BioLogic Software & Instrumentation Guide

Chemistry 248 – Electrochemistry

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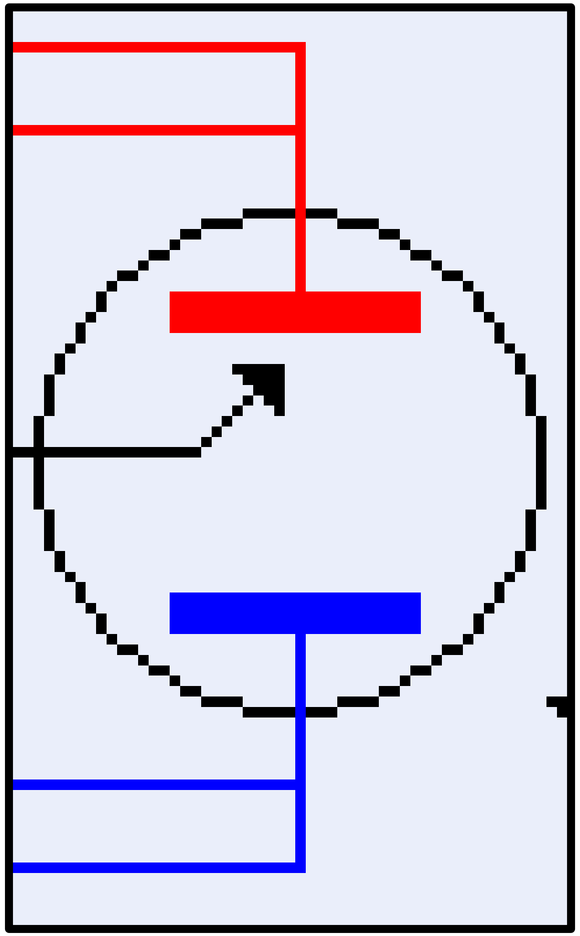
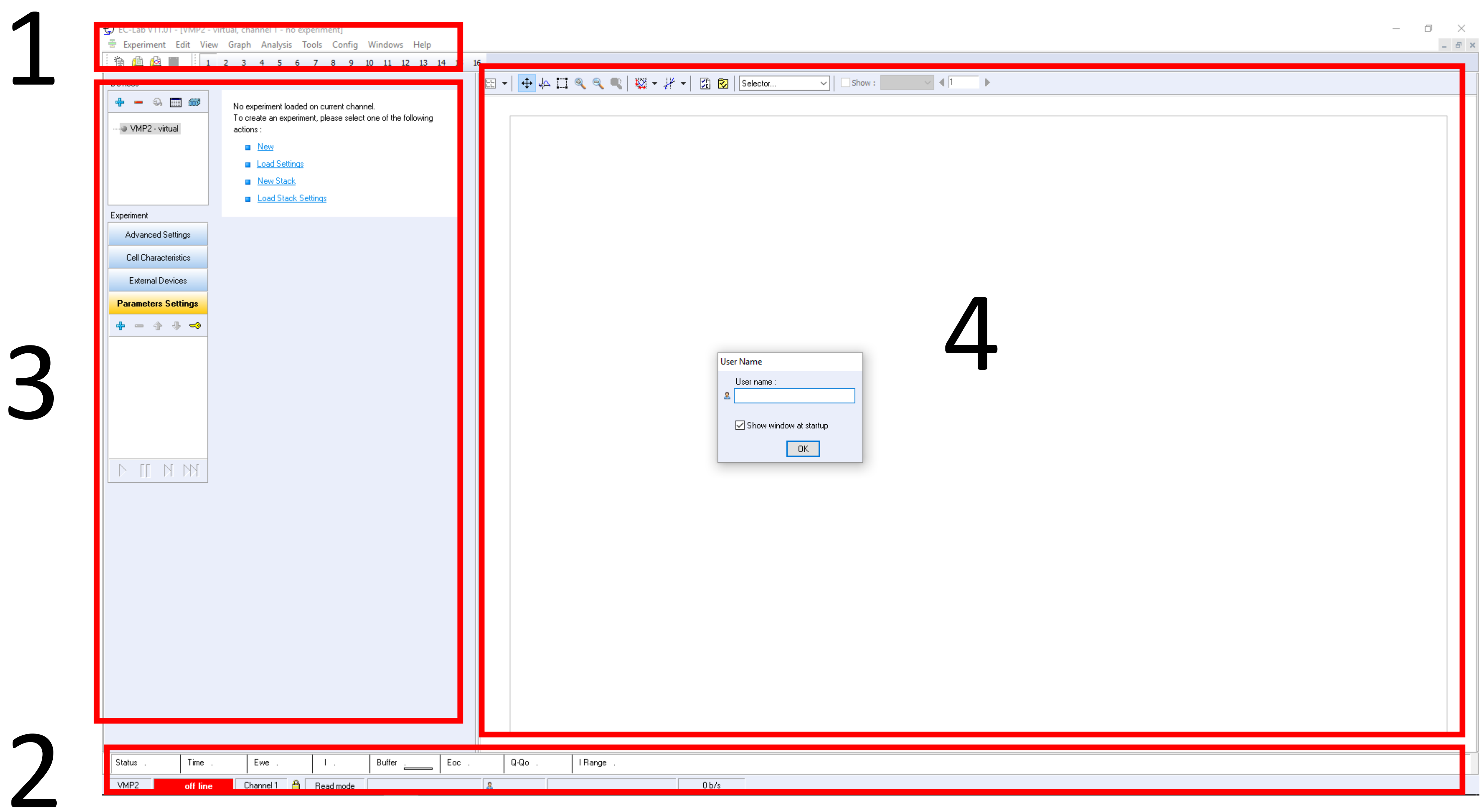
BioLogic Software

Install the BioLogic software (EC-Lab) onto your compatible PC. Sorry Mac/Linux users, this software is only available on Windows.

Double-click the icon shown at the right to execute the program.

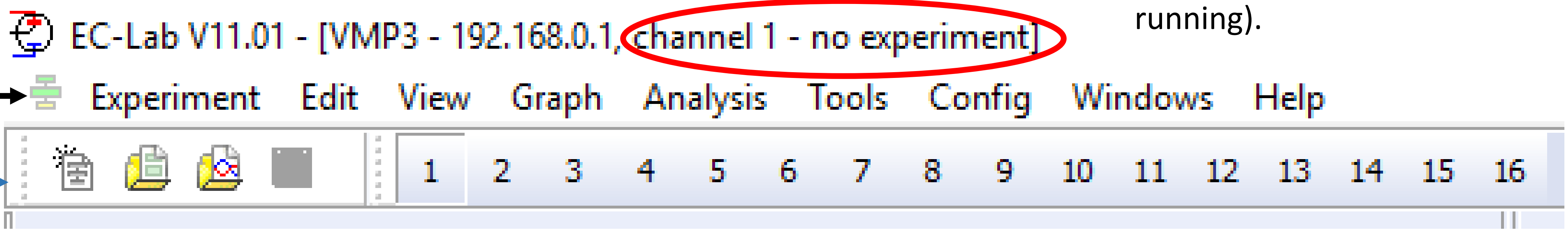


There are four main sections to pay attention to in EC-Lab… each one provides the scientist with a variety of information.



Section 1 – Top Toolbar

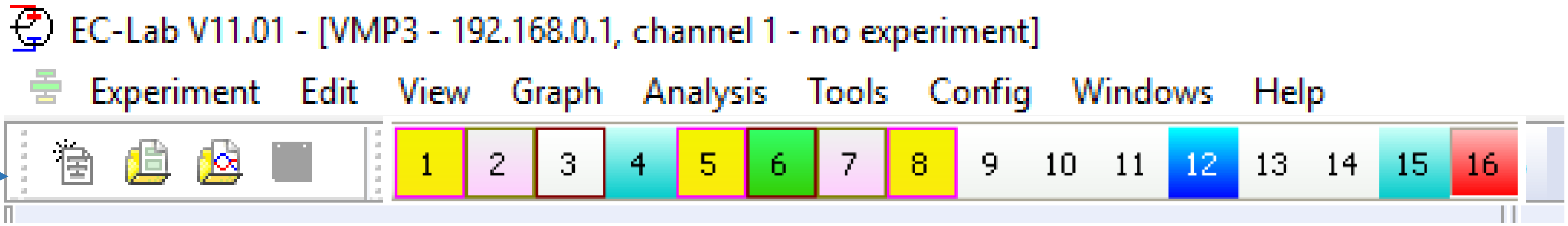
Information on the current channel # (which is the potentiostat #): status (running/non-running), which technique is active, and the file name that is currently being written (if running).



Toolbar – categories will be described as appropriate later

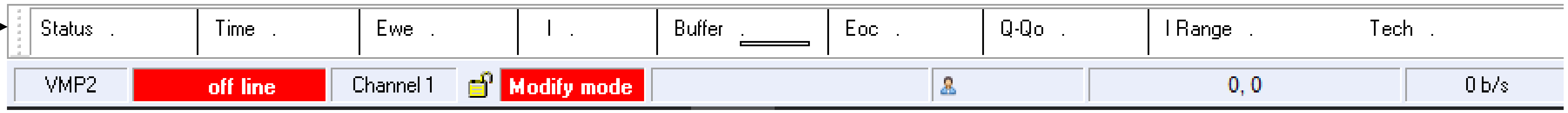
Sub-Toolbar – The left-hand side contains, in order, buttons for "a new experiment," "load settings," "load data," and "save file." The right-hand side contains numbers and provides information on the status of all channels connected to the potentiostat (the toolbar shown here is for a potentiostat with 16 channels; ours has 5 channels). A "depressed" button indicates that the channel is currently in use and *clicking on it* opens its settings/techniques (see Section 3).

Section 1 – Sub-Toolbar, Right Side



status - the running sequence of an experiment is in progress: **Oxidation/Charge**, **Reduction/Discharge**, or either oxidation or reduction in impedance technique, **Relax** for open circuit potential, Paused for a paused experiment and stopped for channel where an error happened.

Section 2 – Bottom Toolbar



Current channel's values panel – provides important information on the status of the current channel including

Status: informs user if experiment is currently under oxidation, reduction, paused, etc.

Time: displays the total elapsed time for all experiments performed on the channel

Ewe: displays the potential of the working electrode

I: displays the current being passed

Buffer: displays the buffer status of information flow from the potentiostat to the computer; *low numbers (single or double digit) are ideal and large numbers (thousands) are bad*. **If you fill up the buffer before the data can be written to your hard drive, any information exceeding the buffer limit will be lost; buffers fill when a lot of data is taken over a short amount of time.**

Status bar – provides a variety of information of lesser importance to the user including

VMP2: displays the model of potentiostat you are connected to

offline: displays the status of the connection to the potentiostat and of the currently selected channel

Channel 1: displays the current channel

person: displays the name of the user

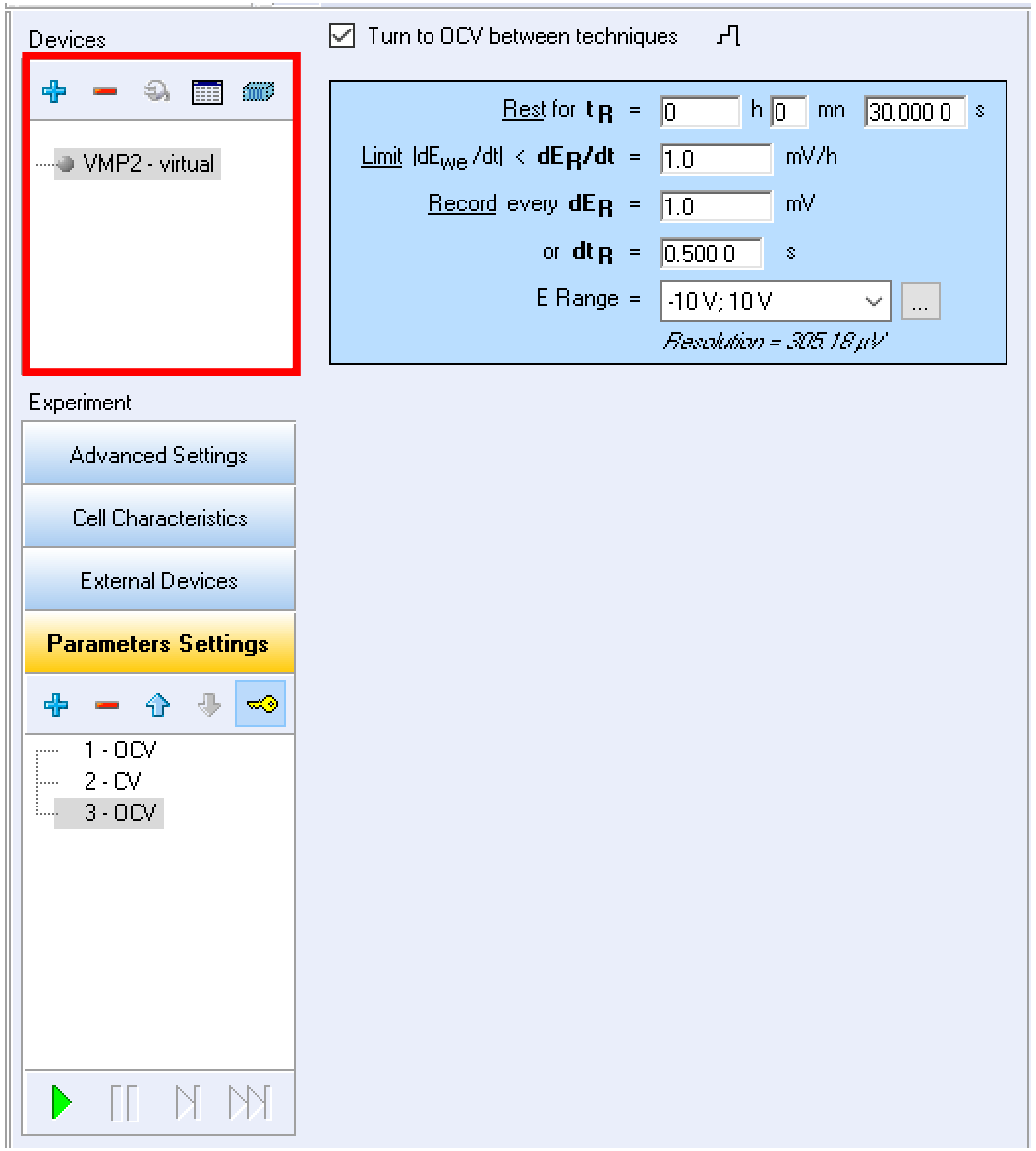
etc.: ignore the rest of the information on the bar

Section 3

Device information. Provides information on connection to the potentiostat.

Green: connected
Red: disconnect/unavailable
"+": add a potentiostat
"–": remove a potentiostat

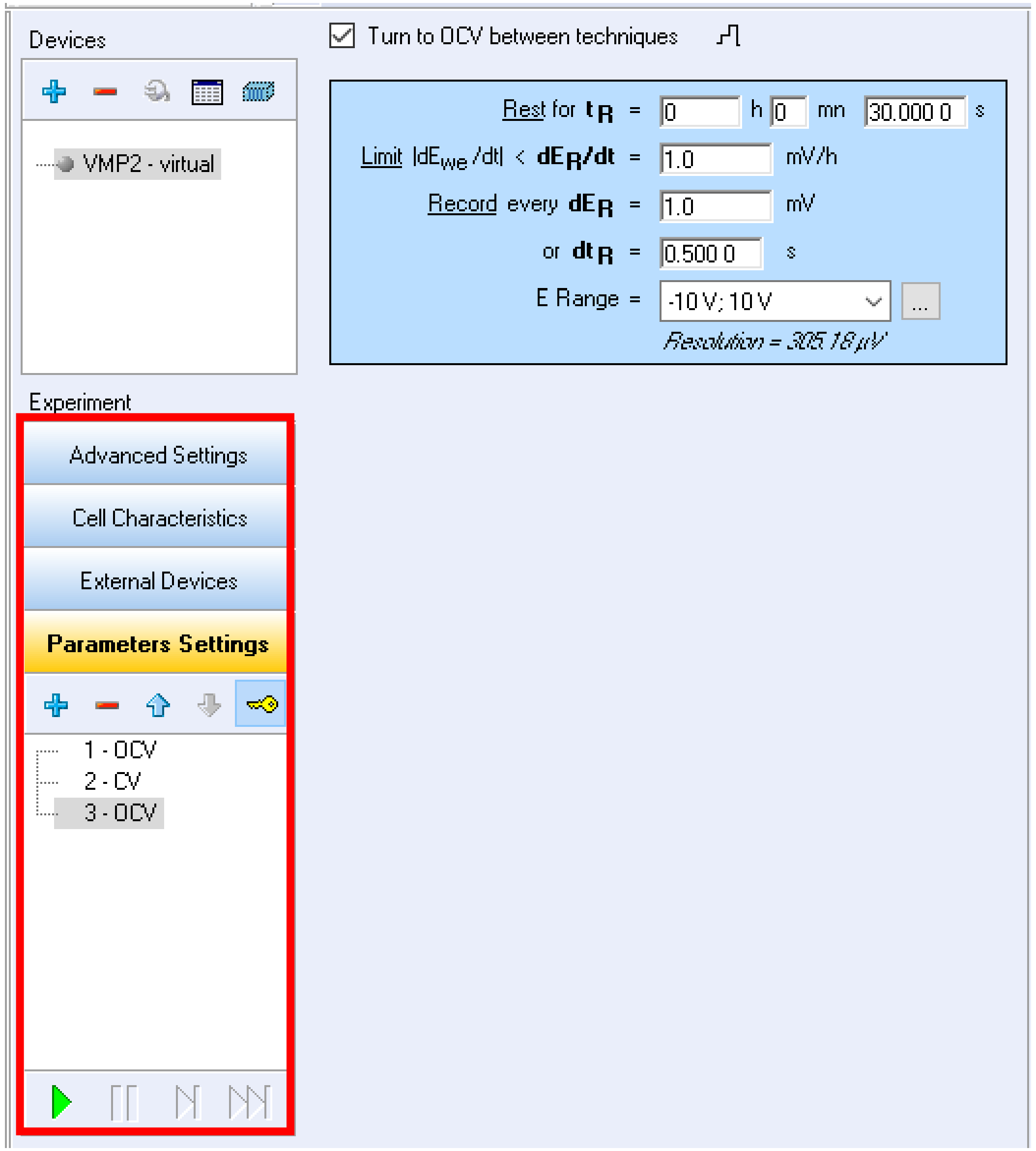
On occasion to clear a software issue you will need to remove and then re-add the potentiostat to the **Devices** sub-section.



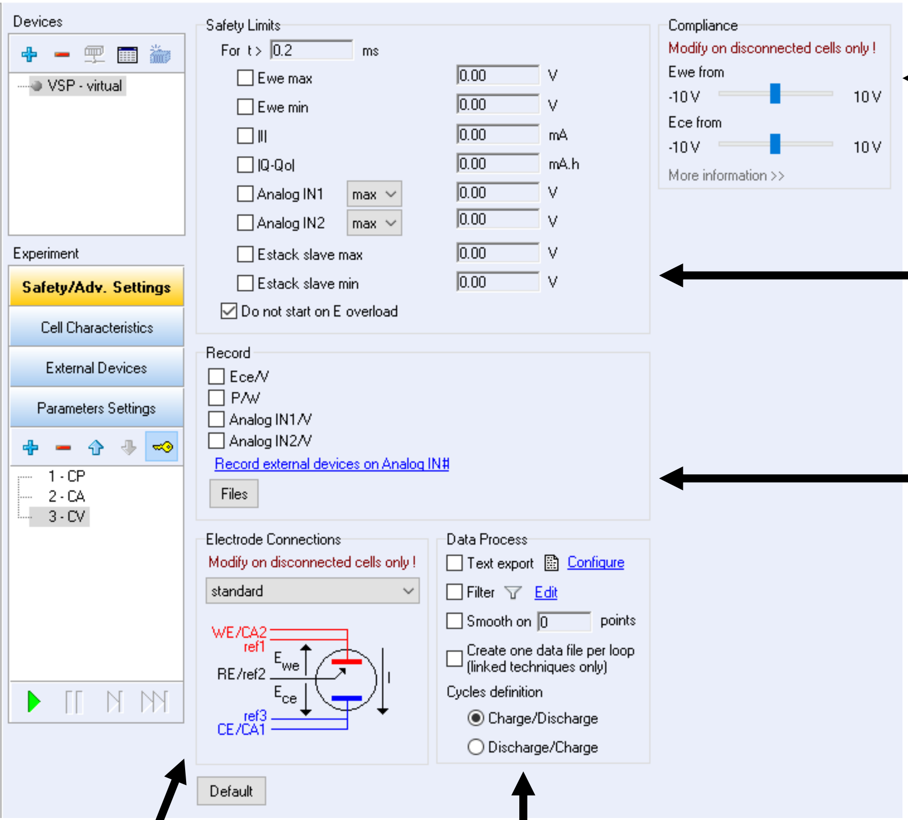
Section 3

Experiment information. Provides tabs to control various parts of the experiment and to add techniques (**+**).

<u>“**+**”</u>: add a technique
<u>“**–**”</u>: remove a technique
<u>Arrows</u>: moves a highlighted technique up or down in the ordered sequence
“The Key Image” – allows one to enter “Modify mode” and modify most of the properties (settings, techniques, parameters, etc.). Some properties can be edited while the technique is running. If you click the key and update a property while the technique is running, you MUST click the key again to immediately implement the property change.



Section 3 – Sub A – Advanced Settings



Ignore this section for now

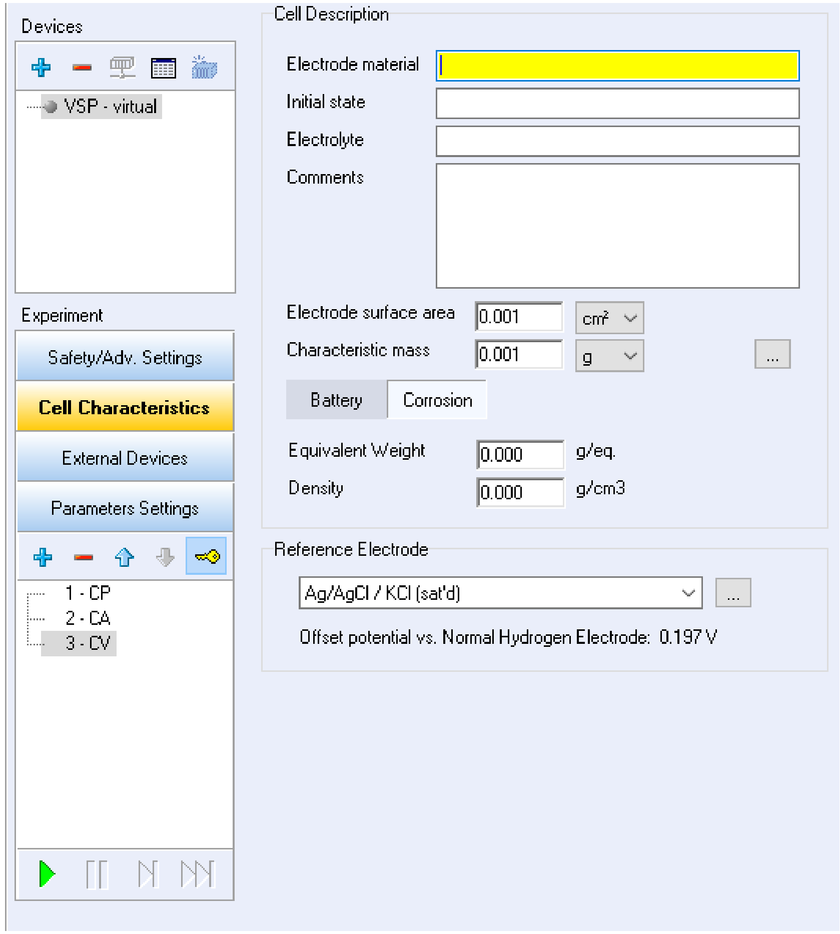
Compliance. Depending on the sensitivity of your experiment, too large of a potential can damage your materials, etc. Set as appropriate. Most users ignore this; we will ignore this for the hands-on discussion activities, but be aware that the compliance voltage is 10 V.

Safety limits. Depending on the sensitivity of your experiment, too large of a potential, current, and/or charge can damage your materials, etc. Most users ignore this; we will ignore this for the Discussion activities. But, **make sure to check the "Do not start on E overload" box.**

Record information. BioLogic is one of few, if not the only, potentiostat manufacturer that allows you to simultaneously record potential information at the working and counter electrodes! **Check the box for "Ece/V" to record the potential of the counter electrode. You should treat this as an essential step when setting up a measurement.** While it is technically not necessary to do so, recording the potential of the counter electrode can be a helpful diagnostic when issues arise. *It is not a matter of if issues will arise, but of when issues will arise!* You can ignore everything else under "Record".

Electrode connections. This section allows you to adjust the internal connections of the potentiostat for greater customization of electronic configuration(s). Keep it in "**standard**" mode, unless otherwise directed. Also, the diagram below the drop-down box shows how to configure your electronic connections and what cables should go to your working, counter, and reference electrodes.

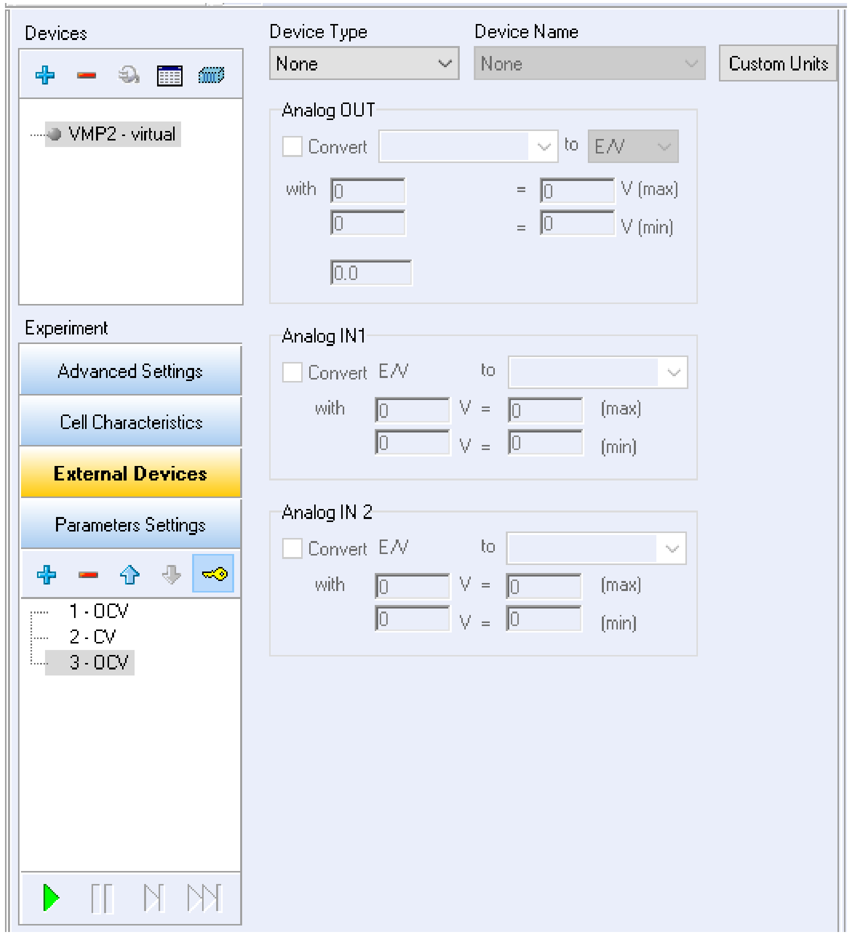
Section 3 – Sub B – Cell Characteristics



Cell description. You can ignore this section, unless you plan to use a more specific feature in EC-Lab. As an example, you can use EC-Lab to calculate values like current density provided that you enter information about the surface area of your electrode.

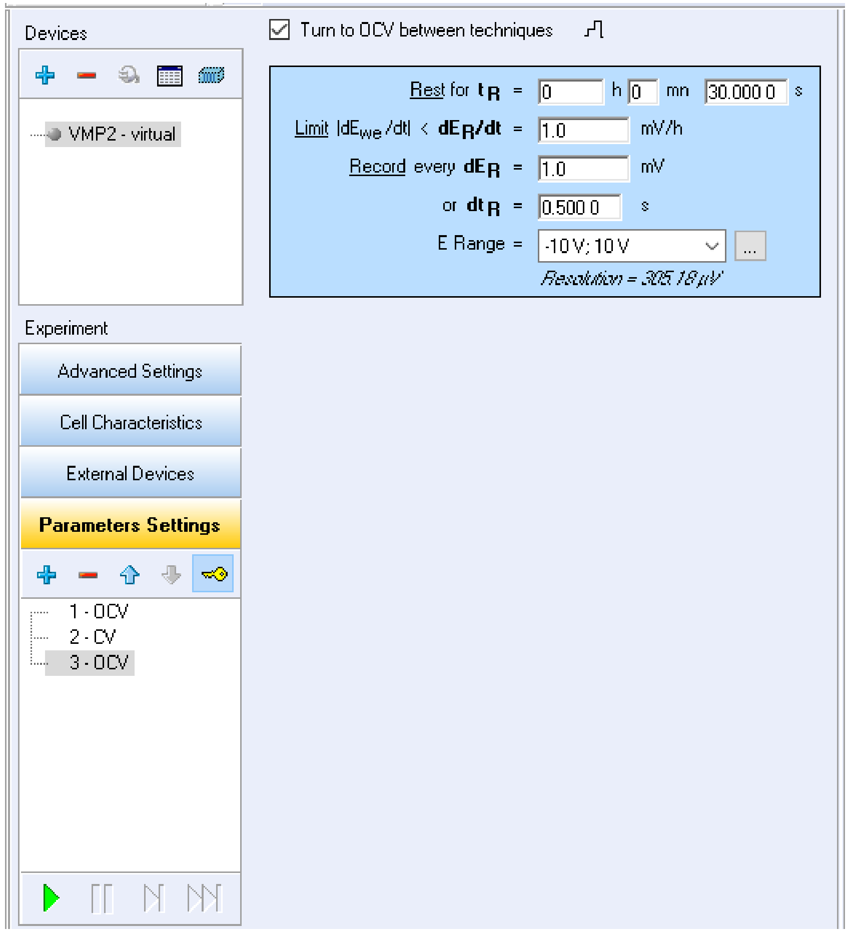
Reference electrode information. You can set the type of reference electrode you are using here. Its potential *versus* NHE will be displayed and each of your plots will have this reference noted on its potential axis.

Section 3 – Sub C – External Devices



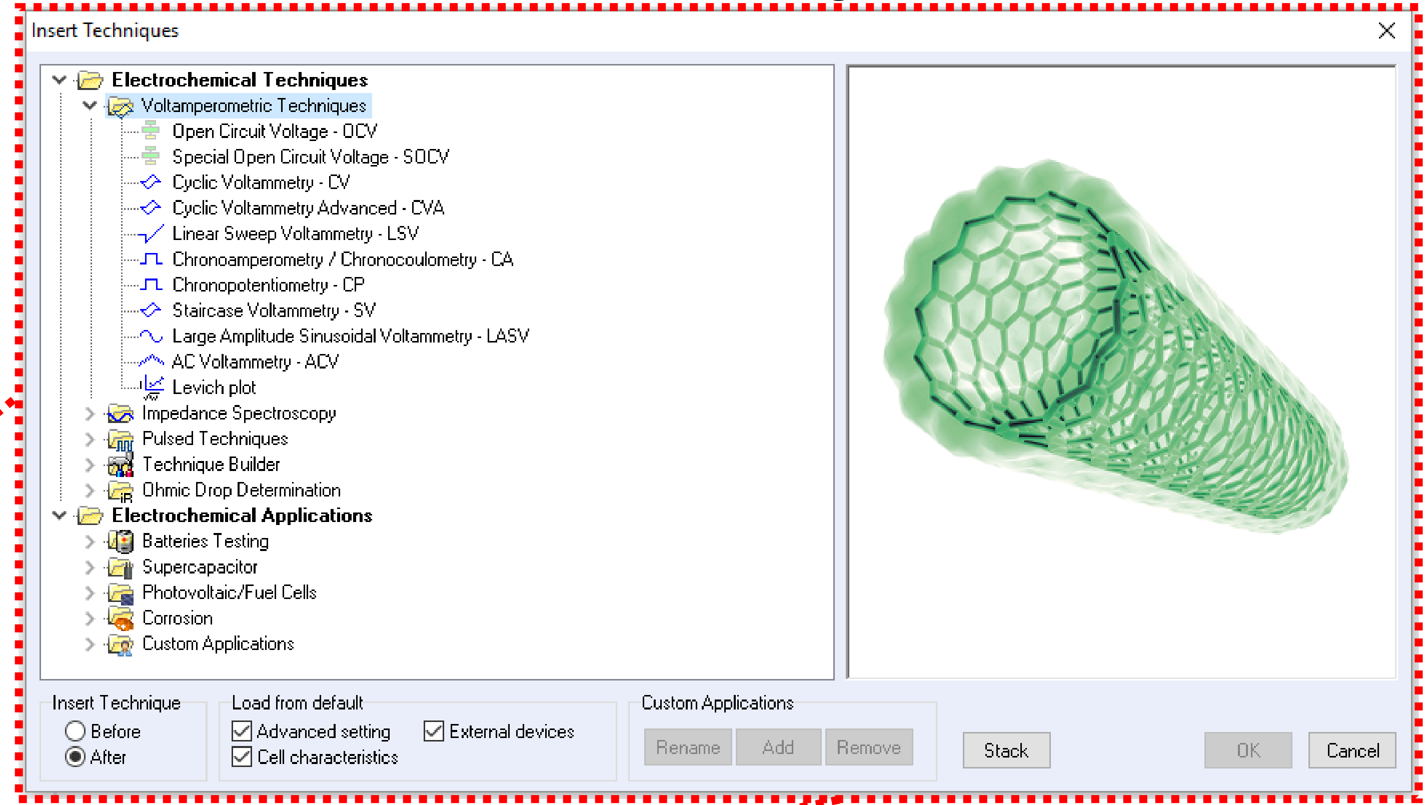
External devices subsection. You can ignore this section, unless you plan to use and control an external device(s), either alone or in tandem with your electrochemical experiments (e.g. rotating electrodes, pH meters, thermocouples, etc.).

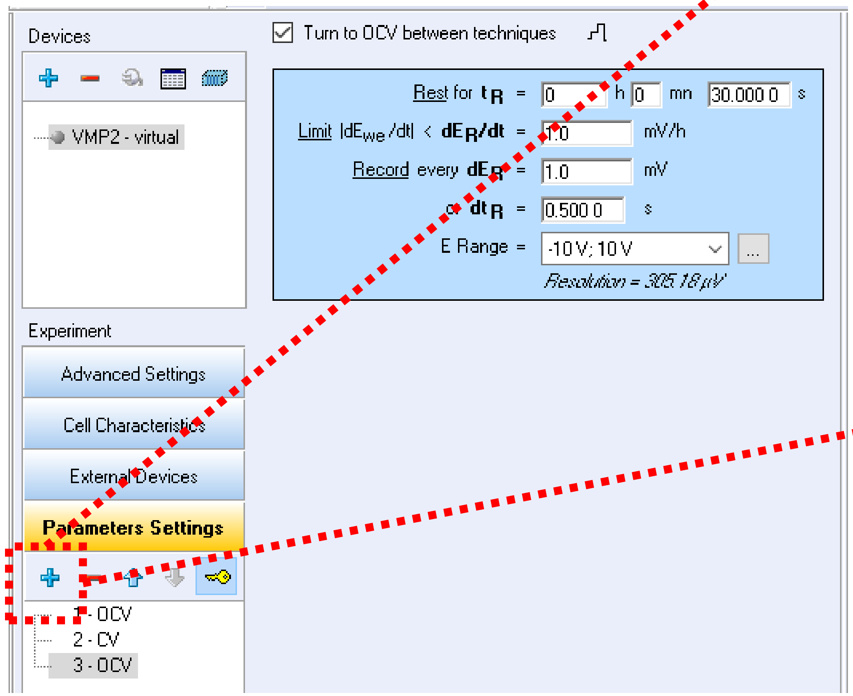
Section 3 – Sub D – Parameter Settings



You will need to pay attention to this subsection as it controls all the parameters that dictate your experiment! Available parameters are dependent on the electrochemical technique currently selected. Details are provided for specific electrochemical techniques (see Section 3, Sub E).

Section 3 – Sub E – Techniques





Voltamperometric Techniques. For our hands-on discussion activities, we will use techniques under this drop-down list almost exclusively, namely OCV, CP, CA, and CV. Moreover, you are likely to need these techniques if you perform electrochemistry in your own labs. Feel free to peruse the other sections.

Section 3 – Sub E' – Techniques

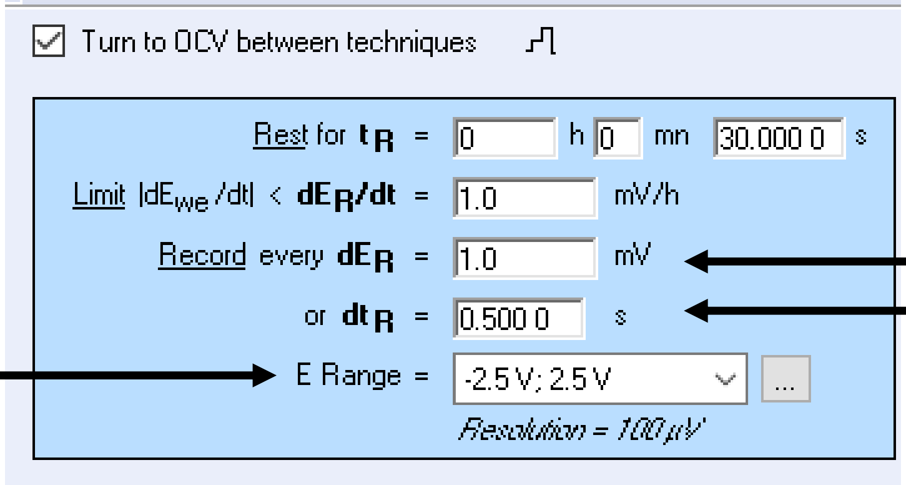
OCV – Open-Circuit Voltage

◆ *Cannot be changed while the experiment is running*

((Galvanostatic) Chronopotentiometry at $\mathbf{I_s}$ = 0)

Set a limit to the change in potential over time (**dE_R/dt**). Setting a limit here can often result in experiments ending prematurely. Thus, it is common to eliminate this limit by setting it to 0. ◆

Set the potential range of an experiment and by doing this, control and display the potential *Resolution*. ◆



Set the length of time the experiment is performed

◆

Set how often the potential is recorded. **Only record based on time (dt_R) and thus, leave dE_R blank.** (If **dE_R** is too small and the data has rapid fluctuations, e.g. noise, potential will be recorded very often.) **Recording data too quickly/often can fill the buffer**.

Section 3 – Sub E' – Techniques

CP – (Galvanostatic) Chronopotentiometry

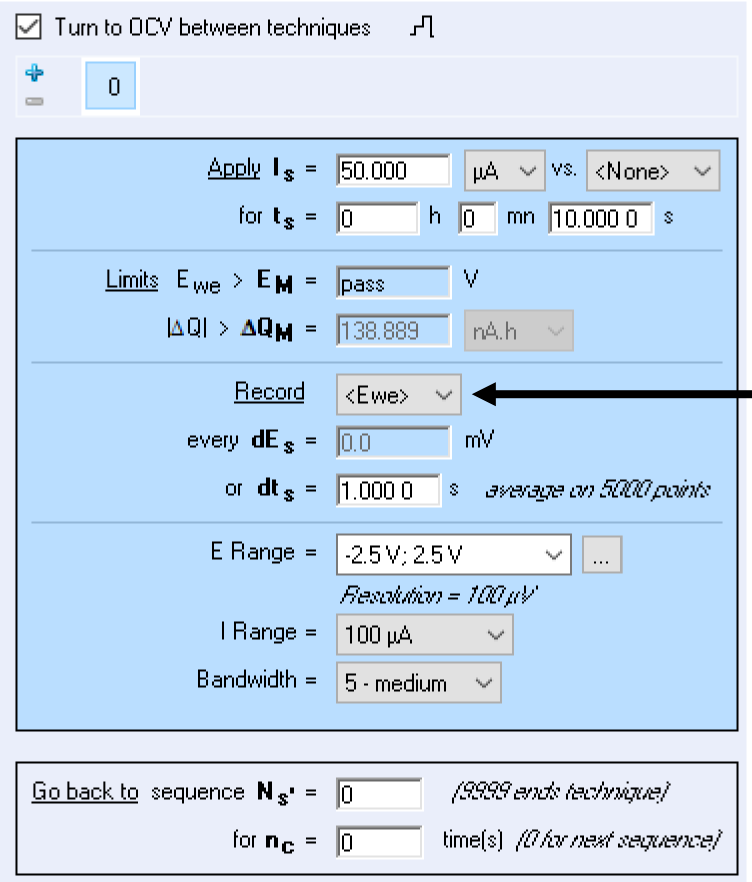
◆ *Cannot be changed while the experiment is running*

Advanced sequencing option to link a sequence of multiple runs ◆ →

Set limitations to prevent damage or safety issues as appropriate; "pass" means to skip it. ◆ →

Set the potential ◆ → and current ranges. ◆ →

In a "quick and dirty" experiment usually use "Auto" (I Range) or the default setting (E Range). However, when the ranges are known, set them in order to maximize the resolution of your signals (signal-to-noise).



← Set the current ($\mathbf{I_s}$); perform the experiment for a given amount of time ($\mathbf{t_s}$).

← ◆ **Record the *average* potential (<Ewe>)** every time period ($\mathbf{dt_s}$). **Never record *raw* potential (Ewe)**, because each data point is only measured over 200 µs, and thus is very noisy.

← ◆ Advanced sequencing option to link a sequence of multiple runs

Section 3 – Sub E' – Techniques

CA – (Potentiostatic) Chronoamperometry / Chronocoulometry

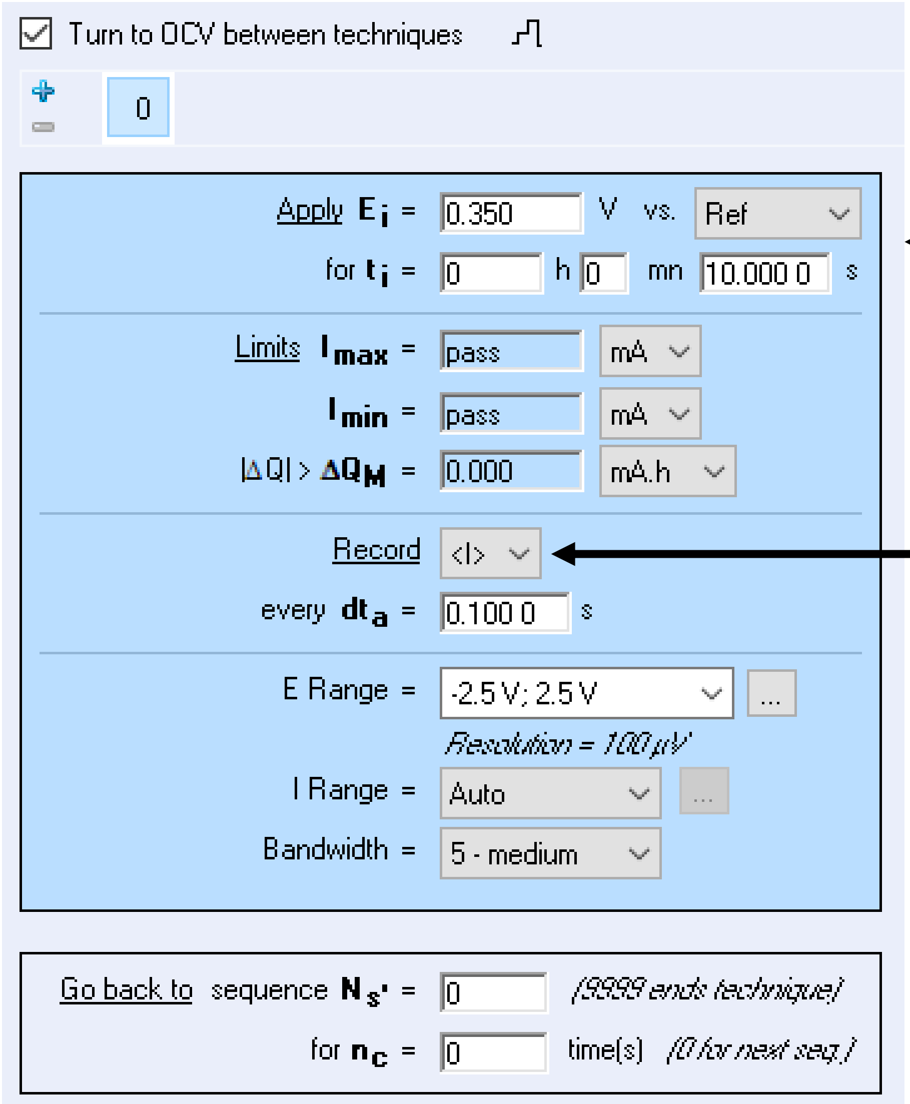
Cannot be changed while the experiment is running

Advanced sequencing option to link a sequence of multiple runs

Set limitations to prevent damage or safety issues as appropriate; “pass” means to skip it.

Set the potential and current ranges.

In a “quick and dirty” experiment usually use “Auto” (I Range) or the default setting (E Range). However, when the ranges are known, set them in order to maximize the resolution of your signals (signal-to-noise).



Set the potential (**E**$_i$) (*versus* something); perform the experiment for a given amount of time (**t**$_i$).

Record the *average* current (<I>) every time period (**dt**$_a$). **Never record *raw* current (I)**, because each data point is only measured over 200 µs, and thus is very noisy.

Advanced sequencing option to link a sequence of multiple runs

Section 3 – Sub E' – Techniques

CV – Cyclic Voltammetry

◆ *Cannot be changed while the experiment is running*

Set initial potential (E_i) ◆ →

Set scan rate (**dE/dt**) →

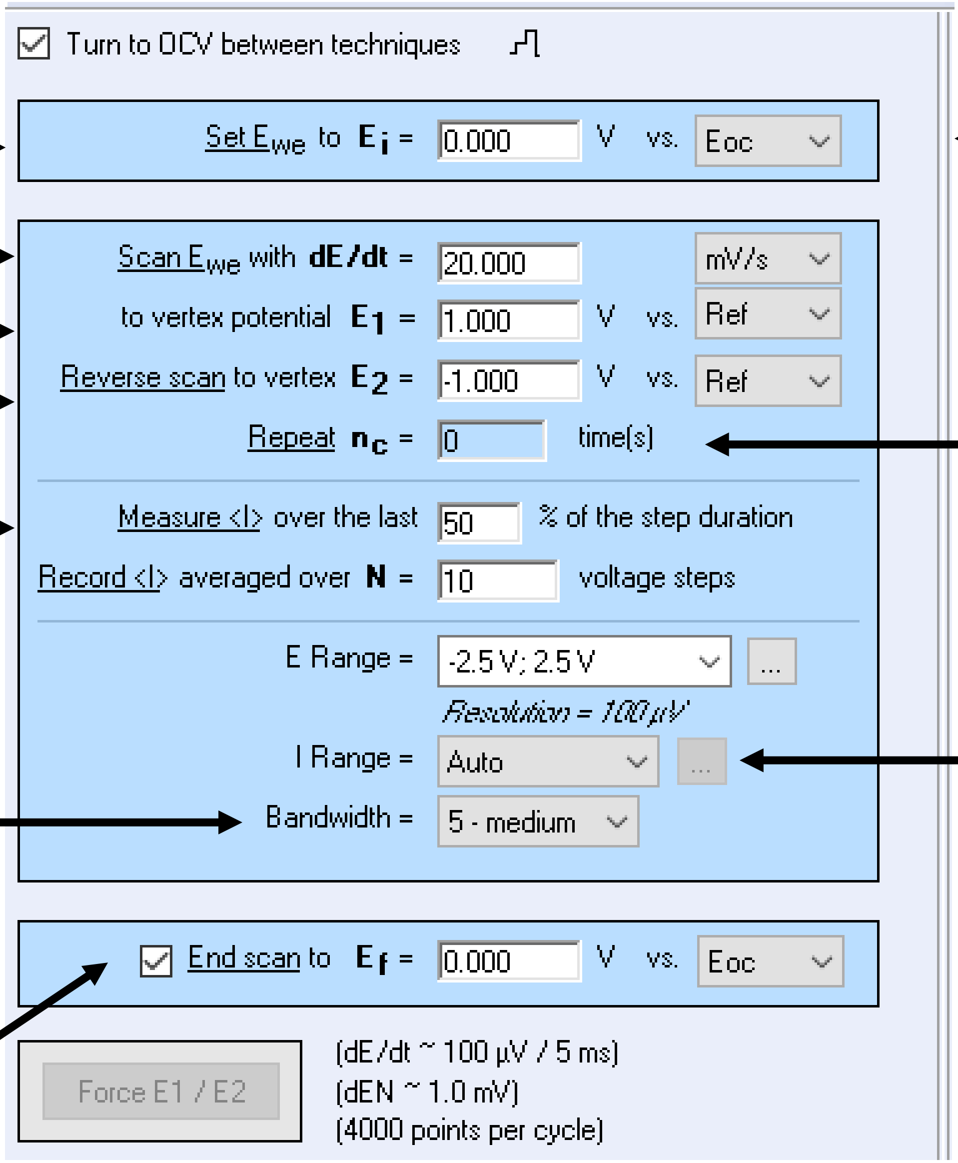
Set $\mathbf{E_1}$, to scan from $\mathbf{E_i}$ to $\mathbf{E_1}$ →

Set $\mathbf{E_2}$, to scan *back* from $\mathbf{E_1}$ to $\mathbf{E_2}$ →

Measure average current at the end of the potential step *(50% is standard.)* Repeat (**N** – 1) more times and average them; value affected by RC. ◆ →

Bandwidth performs a sort of hardware filtering that removes noise associated with RC of your circuit. **Keep it at 8 unless you know what you are doing**! ◆ →

Set final, ending potential ($\mathbf{E_f}$) ↗



← ◆ **E** *versus* **reference (*Ref*)** or measured **open-circuit potential (*E_{oc}*)** (or previous controlled potential (E_{ctrl}) or measured potential (E_{meas}))

← **Repeat n_c times and thus, scan a total of (n_c + 1) times**, e.g. $\mathbf{n_c}$ = 5 would scan 6 times

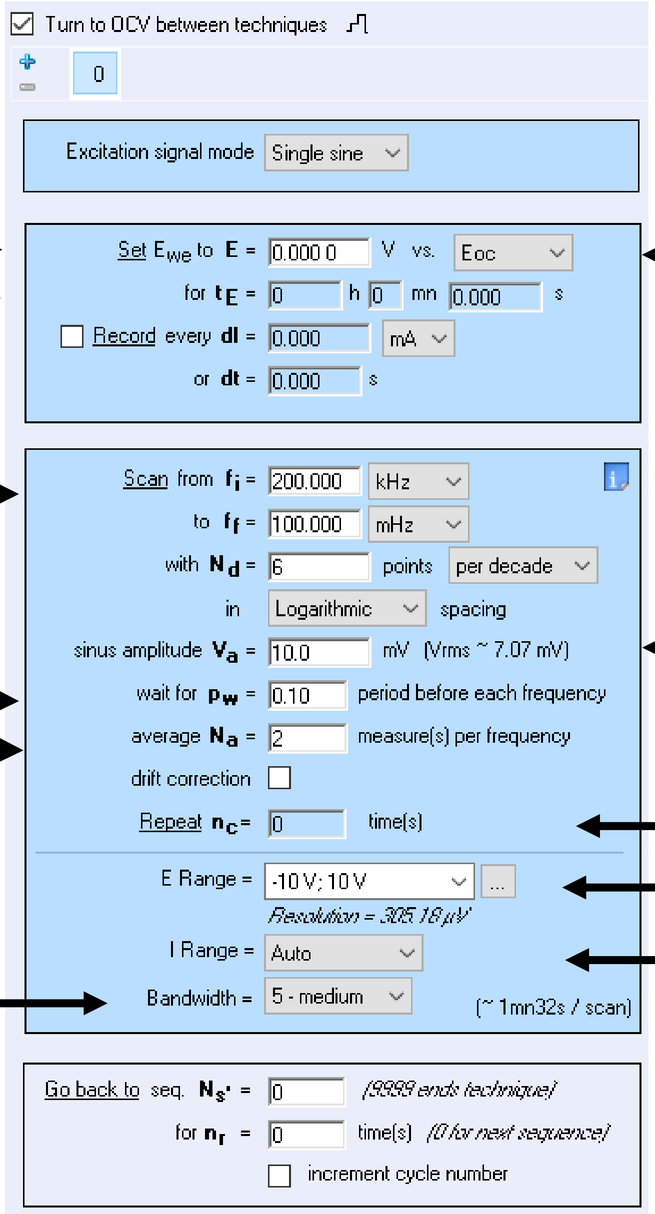
← ◆ Set the potential and current ranges. ◆ ←

In a "quick and dirty" experiment usually use "Auto" (I Range) or the default setting (E Range). However, when the ranges are known, set them in order to maximize the resolution of your signals (signal-to-noise).

Section 3 – Sub E' – Techniques

PEIS: Potentio(static) Electrochemical Impedance Spectroscopy

◆ *Cannot be changed while the experiment is running*



Set initial potential (**E_i**) ◆

Time before measurement, needed for current to stabilize at the given potential (**t_E**) ◆

Range of highest (**f_i**) to lowest (**f_f**) frequency ◆

Number of points per decade of frequencies (**N_d**). Determines the total length of experiment and resolution of data obtained ◆

Delay before each frequency (**p_w**) ◆

Repeat measurement at same frequency (**N_a**). Set to 1 ◆

Bandwidth performs a sort of hardware filtering that removes noise associated with RC of your circuit. **Keep it at 8 unless you know what you are doing**! ◆

◆ **E** *versus* **reference (*Ref*)** or measured **open-circuit potential (*E_{oc}*)** (or previous controlled potential (E_{ctrl}) or measured potential (E_{meas}))

Click here to get the list of frequencies used

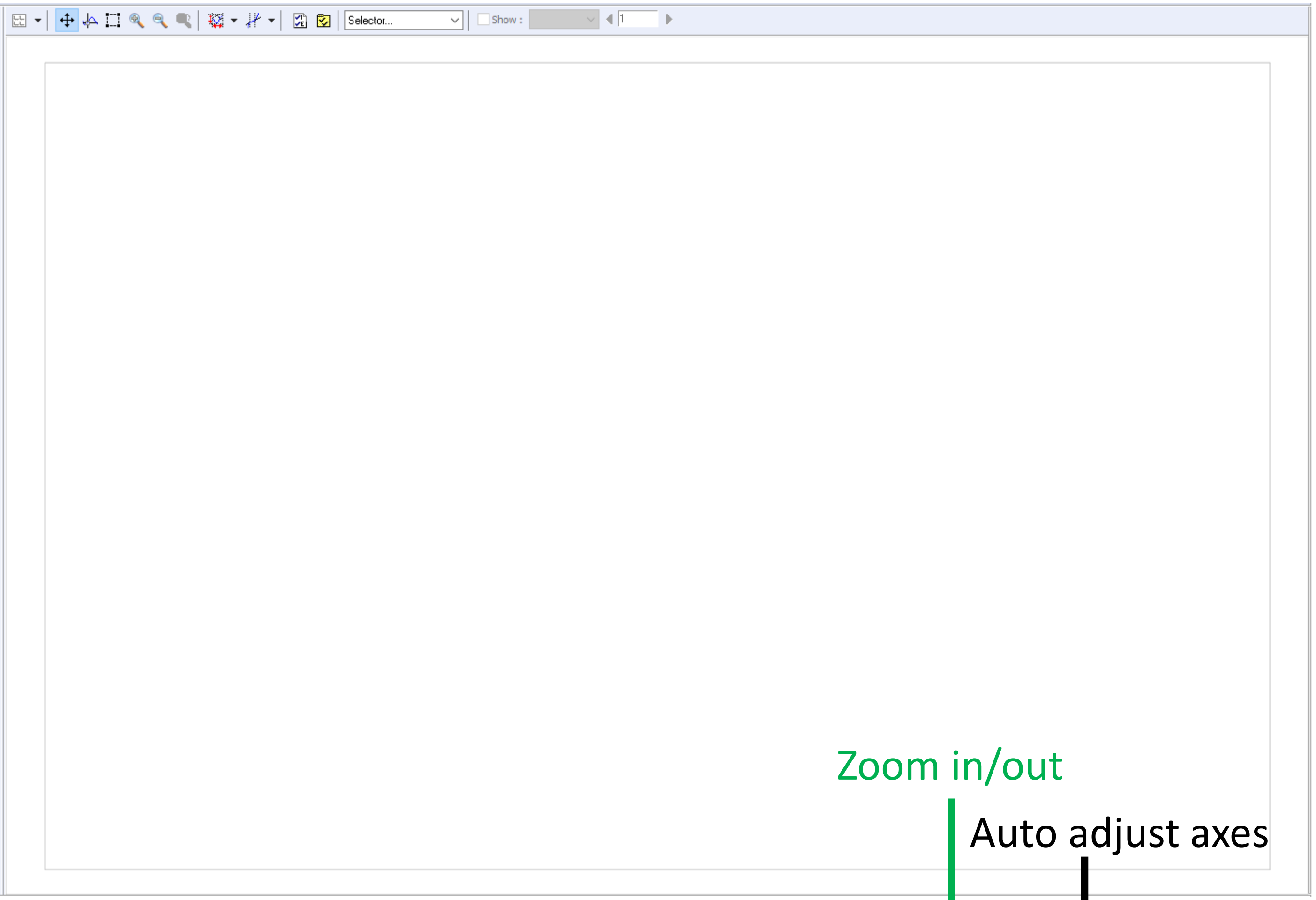
◆ Amplitude of sine wave (**V_a**). 10 mV is a good amplitude as it will not perturb the system significantly, and that is desired

Repeat n_c times and thus, scan a total of (n_c + 1) times

◆ Set the potential and current ranges.

◆ *In a "quick and dirty" experiment usually use "Auto" (I Range) or the default setting (E Range). However, when the ranges are known, set them in order to maximize the resolution of your signals (signal-to-noise).*

Section 4



Graph tool bar. Provides a variety of tools to manipulate the related graph. More information below.

Graph. Your graph will appear here. You can manipulate your image after you have selected a tool. You can right click your mouse here to get to many advanced options for further customization.

Cycle plot selector. Allows choice in what is plotted in the Graph section. You can choose to plot all cycles or one specific cycle.

Zoom in/out

Auto adjust axes

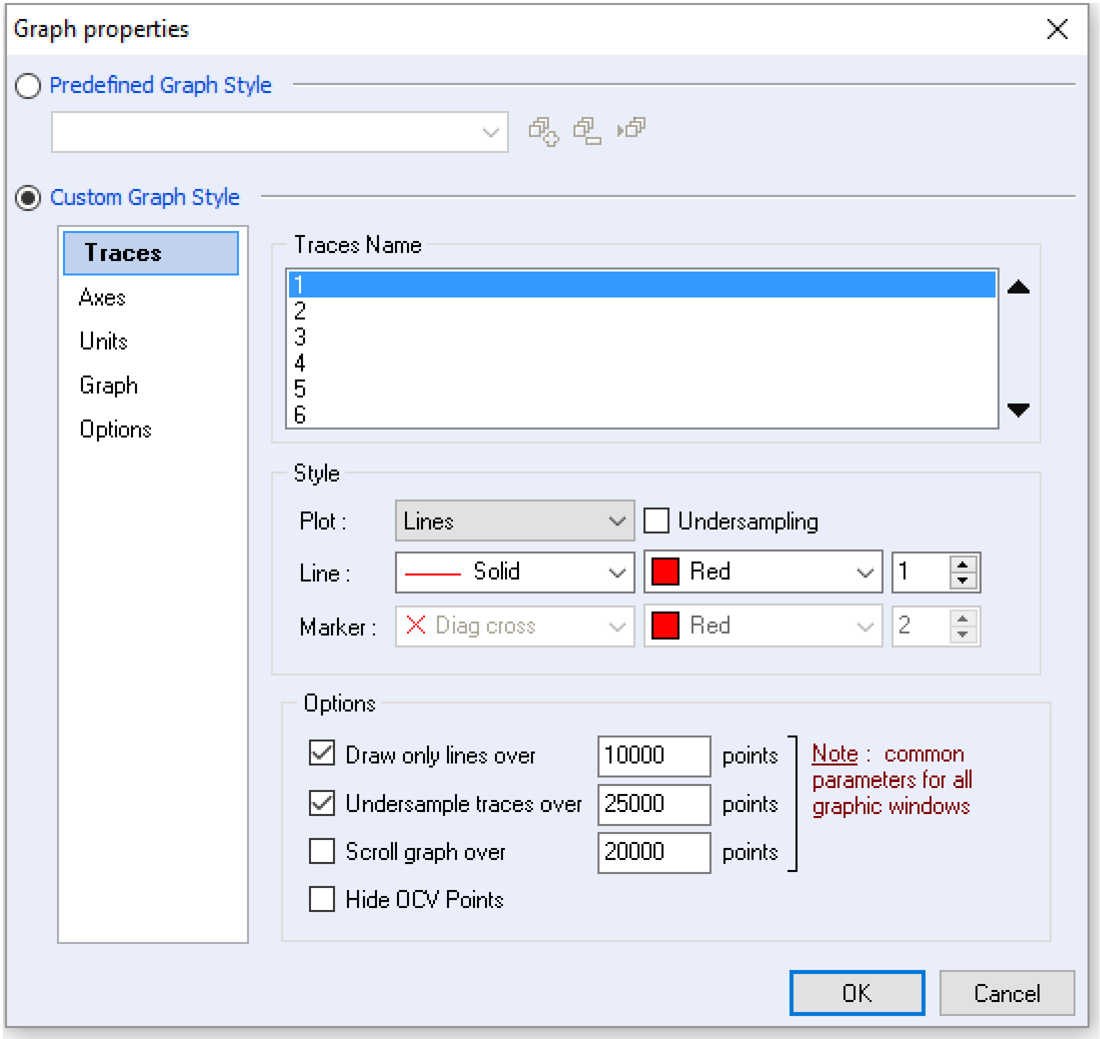
Select points within box

Cursor location tool (to get x and y coordinates)

Selector. Allows choice in what variables to plot. Examples: I-V, J-V, I-t, V-t, Q-t, etc.

Section 4 – Graph Properties

Right mouse click on graph or type ALT+P



Traces. Allows one to select and change the line/marker style, color, line thickness, and under-sampling of each trace.

Axes. Allows one to select and change the axes title, scale, range, font, and font size.

Units. Allows one to select and change the size of the unit (e.g. MV or V or mV), reference electrode, mass & surface area of the working electrode, etc.

Graph. Allows one to select and change the legend and title styling.

Options. Allows one to select and change the graphing conventions from IUPAC to a less historically consistent convention that should never be used, unless you are from Texas. **Make sure "Positive oxidation (standard IUPAC convention)" is selected.**