Getting started with PalmSens SDK for Python

Based on PalmSens SDK v5.12

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www.palmsens.com

Contents

1 Contents of the PalmSens SDK

The PalmSens SDK contains the following libraries and projects:

PalmSens.Core.dll & PalmSens.Core.Windows.BLE.dll:
These libraries contain the namespaces with all the necessary files for using PalmSens/EmStat/Nexus/Sensit devices in your software.

▪ PalmSens	All necessary classes and functions for performing measurements and doing analysis with PalmSens, EmStat, Sensit or Nexus.
▪ PalmSens.Comm	For Serial, USB, TCP, Bluetooth (Classic/Low Energy) communication with instruments.
▪ PalmSens.DataFiles	For saving and loading method and data files.
▪ PalmSens.Devices	For handling communications and device capabilities.
▪ PalmSens.Techniques	Contains all measurement techniques.
▪ PalmSens.Units	Contains a collection of units used by these libraries.

pspython
A python wrapper for the abovementioned .NET libraries.

▪ pspyinstruments.py	Contains the functions to scan for available instruments and the InstrumentManager class used to control the PalmSens, EmStat, Sensit or Nexus instruments.
▪ pspydata.py	Defines the measurements and curves classes
▪ pspyfiles.py	For saving/loading session and method files
▪ pspymethods.py	Work in progress, helper functions to create methods

1.1 Example programs

The following examples are included.

LoadSaveDataExample.py:
Shows how to load/save methods and measurements and how to inspect the data.

ManualControlExample.py:
Shows how to discover devices, establish a connection and control an instrument manually.

ManualControlExampleAsync.py:
Shows how to discover devices, establish a connection and control an instrument manually using the asynchronous instrument manager.

MeasurementExampleCA.py:
Shows how to configure and run a chronoamperometry measurement.

MeasurementExampleCAAsync.py:
Shows how to configure and run a chronoamperometry measurement using the asynchronous instrument manager.

MeasurementExampleCV.py:
Shows how to configure and run a cyclic voltammetry measurement.

MeasurementExampleEIS.py:
Shows how to configure and run a EIS measurement.

MeasurementExampleMethodSCRIPTSandbox.py:
Shows how to configure and run a MethodSCRIPT Sandbox measurement.

MeasurementExampleStreamToCSV.py:
Shows how to configure and run a chronoamperometry measurement and write the results to a CSV file in real-time.

MeasurementExampleSWVversusOCP.py:
Shows how to configure and run a square wave voltammetry measurement versus OCP.

MultiplexerExample.py:
Shows how to configure and control a multiplexer and run consecutive and alternating multiplexer measurments.

MultiChannelMeasurementExample.py:
Shows how to connect to a collection of instruments and run a chronoamperometry measurement on all channels simultaneously.

MultiChannelMeasurementCustomLoopExample.py:
Shows how to run and configure a sequence of measurements on a collection of channels simultaneously.

MultiChannelHWSyncExample.py.py:
Shows how to connect to a collection of instruments and run a chronopotentiometry measurement on all channels simultaneously using hardware synchronization.

1.2 Compatible devices and firmware

	Minimum required firmware version
EmStat	3.7
EmStat2	7.7
EmStat3	7.7
EmStat3+	7.7
EmStat4	1.3
EmStat Go	7.7
EmStat Pico	1.5
Sensit Smart	1.5
Sensit BT	1.5
Sensit Wearable	1.5
MultiEmStat3	7.7
MultiEmStat4	1.3
PalmSens3	2.8
PalmSens4	1.7
MultiPalmSens4	1.7

2 Using the SDK in Windows

2.1 Requirements

- Python version 3.8 or newer
- Python dependencies listed requirements.txt
    - Either run the following command or refer to the steps in 2.2

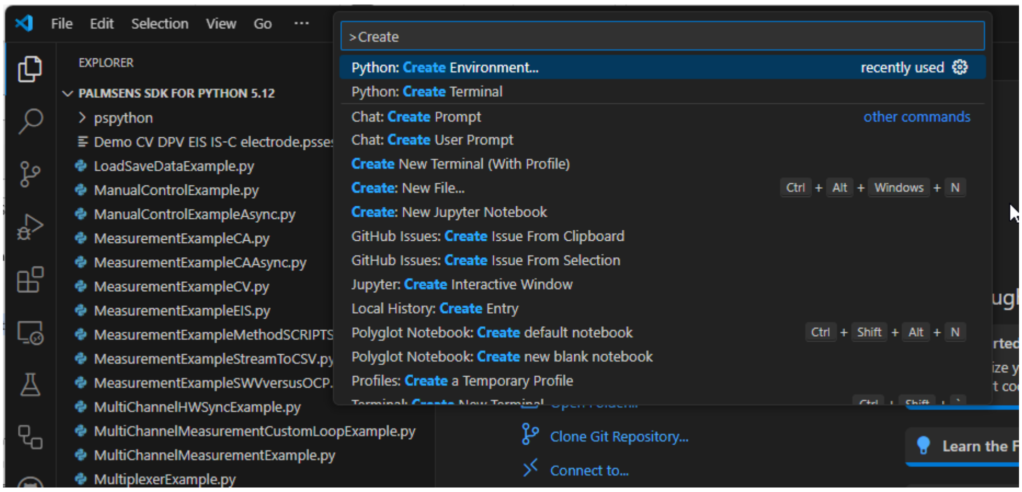
      `pip -r requirements.txt`
- .NET Framework 4.7.2
- Drivers included with PSTrace5.x, MultiTrace4.x, PSTrace Xpress or the included driver installer

> **Python 3.13**
> Python 3.13 contains a known issue which will print errors to the output due to threads not being disposed correctly, these errors can safely be ignored.
>
> Exception ignored in: <function _DeleteDummyThreadOnDel.__del__ at 0x000001B73AEEE5C0>
>
> https://github.com/python/cpython/issues/130522

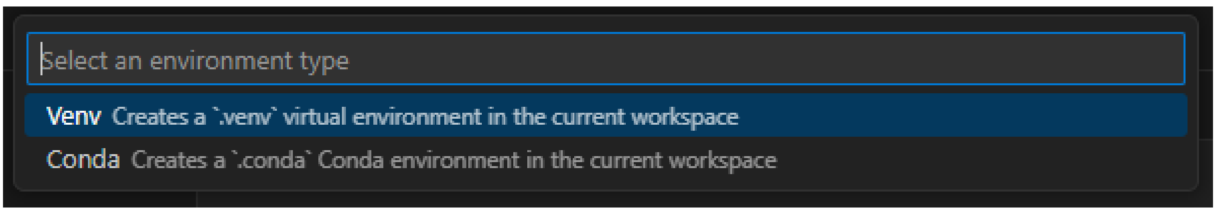
2.2 [Optional] Create a virtual environment in Visual Studio Code

Visual studio code in combination with the Python, Python Debugger and Pylance extensions offer an easy command to create a virtual environment and load the python dependencies.

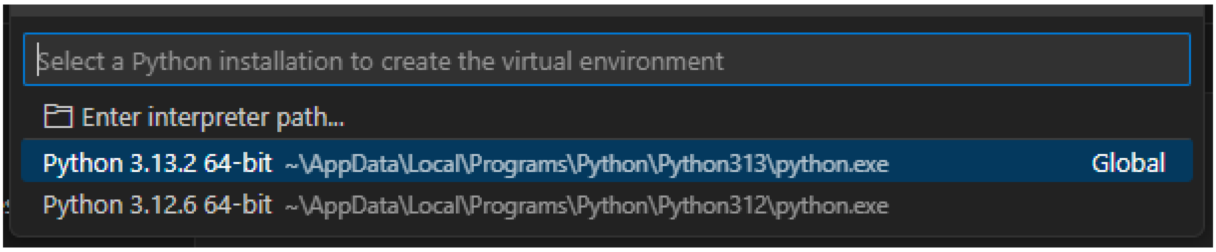
Press control+shift+p to open the command pallete and select the Python: Create Environment command to create a new virtual environment.



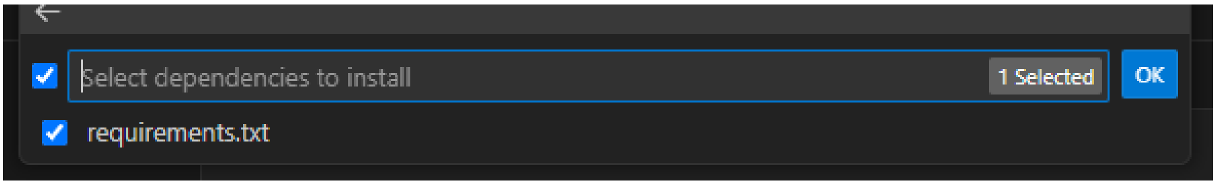
Select the Venv option



Select an install python interpreter



Select the requirements.txt to install the python dependencies for the pspython SDK module and examples.



3 Working with files

As of version 5 of the PalmSens SDK and PSTrace measurements and their corresponding methods are stored in ***.pssession** files. Methods can be stored separately in ***.psmethod** files.

The PalmSens SDK is backward compatible with following filetypes:

	vs potential (scan method)	**Measurement vs time**
Method file	.pms (before 2012)	.pmt (before 2012)
Method file	.psmethod (default)	.psmethod (default)
Data (single curve) file	.pss	.pst
Analysis curves file	.psd	
Multiplexer curves file		.mux

The pspyfiles script in the pspython module contains the functions needed to load and save methods and session files. The pspydata script contain the python classes that store the loaded data. The pspymethods scripts contains helper functions for creating and working with methods.

3.1 Loading a method file (.psmethod)

The pspyfiles script function load_method_file can be used to load method files. This function returns a PalmSens.Method .NET object which can be used to run a measurement.

```
method = pspyfiles.load_method_file(os.path.join(scriptDir,
'PSDummyCell_LSV.psmethod'))
```

3.2 Setting up a method

The pspymethods script contains helper functions to create .NET method objects for the following techniques:

- Linear sweep voltammetry
- Cyclic voltammetry
- Square-wave voltammetry
- Differential pulse voltammetry
- Chronoamperometry
- Multi-step amperometry
- Open circuit potentiometry
- Chronopotentiometry
- Electrochemical impedance spectroscopy
- Galvanostatic impedance spectroscopy

This example creates a method for a square-wave voltammetry measurement versus the open circuit potential:

```
method = pspymethods.square_wave_voltammetry(
    conditioning_potential = 2.0, # V
    conditioning_time = 2, # seconds
    versus_ocp_mode = 3, # versus begin and end potential
    versus_ocp_max_ocp_time = 1, # seconds
    begin_potential = -0.5, # V
    end_potential = 0.5, # V
    step_potential = 0.01, # V
    amplitude = 0.08, # V
    frequency = 10, # Hz
)
```

Appendix A contains a reference to the method parameters for each technique. Parameters of a .NET method object can be modified by adjusting these properties.

For example the frequency of a square-wave voltammetry is modified by adjusting the Frequency property on the .NET object.

```
method.Frequency = 50
```

To create an instance of a method without using one of the helper functions in pspymethods you need to import the .NET class, create an instance and adjust the parameters. Appendix A lists the classes for the techniques.

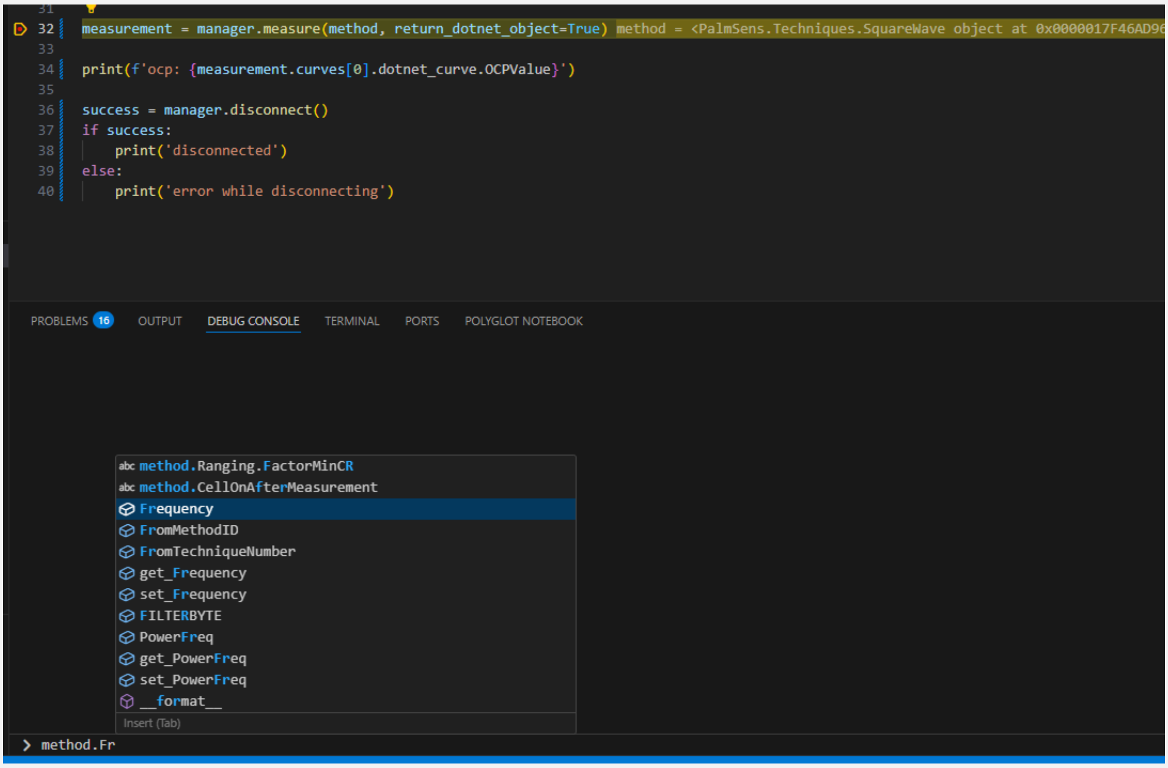
This example creates an instance of an alternating current voltammetry method.

```
import pspython

# import the alternating current voltammetry method object
from PalmSens.Techniques import ACVoltammetry

# create a new method object
method = ACVoltammetry()
method.BeginPotential = -.5 # volts
method.EndPotential = 0.5 # volts
method.StepPotential = 0.01 # volts
method.SineWaveAmplitude = 0.05 # volts RMS
method.Frequency = 50 # Hz
```

Tip
The VSCode Debug Console or another Python REPL environment will auto complete on the properties and functions of .NET objects like the PalmSens.Method objects returned by the helper methods.



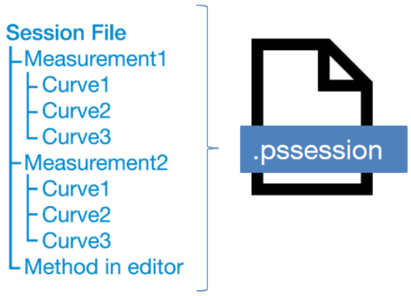
3.3 Saving a method

The pspyfiles script function save_method_file can be used to save method files.

```
pspyfiles.save_method_file(os.path.join(scriptDir,
'PSDummyCell_LSV_copy.psmethod'), method)
```

3.4 Loading and saving data

Data from measurements can be loaded from and stored to ***.pssession** files. This contains a session with one or more measurements containing its respective method and curves.



The pspyfiles script function load_session_file can be used to load session files. It returns a list of measurements, with the exception of (galvanostatic/) electrochemical impedance spectroscopy measurements measurements contain one or more curves. The measurement and curve classes are defined in the pspydata script.

The load_session_file function contains overloads for loading equivalent circuit fit results and peaks and an overload to keep the underlying .NET objects. Keeping the underlying .NET objects is not necessary but useful when you need to access extra information or functionality not provided in the python measurement and curve classes.

The following example loads a collection of measurements from a session file and saves the first measurement to a different file, important to note is that saving to a session file requires the underlying .NET objects to be loaded, i.e. setting return_dotnet_object to true.

```
measurements = pspyfiles.load_session_file(os.path.join(scriptDir, 'Demo CV
DPV EIS IS-C electrode.pssession'), load_peak_data=True, load_eis_fits=True,
return_dotnet_object=True)
pspyfiles.save_session_file(os.path.join(scriptDir, 'Demo CV DPV EIS IS-C
electrode_copy.pssession'), [measurements[0]])
```

4 Connecting and Measuring

The following chapter details how to connect to a device, read data from the device, manually controlling the potential, run measurements on the device and finally how to properly close a connection to a device.

The pspyinstruments script in the pspython module contains all the relevant functions for discovering and controlling instruments. The InstrumentManager and InstrumentManagerAsync class are wrappers around our .NET libraries which make it possible to connect to and control PalmSens instruments from python.

4.1 Connecting to a device

The following example shows how to get a list of all available devices, and how to connect to one of the discovered devices that.

```
available_instruments = pspyinstruments.discover_instruments()
manager = pspyinstruments.InstrumentManager()
manager.connect(available_instruments[0])
```

Currently the pspython module supports discovering instruments connected via FTDI, serial (usbcdc/com), and Bluetooth (classic/low energy). By default scanning with Bluetooth is disabled.

4.2 Manually controlling the device

Depending on your device's capabilities it can be used to set a potential/current and to switch current ranges. The potential can be set manually in potentiostatic mode and the current can be set in galvanostatic mode. The following example show how to manually set a potential, for more examples refer to the ManualControlExample and ManualControlExampleAsync scripts included with the SDK.

```
manager.set_potential(1)
```

4.3 Measuring

Starting a measurement is done by sending method parameters to a PalmSens/Nexus/EmStat/Sensit device. The InstrumentManager measure function returns a Measurement and also supports keeping a reference to the underlying .NET object for more information please refer to Chapter 3.4.

The following example runs a chronoamperometry measurement on an instrument.

```
method = pspymethods.chronoamperometry(interval_time=0.01, e=1.0,
run_time=10.0)
measurement = manager.measure(method)
```

It is possible to process measurement results in real-time by specifying a callback on the InstrumentManager/InstrumentManagerAsync either by providing it as an override when it is created using the new_data_callback argument:

```
def new_data_callback(new_data):
    for point in new_data:
        for type, value in point.items():
            print(type + ' = ' + str(value))

manager =
pspyinstruments.InstrumentManager(new_data_callback=new_data_callback)
```

or by setting it on the InstrumentManager's new_data_callback field.

```
manager.new_data_callback = stream_to_csv_callback(csv_writer)
```

The callback is passed a collection of points that have been added since the last time it was called. Points contain a dictionary with the following information:

- Non-impedimetric techniques: techniques such as linear sweep voltammetry or chronopotentiometry return a dictionary containing the following values:
  - index: the index of the point
  - x, x_unit and x_type: depending on the technique this will be:
    - Time in seconds for amperometry and potentiometry techniques that do not specify a begin and an end potential
    - Potential in volts for voltammetry techniques such as linear sweep, cyclic and square-wave voltammetry
    - Current in micro amperes for linear sweep potentiometry
  - y, y_unit and y_type: depending on the techniques this will be:
    - Current in micro amperes for all potentiometric techniques such as linear sweep and cyclic voltammetry and chronoamperometry and multistep amperometry
    - Potential in volts for all galvanostatic techniques such as chronopotentiometry and linear sweep potentiometry
- Impedimetric techniques: the exception are (galvanostatic/) electrochemical impedance spectroscopy. These techniques return the following:
  - frequency: the applied frequency of the sample in hertz
  - z_re: the real impedance in ohms
  - z_im: the imaginary impedance in ohms

Mains Frequency
To eliminate noise induced by other electrical appliances it is highly recommended to set your regional mains frequency (50/60 Hz) in the static property PalmSens.Method.PowerFreq.

4.4 MethodSCRIPT™

The MethodSCRIPT™ scripting language is designed to integrate our OEM potentiostat (modules) effortlessly in your hardware setup or product.

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

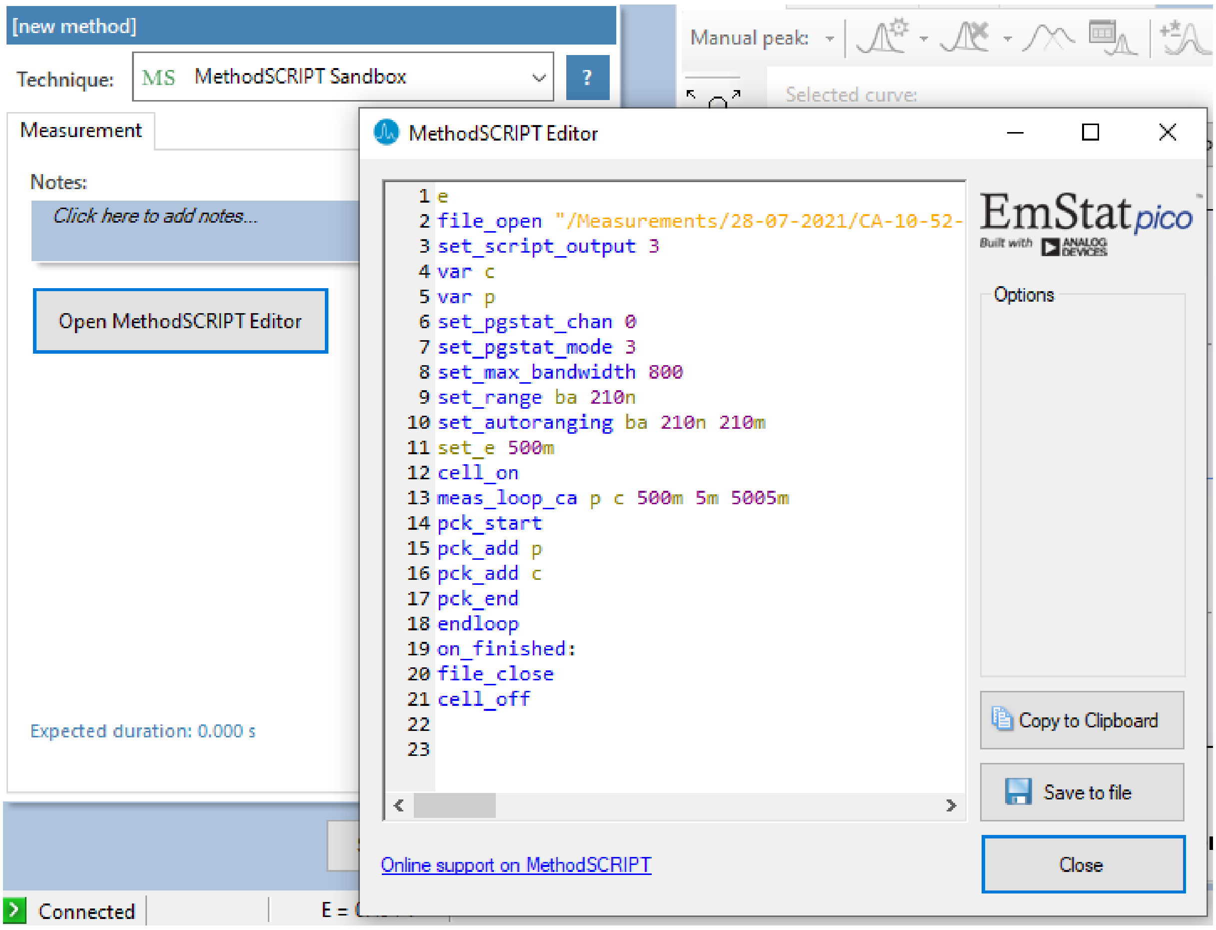
More script features include:

- Use of variables
- (Nested) loops
- Logging results to an SD card
- Digital I/O for example for waiting for an external trigger
- Reading auxiliary values like pH or temperature
- Going to sleep or hibernate mode

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

4.4.1 Sandbox Measurements

PSTrace includes an option to make use MethodSCRIPT™ Sandbox to write and run scripts. This is a great place to test MethodSCRIPT™ measurements to see what the result would be. That script can then be used in the MethodScriptSandbox technique in the SDK as demonstrated below.



4.5 Disconnecting from the device

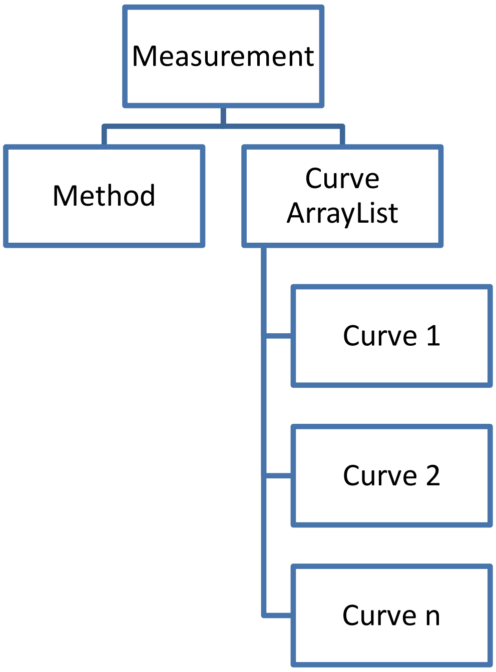
The InstrumentManager disconnect function disconnects from the device freeing it up for other things to connect to it.

```
manager.disconnect()
```

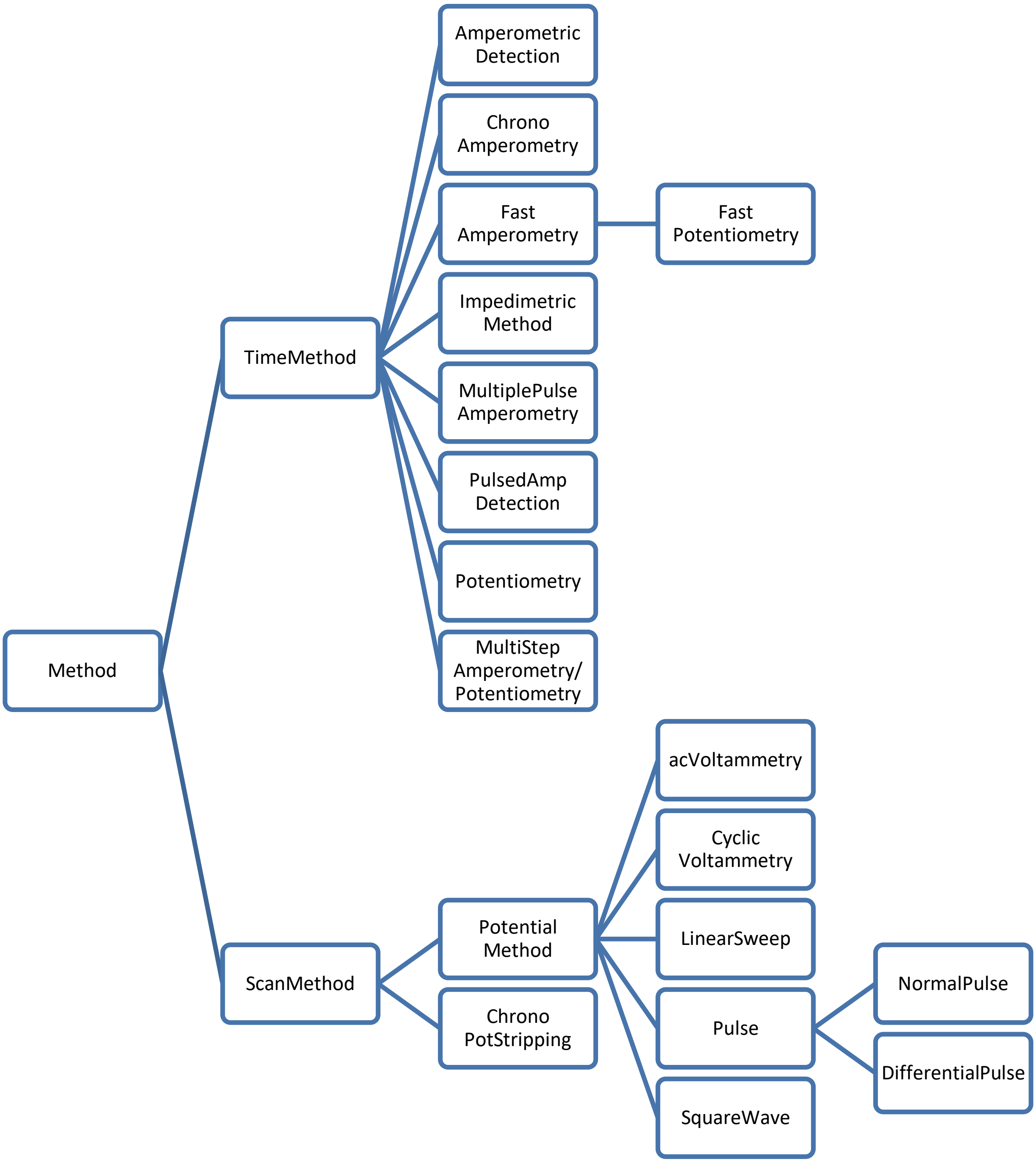
5 PalmSens.Core.dll

The basis for handling measurements is the **PalmSens.Measurement** class, or the **PalmSens.Core.Simplified.Data.SimpleMeasurement** class when using the simplified wrapper.

The measurement class contains all classes, functions, and parameters necessary for performing a measurement with a PalmSens or EmStat instrument. It has one method and can contain multiple curves. Curves are a representation of the data in the measurement used for plotting and analysis.



The following diagram shows the inheritance structure of the Method classes:



6 Appendix A: Parameters for each technique

All applicable parameters for each technique can be found here. For the inheritance hierarchy of the the techniques, see section 3 in this document. See section ‘Available techniques’ in the PSTrace manual for more information about the techniques.

Each technique is identified by a specific integer value. This integer value can be used to create a class derived from the corresponding technique, as follows:

```
PalmSens.Method.FromTechniqueNumber(integervalue)
```

The integer values are indicated in this appendix inside the brackets [ ] following each technique name.

The techniques are also directly available from the **PalmSens.Techniques** namespace.

Please refer to the PSTrace manual for explanations and expected values for each parameter.

6.1 Common properties

Property	Description	Type
Technique	The technique number used in the firmware	System.Int
Notes	Some user notes for use with this method	System.String
StandbyPotential	Standby Potential (for use with cell on after measurement)	System.Float
StandbyTime	Standby time (for use with cell on after measurement)	System.Float
CellOnAfterMeasurement	Enable/disable cell after measurement	System.Boolean
MinPeakHeight	Determines the minimum peak height in µA. Peaks lower than this value are neglected.	System.Float
MinPeakWidth	The minimum peak width, in the unit of the curves X axis. Peaks narrower than this value are neglected.	System.Float
SmoothLevel	The smoothlevel to be used. -1 = none 0 = no smooth (spike rejection only) 1 = 5 points 2 = 9 points 3 = 15 points 4 = 25 points	System.Int
Ranging	Ranging information, settings defining the minimum/maximum/starting current range	PalmSens.Method.Ranging
PowerFreq	Adjusts sampling on instrument to account for mains frequency. It accepts two values: 50 for 50Hz 60 for 60Hz	System.Int

6.2 Pretreatment settings

The following properties specify the measurements pretreatment settings:

Property	Description	Type
ConditioningPotential	Conditioning potential in volt	System.Float
ConditioningTime	Conditioning duration in seconds	System.Float
DepositionPotential	Deposition potential in volt	System.Float
DepositionTime	Deposition duration in seconds	System.Float
EquilibrationTime	Equilibration duration in seconds. BeginPotential is applied during equilibration and the device switches to the appropriate current range	System.Float

6.3 Linear Sweep Voltammetry (LSV) [0]

Class: Palmsens.Techniques.LinearSweep

Property	Description	Type
BeginPotential	Potential where scan starts.	System.Float
EndPotential	Potential where measurement stops.	System.Float
StepPotential	Step potential	System.Float
Scanrate	The applied scan rate. The applicable range depends on the value of E step since the data acquisition rate is limited by the connected instrument.	System.Float

6.4 Differential Pulse Voltammetry (DPV) [1]

Class: Palmsens.Techniques.DifferentialPulse

Property	Description	Type
BeginPotential	Potential where scan starts.	System.Float
EndPotential	Potential where measurement stops.	System.Float
StepPotential	Step potential	System.Float
Scanrate	The applied scan rate. The applicable range depends on the value of E step since the data acquisition rate is limited by the connected instrument.	System.Float
PulsePotential	Pulse potential	System.Float
PulseTime	The pulse time	System.Float

6.5 Square Wave Voltammetry (SWV) [2]

Class: Palmsens.Techniques.SquareWave

Property	Description	Type
BeginPotential	Potential where scan starts.	System.Float
EndPotential	Potential where measurement stops.	System.Float
StepPotential	Step potential	System.Float
PulseAmplitude	Amplitude of square wave pulse. Values are half peak-to-peak.	System.Float
Frequency	The frequency of the square wave	System.Float

6.6 Normal Pulse Voltammetry (NPV) [3]

Class: Palmsens.Techniques.NormalPulse

Property	Description	Type
BeginPotential	Potential where scan starts.	System.Float
EndPotential	Potential where measurement stops.	System.Float
StepPotential	Step potential	System.Float
Scanrate	The applied scan rate. The applicable range depends on the value of E step since the data acquisition rate is limited by the connected instrument.	System.Float
PulseTime	The pulse time	System.Float

6.7 AC Voltammetry (ACV) [4]

Class: Palmsens.Techniques.ACVoltammetry

Property	Description	Type
BeginPotential	Potential where scan starts.	System.Float
EndPotential	Potential where measurement stops.	System.Float
StepPotential	Step potential	System.Float
SineWaveAmplitude	Amplitude of sine wave. Values are RMS	System.Float
Frequency	The frequency of the AC signal	System.Float

6.8 Cyclic Voltammetry (CV) [5]

Class: Palmsens.Techniques.CyclicVoltammetry

Property	Description	Type
BeginPotential	Potential where scan starts and stops.	System.Float
Vtx1Potential	First potential where direction reverses.	System.Float
Vtx2Potential	Second potential where direction reverses.	System.Float
StepPotential	Step potential	System.Float
Scanrate	The applied scan rate. The applicable range depends on the value of E step since the data acquisition rate is limited by the connected instrument.	System.Float
nScans	The number of repetitions for this scan	System.Float

6.8.1 Fast Cyclic Voltammetry Scans

Class: Palmsens.Techniques.FastCyclicVoltammetry

Outdated class. PalmSens 3 and 4 only. CV's with sampling over 5000 data points per second, use the regular **Palmsens.Techniques.CyclicVoltammetry()** constructor instead.

6.9 Chronopotentiometric Stripping (SCP) [6]

Class: PalmSens.Techniques.ChronoPotStripping

Property	Description	Type
EndPotential	Potential where measurement stops.	System.Float
MeasurementTime	The maximum measurement time. This value should always exceed the required measurement time. It only limits the time of the measurement. When the potential response is erroneously and E end is not found within this time, the measurement is aborted.	System.Float
AppliedCurrentRange	The applied current range	PalmSens. CurrentRange
Istrip	If specified as 0, the method is called chemical stripping otherwise it is constant current stripping. The current is expressed in the applied current range.	System.Float

6.10 Chronoamperometry (CA) [7]

Class: PalmSens.Techniques.AmperometricDetection

Property	Description	Type
Potential	Potential during measurement.	System.Float
IntervalTime	Time between two current samples.	System.Float
RunTime	Total run time of scan.	System.Float

6.11 Pulsed Amperometric Detection (PAD) [8]

Class: PalmSens.Techniques.PulsedAmpDetection

Property	Description	Type
Potential	The dc or base potential.	System.Float
PulsePotentialAD	Potential in pulse. Note that this value is not relative to dc/base potential, given above.	System.Float
PulseTime	The pulse time.	System.Float
tMode	DC: I(dc) measurement is performed at potential E pulse: I(pulse) measurement is performed at potential E pulse differential: I(dif) measurement is I(pulse) - I(dc)	PalmSens.Techniques. PulsedAmpDetection. enumMode
IntervalTime	Time between two current samples.	System.Float
RunTime	Total run time of scan.	System.Float

6.12 Fast Amperometry (FAM) [9]

Class: PalmSens.Techniques.FastAmperometry

Property	Description	Type
EqPotentialFA	Equilibration potential at which the measurement starts.	System.Float
Potential	Potential during measurement.	System.Float
IntervalTimeF	Time between two current samples.	System.Float
RunTime	Total run time of scan.	System.Float

6.13 Chronopotentiometry (CP) [10]

Class: PalmSens.Techniques.Potentiometry

Property	**Description**	**Type**
Current	The current to apply. The unit of the value is the applied current range. So if 10 uA is the applied current range and 1.5 is given as value, the applied current will be 15 uA.	System.Float
AppliedCurrentRange	The applied current range.	PalmSens. CurrentRange
RunTime	Total run time of scan.	System.Float
IntervalTime	Time between two potential samples.	System.Float

6.13.1 Open Circuit Potentiometry (OCP)

Class: PalmSens.Techniques.OpenCircuitPotentiometry

The same as setting the Current to 0.

Property	**Description**	**Type**
RunTime	Total run time of scan.	System.Float
IntervalTime	Time between two potential samples.	System.Float

6.14 Multiple Pulse Amperometry (MPAD) [11]

Class: PalmSens.Techniques.MultiplePulseAmperometry

Property	**Description**	**Type**
E1	First potential level in which the current is recorded	System.Float
E2	Second applied potential level	System.Float
E3	Third applied potential level	System.Float
t1	The duration of the first applied potential	System.Float
t2	The duration of the second applied potential	System.Float
t3	The duration of the third applied potential	System.Float
RunTime	Total run time of scan.	System.Float

6.15 Electrochemical Impedance Spectroscopy (EIS)

Class: PalmSens.Techniques.ImpedimetricMethod

The most common properties are described first. These are used for a typical EIS measurement, a scan over a specified range of frequencies (i.e. using the default properties **ScanType** = **ImpedimetricMethod**.
enumScanType.FixedPotential and **FreqType** = **ImpedimetricMethod.enumFrequencyType.Scan**). The additional properties used for a **TimeScan** and a **PotentialScan** are detailed separately in next sections.

Property	**Description**	**Type**
ScanType	Scan type specifies whether a single or multiple frequency scans are performed. When set to FixedPotential a single scan will be performed, this is the recommended setting. **The TimeScan and PotentialScan are not fully supported in the SDK**, we highly recommend you to implement yourself. A TimeScan performs repeated scans at a given time interval within a specified time range. A PotentialScan performs scans where the DC Potential of the applied sine is incremented within a specified range. A PotentialScan should not be performed versus the OCP.	ImpedimetricMethod. enumScanType
Potential	The DC potential of the applied sine	System.Float

Eac	The amplitude of the applied sine in RMS (Root Mean Square)	System.Float
FreqType	Frequency type specifies whether to perform a scan on a range of frequencies or to measure a single frequency. The latter option can be used in combination with a TimeScan or a PotentialScan.	ImpedimetricMethod.enumFrequencyType
MaxFrequency	The highest frequency in the scan, also the frequency at which the measurement is started	System.Float
MinFrequency	The lowest frequency in the scan	System.Float
nFrequencies	The number of frequencies included in the scan	System.Int
SamplingTime	Each measurement point of the impedance spectrum is performed during the period specified by SamplingTime. This means that the number of measured sine waves is equal to SamplingTime * frequency. If this value is less than 1 sine wave, the sampling is extended to 1 / frequency. So for a measurement at a frequency, at least one complete sine wave is measured. Reasonable values for the sampling are in the range of 0.1 to 1 s.	System.Float
MaxEqTime	The impedance measurement requires a stationary state. This means that before the actual measurement starts, the sine wave is applied during MaxEqTime only to reach the stationary state. The maximum number of equilibration sine waves is however 5. The minimum number of equilibration sines is set to 1, but for very low frequencies, this time is limited by MaxEqTime. The maximum time to wait for stationary state is determined by the value of this parameter. A reasonable value might be 5 seconds. In this case this parameter is only relevant when the lowest frequency is less than 1/ 5 s so 0.2 Hz.	System.Float

6.15.1 Time Scan

In a Time Scan impedance spectroscopy measurements are repeated for a specific amount of time at a specific interval. The SDK does not support this feature fully, we recommend you to design your own implementation for this that suits your demands.

Property	Description	Type
RunTime	RunTime is not the total time of the measurement, but the time in which a measurement iteration can be started. If a frequency scan takes 18 seconds and is measured at an interval of 19 seconds for a RunTime of 40 seconds three iterations will be performed.	System.Float
IntervalTime	IntervalTime specifies the interval at which a measurement iteration should be performed, however if a measurement iteration takes longer than the interval time the next measurement will not be triggered until after it has been completed.	System.Float

6.15.2 Potential Scan

In a Potential Scan impedance spectroscopy measurements are repeated over a range of DC potential values. The SDK does not support this feature fully, we recommend you to design your own implementation for this that suits your demands.

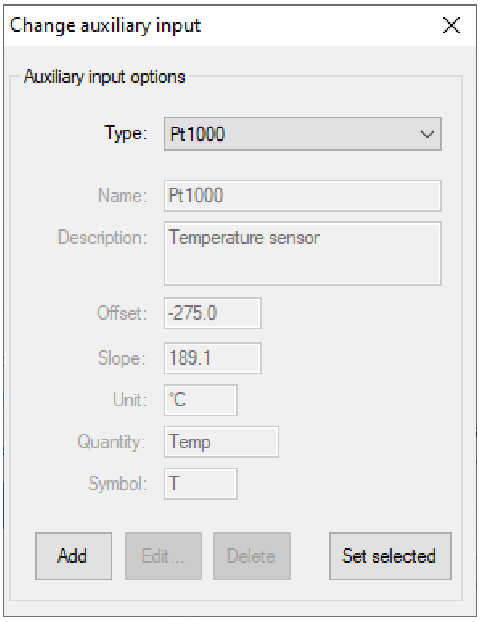
Property	Description	Type
BeginPotential	The DC potential of the applied sine wave to start the series of iterative measurements at.	System.Float
EndPotential	The DC potential of the applied sine wave at which the series of iterative measurements ends.	System.Float
StepPotential	The size of DC potential step to iterate with.	System.Float

6.16 Recording extra values (BiPot, Aux, CE Potential…)

The **PalmSens.Method.ExtraValueMsk** property allows you to record an additional value during your measurement. Not all techniques support recording extra values, the **SupportsAuxInput** and **SupportsBipot** properties are used to indicate whether a technique supports the recording of these values. The default value for **PalmSens.Method.ExtraValueMsk** is **PalmSens.ExtraValueMask.None**.

- None, no extra value recorded (default)
- Current
- Potential
- WE2, record BiPot readings (The behavior of the second working electrode is defined with the method’s **BipotModePS** property. **EnumPalmSensBipotMode.Constant** sets it to a fixed potential and **EnumPalmSensBipotMode.Offset** sets it to an offset of the primary working electrode. The value in Volt of the fixed or offset potential is defined with the method’s **BiPotPotential** property.)

- AuxInput, similar to PSTrace it is possible to configure the readings of the auxilliary input. Using the **PalmSens.AuxInput.AuxiliaryInput** class you can assign a name, offset, gain and unit to the auxilliary input. The following example demonstrates how to set up the Pt1000 temperature sensor from PSTrace.




```
psCommSimpleWinForms.comm.AuxInputSelected = new PalmSens.AuxInput.Auxiliar
yInputType(true, "Pt1000", "Temperature sensor", -275f, 189.1f,
             new PalmSens.Units.Temperature());
```

  The can be ignored and set to true, the second argument is the name, third is the description, fourth the offset, fifth the slope and the final argument is an instance of one of the unit classes in the **PalmSens.Units** namespace.
- Reverse, record reverse current as used by Square Wave Voltammetry
- PolyStatWE, not supported in the PalmSens SDK
- DCcurrent, record the DC current as used with AC Voltammetry
- CEPotential, PalmSens 4 only

The PSSDKBiPotAuxExample example project demonstrates how to record extra values.

6.17 Multiplexer

The **PalmSens.Method** class is also used to specify the multiplexer settings for sequential and alternating measurements. Alternating multiplexer measurements restricted to the chronoamperometry and chronopotentiometry techniques.

The enumerator property **PalmSens.Method.MuxMethod** defines the type multiplexer measurement.

```
methodCA.MuxMethod = MuxMethod.None; //Default setting, no multiplexer
methodCA.MuxMethod = MuxMethod.Alternatingly;
methodCA.MuxMethod = MuxMethod.Sequentially;

//The channels on which to measure are specified in a boolean array
PalmSens.Method.UseMuxChannel: methodCA.UseMuxChannel = new bool[] { true, true,
false, false, false, false, false, true };
```

The code above will perform a measurement on the first two and last channels of an 8-channel multiplexer. For a 16-channel multiplexer you would also need to assign true or false to the last 8 channels.

Alternating multiplexer measurement can only measure on successive channels and must start with the first channel (i.e. it is possible to alternatingly measure on channels 1 through 4 but it is not possible to alternatingly measure on channel 1, 3 and 5). The multiplexer functionality is demonstrated in the PSSDKMultiplexerExample project.

6.17.1 Multiplexer settings

When using a MUX8-R2 multiplexer the multiplexer settings must be set digitally instead of via the physical switches on the earlier multiplexer models. The type of multiplexer should be specified in the connected device's capabilities, when the multiplexer is connected before connecting to the software the capabilities are updated automatically. Otherwise, when using the MUX8-R2 the **PalmSens.Devices.DeviceCapabilities.MuxType** should be set to **PalmSens.Comm.MuxType.Protocol** manually or by calling **PalmSens.Comm.CommManager.ClientConnection.ReadMuxInfo**, **PalmSens.Comm.CommManager.ClientConnection.ReadMuxInfoAsync** when connected asynchronously.

For the MUX8-R2 the settings for a measurement are set in **PalmSens.Method.MuxSett** property with an instance of the **PalmSens.Method.MuxSettings** class. For manual control these settings can be set using the **PalmSens.Comm.ClientConnection.SetMuxSettings** function, **PalmSens.Comm.ClientConnection.SetMuxSettingsAsync** when connected asynchronously.

```
method.MuxSett = new Method.MuxSettings(false)
{
        CommonCERE = false,
        ConnSEWE = false,
        ConnectCERE = true,
        OCPMode = false,
        SwitchBoxOn = false,
        UnselWE = Method.MuxSettings.UnselWESetting.FLOAT
};
```

6.18 Versus OCP

The versus open circuit potential settings (OCP) are defined in the **PalmSens.Method.OCPmode**, **PalmSens.Method.OCPMaxOCPTime**, and **PalmSens.Method.OCPStabilityCriterion** properties. The OCPmode is a bitmask specifies which of the following technique dependent properties or combination thereof will be measured versus the OCP potential:

- Linear Sweep Voltammetry:
  - BeginPotential = 1
  - EndPotential = 2
- (Fast) Cyclic Voltammetry
  - Vtx1Potential = 1
  - Vtx2Potential = 2
  - BeginPotential = 4
- Chronoamperometry
  - Potential = 1
- Impedance Spectroscopy (Fixed potential and Time Scan)
  - Potential = 1
- Impedance Spectroscopy (Potential Scan)
  - BeginPotential = 1
  - EndPotential = 2

The progress and result of the versus OCP measurement step are reported in the **PalmSens.Comm.MeasureVersusOCP** class, which can be obtained by subscribing to the

PalmSens.Comm.CommManager.DeterminingVersusOCP event which is raised when the versus OCP measurement step is started.

```
//Defining versus OCP measurement step for a Cyclic Voltammetry measurement
_methodCV.OCPmode = 7; //Measure the (Vtx1Potential) 1 + (Vtx2Potential) 2 +
(BeginPotential) 4 = 7 versus the OCP potential
_methodCV.OCPMaxOCPTime = 10; //Sets the maximum time the versus OCP step can take to
10 seconds
_methodCV.OCPStabilityCriterion = 0.02f; //The OCP measurement will stop when the
change in potential over time is less than 0.02mV/s, when set to 0 the OCP measurement
step will always run for the OCPMaxOCPTime
```

6.19 Properties for EmStat Pico

There are two method parameters specific to the EmStat Pico. The **PalmSens.Method.PGStatMode** property sets the mode in which the measurement should be run, low power, high speed or max range. This mode can be set for all techniques but Electrochemical Impedance Spectroscopy. The second property is **PalmSens.Method.SelectedPotentiostatChannel** which let you choose on which channel the EmStat Pico should run the measurement.

Mains Frequency
To eliminate noise induced by other electrical appliances it is highly recommended to set your regional mains frequency (50/60 Hz) in the static property PalmSens.Method.PowerFreq.

6.20 MethodSCRIPT™

The MethodSCRIPT™ scripting language is designed to integrate our OEM potentiostat (modules) effortlessly in your hardware setup or product.

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

More script features include:

- Use of variables
- (Nested) loops
- Logging results to an SD card
- Digital I/O for example for waiting for an external trigger
- Reading auxiliary values like pH or temperature
- Going to sleep or hibernate mode

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

6.20.1 Sandbox Measurements

PSTrace includes an option to make use MethodSCRIPT™ Sandbox to write and run scripts. This is a great place to test MethodSCRIPT™ measurements to see what the result would be. That script can then be used in the MethodScriptSandbox technique in the SDK as demonstrated below.