ELECTROCHEMICAL INTERFACE MODULE
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EmStat Pico: Electrochemical Interface Module

The EmStat Pico is a joint development by PalmSens BV and Analog Devices Inc. PalmSens 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.

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)
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

<table>
<thead>
<tr>
<th></th>
<th>Low Speed mode</th>
<th>High Speed mode</th>
<th>Max Range mode</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full dc-potential range</strong></td>
<td>-1.2 to +2 V</td>
<td>-1.7 to +2 V</td>
<td>-1.7 to +2 V</td>
</tr>
<tr>
<td><strong>Dynamic dc-potential range</strong></td>
<td>2.2 V</td>
<td>1.2 V</td>
<td>2.6 V</td>
</tr>
<tr>
<td><strong>Compliance voltage</strong></td>
<td>-2.0 to +2.3 V</td>
<td>-2.0 to +2.3 V</td>
<td>-2.0 to +2.3 V</td>
</tr>
<tr>
<td><strong>Maximum current</strong></td>
<td>±3 mA</td>
<td>±3 mA</td>
<td>±3 mA</td>
</tr>
<tr>
<td><strong>Max. acquisition rate (datapoints/s)</strong></td>
<td>100</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td><strong>Supports FRA/EIS</strong></td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

### Potentiostat (controlled potential mode)

<table>
<thead>
<tr>
<th></th>
<th>Low Speed mode</th>
<th>High Speed mode</th>
<th>Max Range mode</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Channels</strong></td>
<td>2 (2x WE, 2x RE and 2x CE)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Applied dc-potential resolution</strong></td>
<td>537 µV</td>
<td>395 µV</td>
<td>932 µV</td>
</tr>
<tr>
<td><strong>Applied potential accuracy</strong></td>
<td>&lt; 0.2%</td>
<td>&lt; 0.5%</td>
<td>&lt; 0.5%</td>
</tr>
<tr>
<td><strong>Available current ranges</strong></td>
<td>100 nA, 2 uA, 4 uA, 8 uA, 16 uA, 32 uA, 63 uA, 125 uA, 250 uA, 500 uA, 1 mA, 5 mA</td>
<td>100 nA, 1 uA, 6 uA, 13 uA, 25 uA, 50 uA, 100 uA, 200 uA, 1 mA, 5 mA</td>
<td>100 nA, 1 uA, 6 uA, 13 uA, 25 uA, 50 uA, 100 uA, 200 uA, 1 mA, 5 mA</td>
</tr>
</tbody>
</table>

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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)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Low Speed mode</th>
<th>High Speed mode</th>
<th>Max Range mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current accuracy</td>
<td>&lt; 0.5% of the selected current range</td>
<td>&lt; 1% of the selected current range</td>
<td>&lt; 2% for 100 nA current range</td>
</tr>
<tr>
<td></td>
<td>&lt; 2% for 100 nA current range</td>
<td>&lt; 2% for 5 mA current range</td>
<td></td>
</tr>
<tr>
<td>Measured current resolution</td>
<td>0.006% of selected current range (5.5 pA on 100 nA range)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured potential resolution (for OCP)</td>
<td>56 µV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 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**: \( \Delta E(WE1) + \Delta E(WE2) < 1.6 \text{ V} \)

### Electrometer

- **Electrometer amplifier input**: > 1 TΩ // 10 pF
- **Bandwidth**: 250 kHz

### Communications and peripherals

- **Module communications**: UART
- **Communication with external peripherals**: SPI and I²C
- **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\(^6\)**: ±0.25 °C

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\(^3\) Ch1 has an uncompensated series resistor (typical 110 Ω) in series with the WE_1 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.

\(^6\) 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

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**EIS Accuracy Contour Plot**

![EIS Accuracy Contour Plot](image)

**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.
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.

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

Example MethodSCRIPT for EIS measurement on a test circuit

```plaintext
# 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

# Continue with next step of EIS scan
endloop

# Turn cell off after measurement
cell_off
```

Scripts can easily be generated in PSTrace for Windows. See page 9.

Actual measured result on dummy cell ran in Python
EmStat Pico Development Board

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

Micro-USB for power and connecting

Bluetooth 4.0 Dual Mode

AAA battery holder for ~100 hours of continuous measurements

Micro SD card for data logging

Analog and digital I/O pins for peripherals

LEMO connector and screw terminals for connecting to cell

Arduino MKR headers at the bottom

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**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:

- Arduino
- Visual Studio
- Xamarin
- Python
- C/C++
- Swift
- Java

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PalmSens
Compact Electrochemical Interfaces
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.

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

System requirements
Minimum PC requirements are:
- Windows 7, 8, or 10 (32-bit or 64-bit)
- 1 GHz or faster 32-bit (x86) or 64-bit (x64) processor
- 1 GB RAM (32-bit) or 2 GB RAM (64-bit)

For more information about software visit www.palmsens.com/software
Please don’t hesitate to contact PalmSens BV for more details: info@palmsens.com

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