PalmSens

Electrochemical Instrumentation Explained: An Overview of Multiplexers, Bipotentiostats, and Multi-Channel Devices

Introduction

PalmSens offers you different ways of performing your experiment with as little time investment as possible, e.g. measuring more than one sample at the same time is an easy way to save time. Here you will find a brief explanation of the different possibilities for measuring more than one sample, sequentially or simultaneously. This will help you to choose the ideal PalmSens instrument to support your application.

Multiplexer

The MUX8-R2 and EmStatMUX8-R2 are multiplexer instruments. While the first one is an extension for a PalmSens4 or an EmStat4X the EmStatMUX8-R2 is an EmStat potentiostat with an integrated multiplexer.
Each MUX8-R2 has a maximum of 8 cells, but it can be combined with another MUX8-R2 to create 16 cells. You can stack multiple MUX8-R2s to up to 128 cells.
A multiplexer is like a multi-way valve. One potentiostat is connected to this valve and the valve (the multiplexer) switches the connection of the potentiostat between the different channels.

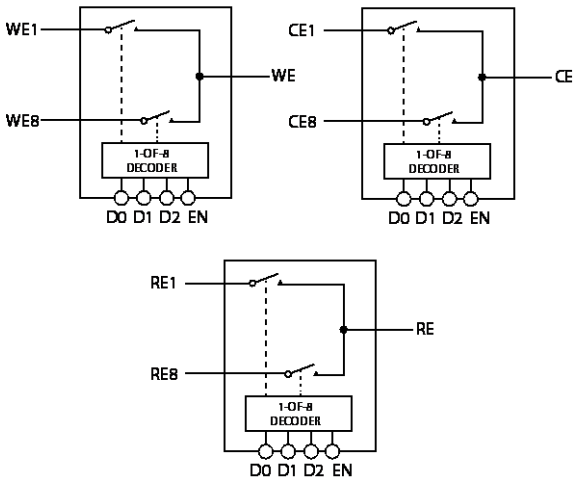

Figure 1 - Functional diagram of an 8-channel multiplexer

Normally, the switching is done after each experiment is finished (e.g. DPV, CV). The measurements are performed consecutively.
It is also possible to operate the MUX8-R2 in a mode that switches the channel after every measurement point. This creates measurements that look like they are measured parallel, but there is a small time difference between each point of each channel. The channel alternates during the measurement. The following techniques support the alternating mode:

- Chronoamperometry (CA);
- Chronopotentiometry (CP);
- Open Circuit Potentiometry (OCP);
- (Galvanostatic) Electrochemical Impedance Spectroscopy (EIS).

In some setups alternating OCP measurements require a special setup. Please consult this application note.
It's important to note that this mode is not entirely equivalent to a simultaneous measurement. During one interval time, i.e. the time between two points of a curve, all channels have been active once. This results in shorter sampling times and idle time while the channel is inactive.

Our software, PSTrace, will offer two options for the idle state of an unselected working electrode:

- Disconnect WE (floating): No potential control and the potential in the idle state will float, tending to return to the OCP/equilibrium state.
- Switch WE to GND: the idle potential will be equal to the active WE vs. RE, as the GND (ground lead) has the same potential as the active WE.

Note that if you have separate cells, the idle electrode will be floating anyway, as the RE leads are independent, making it impossible to polarize the idle WE.

A common observation with floating, idle WEs is a higher current when alternating compared to the consecutive measurement.

An advantage of a multiplexer is that there will be no crosstalk between the channels because only the active electrodes are connected to the potentiostat.

A multiplexer is an economic solution to increase the efficiency of your sample throughput, but it never measures different electrodes at the exact same point in time.

Bipotentiostat / Polypotentiostat

A PalmSens with a BiPot module is a bipotentiostat, which is a special case of a polypotentiostat. A polypotentiostat is a single potentiostat with multiple WEs, but just one RE and one CE. Since it is one potentiostat all electrodes need to be in the same cell. The working electrodes will all be measured simultaneously, so you could perform four CVs synchronized at four different working electrodes in the same electrolyte. Since the electrodes belong all to the same potentiostat they depend on each other. As a consequence, the first WE (WE1) determines what the other WEs should do. You can apply to the other working electrodes either a constant potential or the electrodes follow the WE1 but you can choose a potential offset. For example, your WE1 could do a CV and the other WEs do the same CV but WE2 with 200 mV of an anodic shift, WE3 with 400 mV, and WE4 with 600 mV.

A polypotentiostat is a good instrument to measure a lot of electrodes in the same solution at exactly the same time, for example, to perform electrochemical polishing with gold electrodes.

However, the experiments are not independent and need to be in the same cell and the WEs need to perform the same method or have a constant potential.

The MultiPalmSens4 and MultiEmStat4 can also be used as a polypotentiostat by synchronizing multiple channels or having galvanic isolation (GI).

For more information, continue reading our application note about using multi-channel instruments as polypotentiostats.

Multi-channel instrument

The MultiEmStat series and the MultiPalmSens4 are multi-channel instruments. These instruments are multiple independent potentiostats in a single chassis. Such a compact system requires less bench space compared to having multiple single-channel potentiostats. All the potentiostats just need a single USB connection and can be controlled by one program (MultiTrace). Each independent potentiostat needs to be connected to an electrically independent cell, i.e. the electrodes should not be in the same solution, except if the multi-channel device has individual galvanic isolation for each channel.
The costs for a multi-channel potentiostat are higher than for a multiplexer, but they are lower than for multiple single-channel potentiostats.

A multi-channel instrument offers independent potentiostats that can be used at the same time or at different points in time. The experiments on different channels can either be independent or synchronized on multiple channels.

More information about Galvanic Isolation is available in an application note. If you want your multi-channel device's channels to share one RE and CE, please have a look at our application note about using multi-channel instruments as polypotentiostats.

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