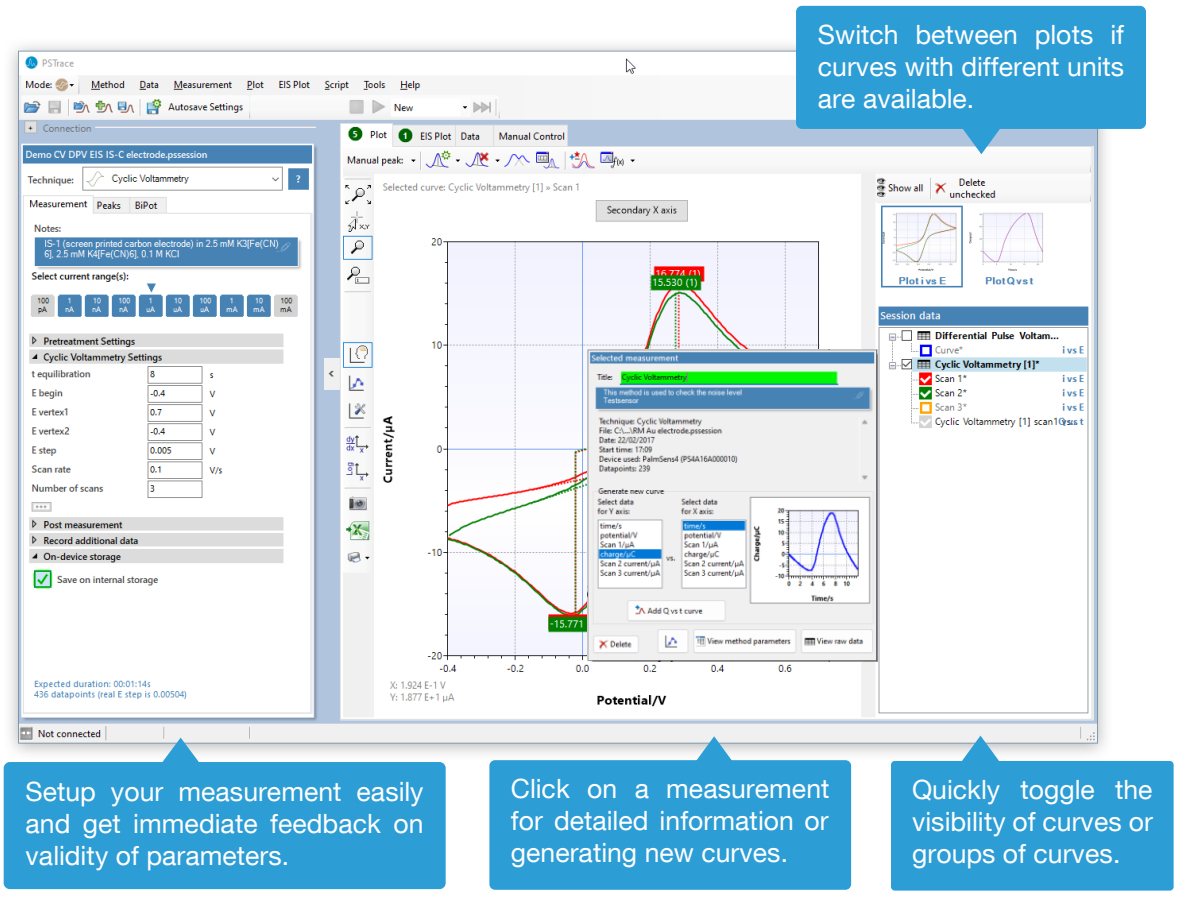
PSTrace is designed to get the most out of your instrument right after installation, without going through a long learning period.

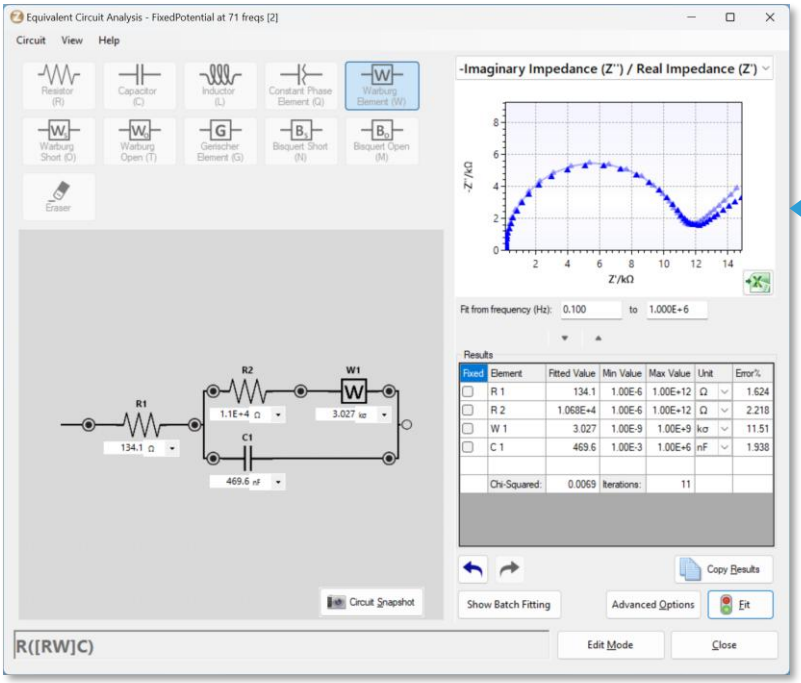
The Analytical Mode is designed for use with (bio)sensors and allows you to do concentration determinations. Extensive help files and prompts guide the user through a typical analysis.

Windows

Minimum System Requirements

- Windows 8, 10 or 11
- 1 GHz 64-bit (x64) processor
- 4 GB RAM (64-bit)
- Screen resolution of 1280 x 800 pixels





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

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 instrument storage
- Direct validation of method parameters
- Run custom MethodSCRIPTS™

Integration with third party software

- Excel
- Origin
- Matlab
- ZView

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

Software Development Kits for .NET

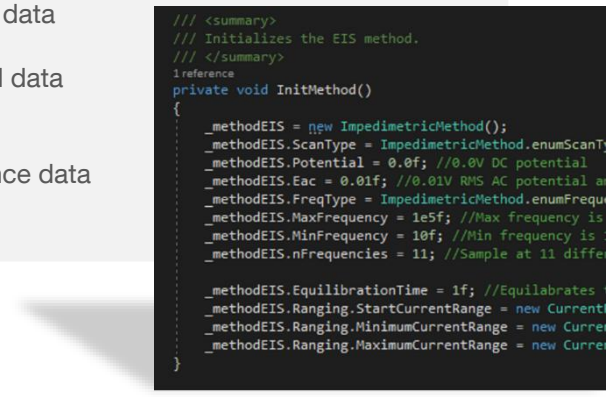
Develop your own application in no time for use with any PalmSens instrument or potentiostat (module). Our SDKs are free of charge.

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

Code examples available 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

PStouch

Available for Sensit Wearable on my.palmsens.com

PStouch is our app for Android devices compatible with all PalmSens, EmStat and Sensit potentiostats.

PStouch features:

- Setting up and running measurements
- Loading and saving measured curves
- Analyzing and manipulating peaks
- Sharing measurement data directly via any service like email or Dropbox
- Concentration determination by means of Standard Addition or Calibration Curve
- Support for PalmSens accessories such as a Multiplexer or Stirrer
- All method and curve files are fully compatible with PSTrace software for Windows.

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

Other resources

- Customizable Android Example App - PalmSens
- Writing code for our hardware - PalmSens
- PalmSens BV (github.com)

PalmSens BV has more than 40 distributors around the world.
Please contact us at **info@palmsens.com** or go to our website to get in touch with a distributor in your region.

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

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PalmSens
ISO 9001:2015 certified