PalmSens

Electrochemical Sensor Interfaces

PalmSens is a handheld and battery-powered interface for electrochemical sensors. It is designed for use with amperometric and voltammetric sensors. The instrument is in fact a potentiostat/galvanostat providing the most relevant electrochemical methods with a wide dynamic range.

This document gives technical details of the PalmSens device used as a generic instrument and controlled by a Pocket PC. The instrument comes with the PSTrace program for desktop PC or laptop. This program is described in a separate document.

General information is found on: www.palmsens.com.

Available voltammetric and amperometric methods and its specifications

The embedded software of PalmSens provides all measurement methods which are relevant for electrochemical sensors. The voltammetric methods are used to measure a curve of current versus potential. Specific determinations require stripping chrono-potentiometry.
Amperometric and pulsed amperometric detection is used to record current as a function of time. Many textbooks give the theoretical background of these techniques. Two examples are:

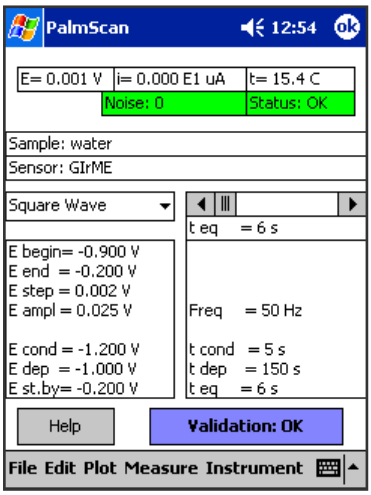
1. Christopher M.A. Brett and Ana Maria Oliveira Brett, Electroanalysis, Oxford Chemistry Series 64, Oxford University Press, ISBN 0 19 854816
2. Joseph Wang, Analytical Electrochemistry Second Edition, Wiley-VCH, ISBN 0471-28272-3

Voltammetry and stripping chronopotentiometry

The available voltammetric methods are:
- Differential pulse voltammetry: DPV,
- Square wave voltammetry: SWV,
- Normal pulse voltammetry: NPV,
- Linear sweep voltammetry: LSV,
- Cyclic voltammetry : CV,
- Ac voltammetry: acV.

These methods can all be used in their stripping modes which are applied for (ultra-) trace analysis.

If stripping voltammetry is used, a blank correction can be made using the method called subtractive stripping voltammetry. The blank is measured immediately after recording the original curve. The blank is measured without applying the conditioning and deposition stages. The blank curve is subtracted from the original curve (see for instance: E. Kirowa-Eisner, M. Brand and D. Tzur in Anal. Chim. Acta, 385, 325-335 (1999)).



The stripping chronopotentiometry SCP (or PSA) methods are:
- Chemical stripping at zero current,
- Constant current stripping.

All voltammetric methods as well as SCP allow blank subtraction by measuring a blank solution.

Amperometry

The amperometric methods available on PalmSens are:
- Amperometric detection: AD
- Pulsed amperometric detection: PAD
- Multiple pulse amperometric detection: MPAD
- Fast amperometry, with sampling rates of 1000 points per second.

The signals evaluated from a measured curve are either the steady-state currents or the peak heights. These methods can be used with a flow-cell for CFA as well as FIA.

Potentiometry

Potentiometry with an interval time of 0.1 s or more is done at open circuit or at a fixed current.

Specifications of the available methods

All electrochemical parameters can be specified by the user. The actual measurement is performed after a pretreatment stage. This pretreatment is sometimes required to condition the electrode and to deposit the analyte(s) in case of stripping analysis. During these stages, the potential and current as well as elapsed time are shown on the display of PalmSens.

The specifications of most of the relevant parameters are:

General pretreatment:		General voltammetric parameters:	
Apply conditioning potential for:	0 – 1600 s	Begin potential:	-2.000 V to + 2.000 V
Apply deposition potential for:	0 – 1600 s	End potential:	-2.000 V to + 2.000 V
Apply begin potential for:	0 – 1600 s	Step potential:	1 mV to 250 mV
Conditioning potential:	-2.000 V to + 2.000 V	Pulse potential:	1 mV to 250 mV
Deposition potential:	-2.000 V to + 2.000 V	ac-amplitude:	1 mV to 250 mV
Standby potential:	-2.000 V to + 2.000 V		

Limits of some technique specific parameters are:

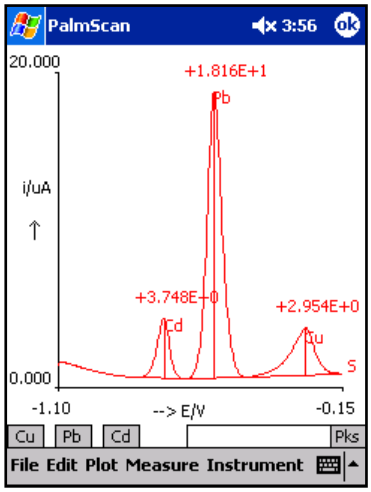
DPV:	Scan rate: Pulse time:	1 mV/s (1mV step) to 50 mV/s (5 mV step) 1 ms to 300 ms
SWV:	Frequency:	1 Hz to 400 Hz
SCP:	Sampling rate:	Approx. 40 kHz., max. 100 s
LSV and CV:	Scan rate:	0.2 mV/s (1 mV step) to 5 V/s (5 mV step)
AcV:	Scan rate: Frequency:	1 mV/s (1 mV step) to 25 mV/s (5 mV step) 28 Hz to 90 Hz
AD and PAD:	Interval time: Pulse time: Run time: Mode: Maximum number of points:	50 ms to 300 s 1 ms to 1 s 10 s to 100000 s dc-amperometry and normal pulse and differential pulse. 30000

MPAD:	Pulse times: Run time: Number of potential levels: Maximum number of points:	10 ms to 2 s 10 s to 100000 s 3 30000
Fast amperometry	Interval time: Maximum run time: Maximum number of points:	1 ms to 1 s 30 s 20000
Potentiometry at open circuit or constant current	Interval time: Maximum run time:	100 ms to 30 s 100000 s

Note: some limits of parameters are set for practical reasons and can be modified on request.

The applicable potential range is –2.000 V to + 2.000 V, with a resolution of 1 mV. The resolution of the sine wave in ac-voltammetry is 0.25 mV.
The applicable current ranges are 1 nA, 10 nA, 100 nA, 1 µA, 10 µA, 100 µA, 1 mA and 10 mA. The maximum current from the instrument is more than 10 mA.
The resolution of the current measurement is 0.1 % of the applied current range, which equals 1 pA on the lowest current range.
During a measurement the current range can be optimized automatically to the current value. Users can limit the selectable current ranges to, for instance, 100 nA, 1 µA to 10 µA.

The bandwidth of the potential and current control is approx. 50 µs.

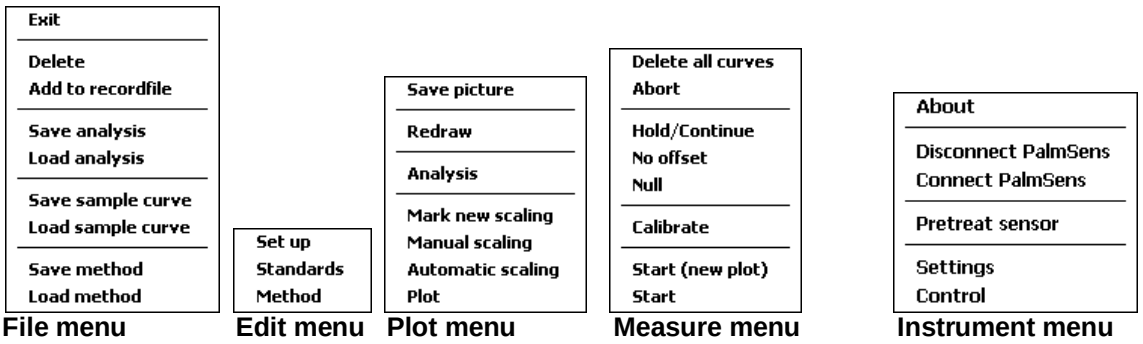


Pocket PC software and its specifications

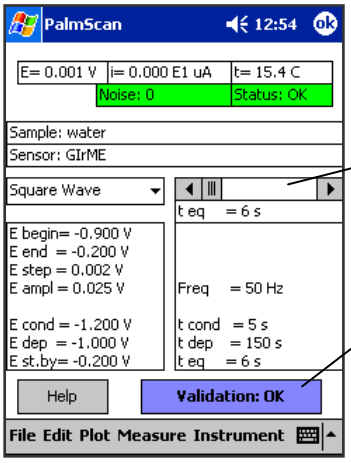
PalmSens is controlled by a Pocket PC. This device is used to specify all parameters, to display the measured curves and to evaluate them. Measured curves can be stored in the memory of the Pocket PC and later easily transferred to a PC. The Pocket PC is connected to PalmSens by means of a serial cable.
PalmSens is delivered with two programs:

- **PalmScan** for measurements of voltammograms (i vs E plots) or SCP curves,
- **PalmTime** for (pulsed) amperometric detection and potentiometry.

Both these programs provide almost the same menus:



The File menu is used to load and store methods and measurements. A sample curve is stored as a standard text file with potential and current values. These files are easily imported in other programs.
Storing an analysis yields a file with the method parameters as well as all voltammetric curves. The recordfile is a plain text file in which the results of an analytical determination are written. Obtained curves can be stored as bitmap files which are easily imported in Windows programs.



Access to the electrochemical as well as analytical parameters is provided by the Edit menu.

Their values are edited by using a scrollbar.

Specified values are checked for inconsistencies. In case a wrong value is detected, an error message is generated.

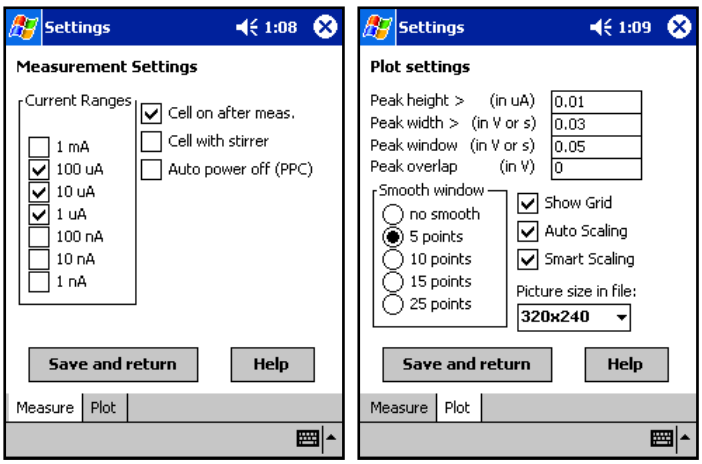
The complete set of parameters can be stored as a standard method. Users can make their own library of standard methods.

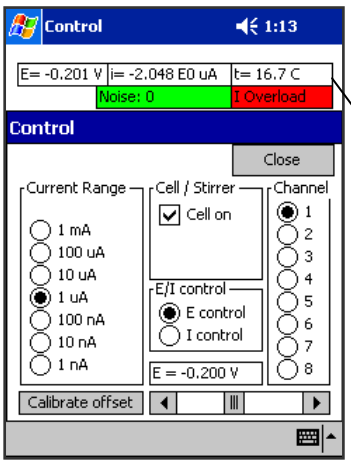
The Plot menu allows re-scaling curves in different ways as well as a manual peak search method in case the automatic peak search fails.

The Analysis plot shows the calibration or standard addition curve for each analyte.

The Measurement Settings window allows specification of instrumental parameters, like applicable current ranges and the use of a stirrer.

The Plot Settings window allows setting the behavior of the plot window like marking peak height, smoothing and grid.





The Control window provides manual control of the potentiostat and galvanostat.

The measured values of the potential and current are continuously displayed.
The status window is used to signal voltage or current overloads. A voltage overload might indicate a problem with the reference electrode.
The noise value indicates electrical interferences from external sources.
In case of problems their background-colors are yellow or red.

The PalmScan program

The PalmScan software is used for voltammetric measurements and determinations. The program can measure a blank, the sample and up to four standard solutions. In a single measurement up to four analytes can be identified.

The standard sequence of a measurement of each voltammogram is:

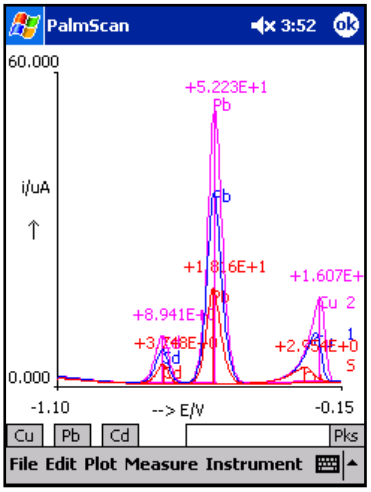
1. Apply the conditioning potential, if the conditioning time is not zero.
2. Apply the deposition potential, if the deposition time is not zero.
3. Apply the begin potential and wait the equilibrium time.
4. Scan the potential until the end potential with the specified step size and scan rate. In CV the scan is continued by reversing the scan direction. The current range is changed automatically if necessary.
5. If the measurement rate is less than 25 points per second then the measured points are displayed on-line. During the measurement the plot can be re-scaled automatically. If the scan rate is too high the points are plotted after completing the scan.
6. In case subtractive stripping is specified, the background is measured by returning to step 3 and subtracting this new voltammogram from the original one.
7. If the cell must remain switched on, the standby potential is applied, otherwise the cell is switched off.

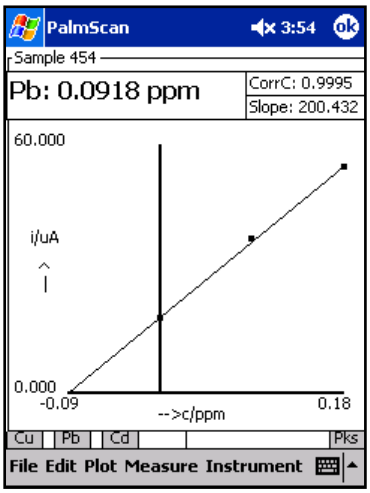
After each measurement automatic peak search is performed. Peaks are identified with their peak potential. The signal used for calculating the concentration is the peak height.
Peak heights are automatically corrected for their baselines, by means of a tangent-fit method. Peaks are identified only if the peakheight exceeds a minimum value, the peak width is larger than a specified value and the peak potential fits within the peak window. In case standard addition is performed the peaks are corrected for dilution effects.

Blank correction is optionally performed by means of the method called subtractive stripping voltammetry or by measuring a voltammogram of the blank solution.

Concentrations are calculated in user-specified units.

The Instrument menu shows the option to pretreat the sensor. This pretreatment allows users, for instance, to plate the sensor with a mercury film or to condition the sensor. The pretreatment consists of up to five potential steps. During the pretreatment the measured curve is displayed and integrated to a total charge. After this pretreatment, scans can be made in order to stabilize the sensor.





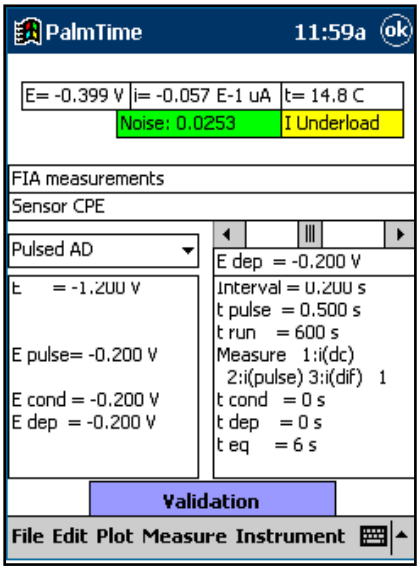
The Plot menu allows automatic and manual rescaling as well as manual peak search by specifying the baseline graphically.

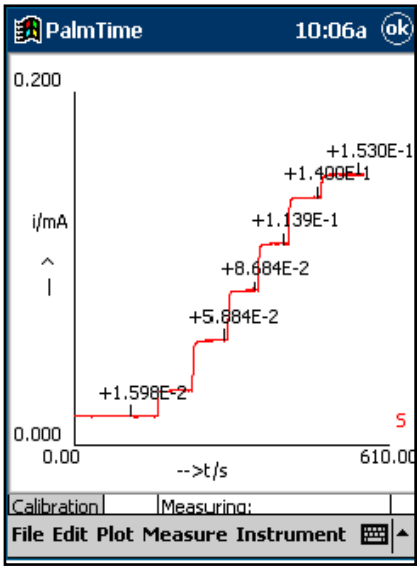
The File menu provides different options to store measurements:
- a single curve,
- an analytical determination with curves of the blank, sample and standards,
- the analytical result with sample identification, sensor description, date and time.

Users can create their own library of analytical methods.

The PalmTime program

This program is used for amperometric and potentiometric measurements, which means that current or potential as a function of time is recorded. The Edit menu of the program gives access to the amperometric as well as analytical parameters. Their values are entered by using a scrollbar or by tapping the keyboard on the screen.





An amperometric determination can be done by using up to 8 calibration solutions. The unit of concentration is specified by the user. The signal used for the determination can be steady-state current or peak height.

The PalmTime program supports the CH8 multiplexer for sensorarrays. The program allows measurements of up to eight curves obtained from different sensors.

PalmSens Instrumental specifications

Controlled potential mode (potentiostat):

- dc-potential range	± 2.000 V
- compliance voltage	± 8.0 V
- dc-potential resolution	1 mV
- dc-offset error	2 mV
- accuracy	≤ 0.2 %
- ac-potential amplitude	1 mV to 250 mV
- current ranges	1 nA to 10 mA (8 ranges)
- maximum current	± 10 mA
- current resolution	0.1 % of current range 1 pA on lowest current range
- accuracy	≤ 0.2 % of current range at 100 nA to 1 mA ≤ 0.5 % at 10 nA and ≤ 1 % at 1 nA all with additional 0.2 % offset error

Controlled current mode (galvanostat):

- current ranges	1 µA to 1 mA
- dc-current range	-2 to + 2 times selected current range
- dc-current resolution	0.1 % of selected current range
- dc-offset error	≤ 0.2 %
- current accuracy	≤ 0.4 %
- maximum output voltage	± 8 V

General:

- electrometer amplifier input	> 100 Gohm // 4 pF
- rise time	approx. 50 µs
Keypad	▲►▼◄ ENTER ESC and Power (7 keys)
Display	4 lines of 16 characters with backlight
Dimensions	155 mm x 85 mm x 35 mm
Temperature range	0º C to + 40º C
Weight	0.43 kg
Power	2 AA cells NiMH 2700 mAh for > 8 hours operation. Battery charger included (6 V- 1500 mA)
Interfacing	Serial RS232
External I/O	Analog: 1 input and 1 output channel (0 V - 4.096 V) Digital: 1 input and 4 output lines

Expansions supported by Pocket PC software:

A **magnetic stirrer** controlled by PalmSens is available for stripping analysis applications. The stirrer is switched on during the conditioning and deposition stages.

CH8 is a multiplexer for use with 2 to 8 sensors. It is connected to the PalmSens instrument. This device allows application of sensorarrays with up to eight working electrodes sharing the reference and counter electrodes, but also with eight working, eight counter and eight reference electrodes. The device can also be used with two-electrode sensorarrays.

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

Palm Instruments BV
The Netherlands
www.palmsens.com