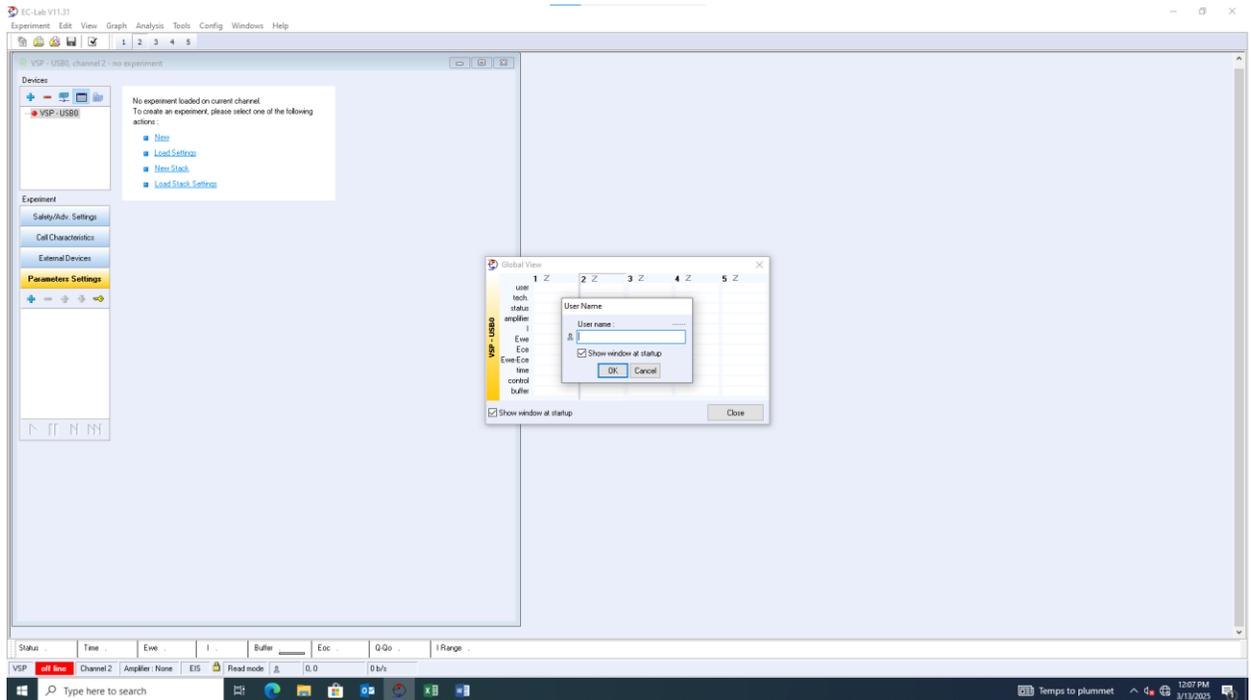


Biologic Quick Manual

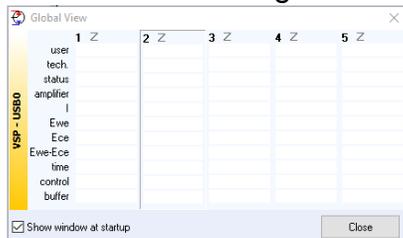
1. **Linking** work station with PC via cable
2. Turn on the power by pressing the **power button** on the back of the work station



3. Double click the **shortcut** to open software
4. You will see

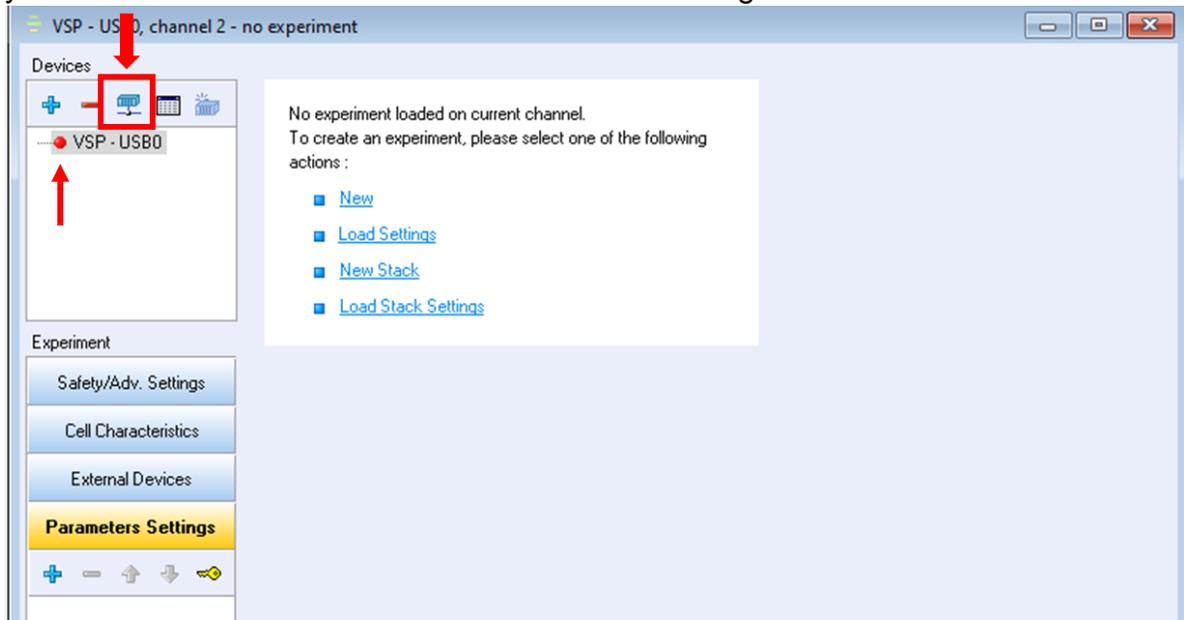


5. The user name pop up will disappear by itself, or you can click ok to continue
6. Click Close for the global view popup



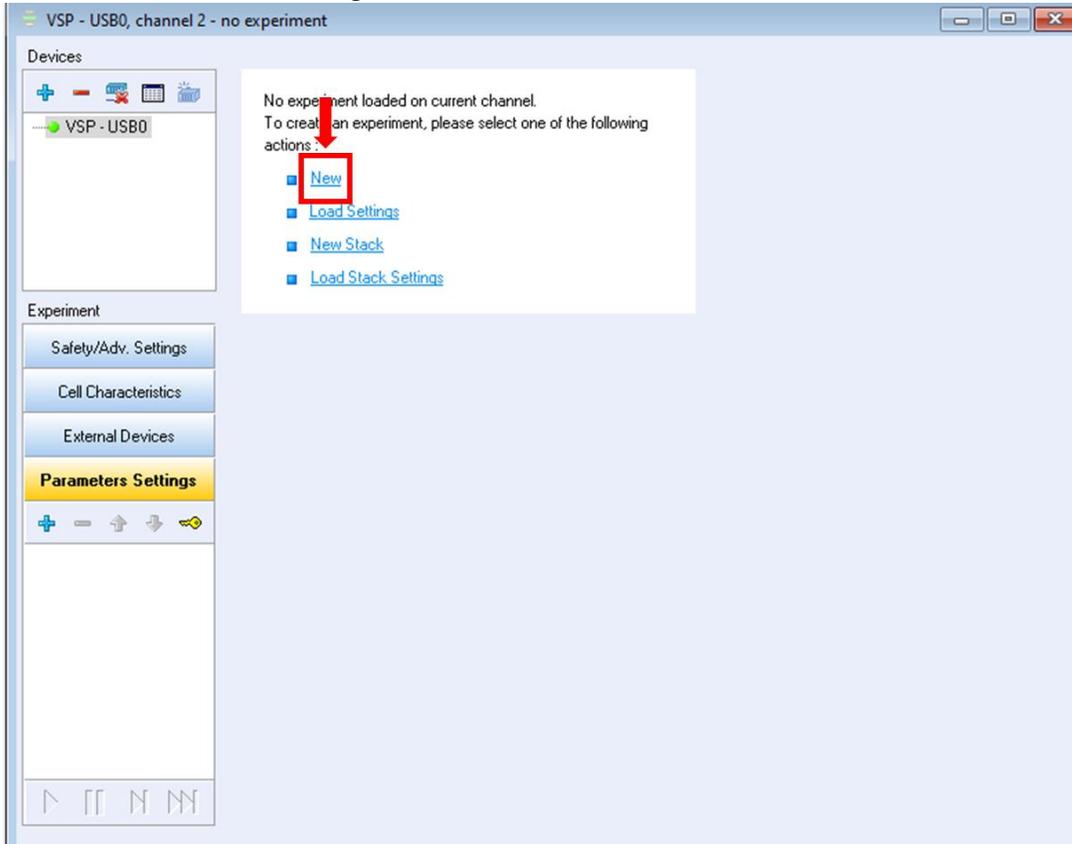
7. **Connect** device by clicking this button after hearing the device beep three times, it will take a few seconds to connect, After the device is successfully connected,

you will see the red circle in front of VSP-US80 turn green.

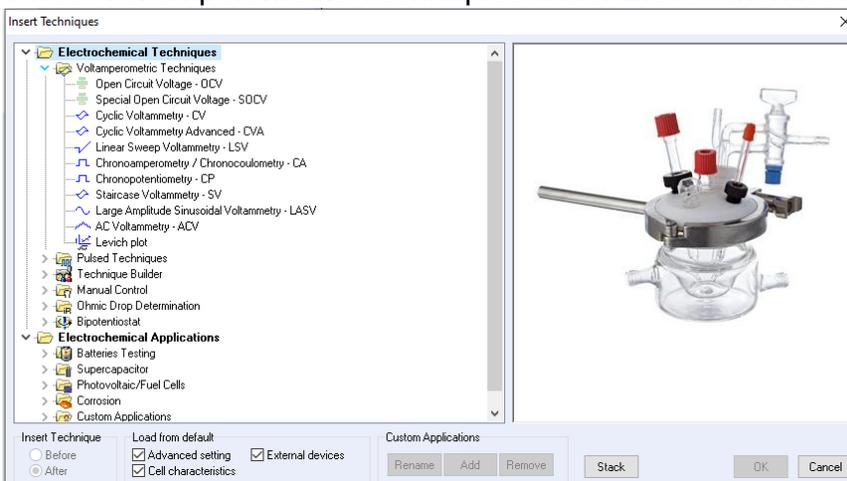


Cyclic Voltammetry (CV)

1. Click new to start an experiment or loading setting if you have one, or click  under Parameters Setting



2. Select Voltamperometric Techniques under Electrochemical Techniques



3. Select Cyclic Voltammetry – CV and press OK

Insert Techniques

Electrochemical Techniques

- ▼ Voltamperometric Techniques
 - Open Circuit Voltage - OCV
 - Special Open Circuit Voltage - SOCV
 - Cyclic Voltammetry - CV
 - Cyclic Voltammetry Advanced - CVA
 - Linear Sweep Voltammetry - LSV
 - Chronoamperometry / Chronocoulometry - CA
 - Chronopotentiometry - CP
 - Staircase Voltammetry - SV
 - Large Amplitude Sinusoidal Voltammetry - LASV
 - AC Voltammetry - ACV
 - Levich plot
- > Pulsed Techniques
- > Technique Builder
- > Manual Control
- > Ohmic Drop Determination
- > Bipotentiostat
- ▼ **Electrochemical Applications**
 - > Batteries Testing
 - > Supercapacitor
 - > Photovoltaic/Fuel Cells
 - > Corrosion
 - > Custom Applications

Cyclic voltammetry (CV) is the most widely used technique for acquiring qualitative informations about electrochemical reactions. CV provides informations on redox processes, heterogeneous electron-transfer reactions and adsorption processes. It offers a rapid location of redox potential of the electroactive species. CV consists of scanning linearly the potential of a stationary working electrode using a triangular potential waveform. During the potential sweep, the potentiostat measures the current resulting from electrochemical reactions (consecutive to the applied potential). The cyclic voltammogram is a current response as a function of the applied potential.

Insert Technique

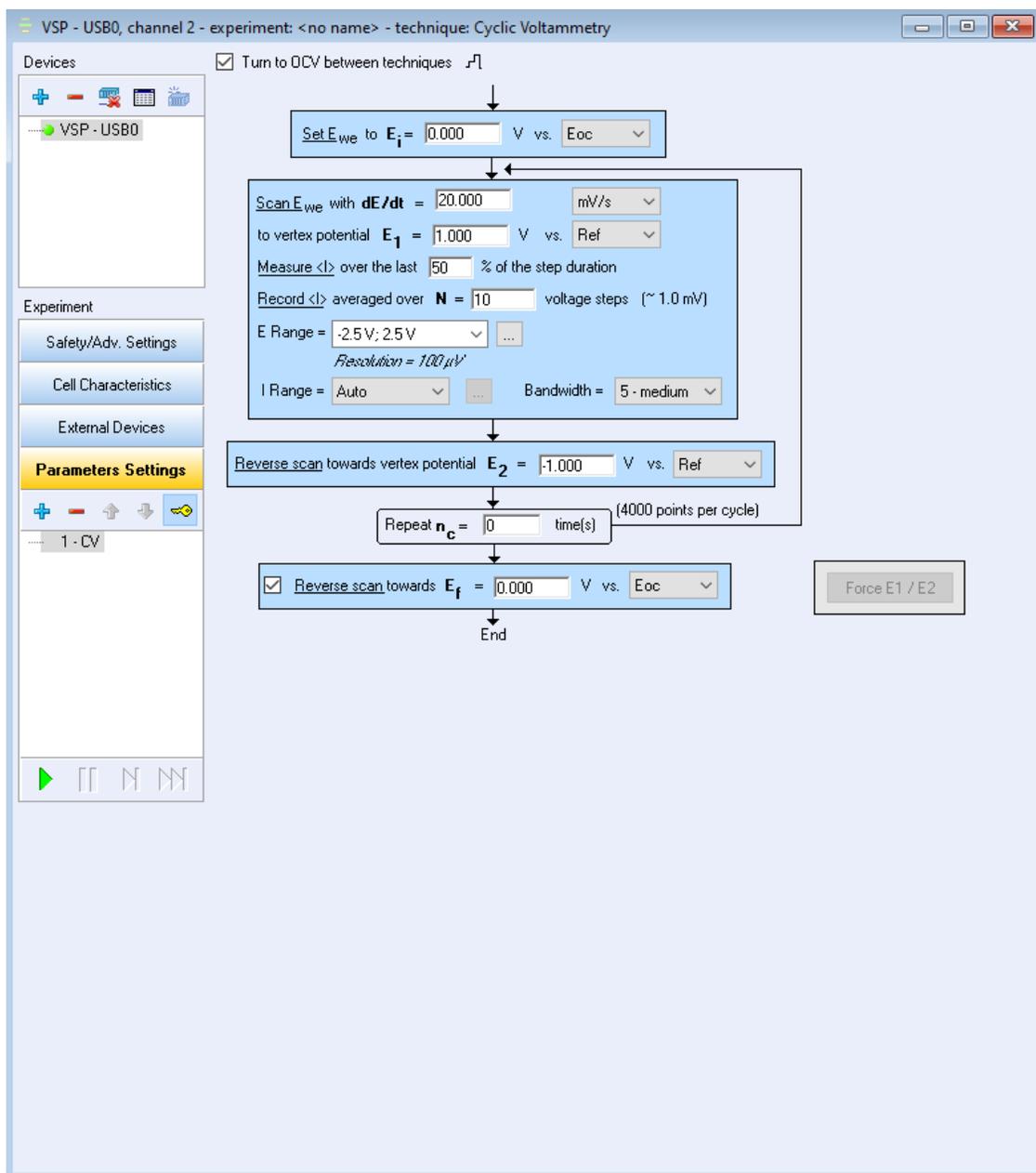
Before Load from default External devices

After Advanced setting Cell characteristics

Custom Applications

Rename Add Remove Stack **OK** Cancel

4. Now you are able to define the parameters you want (Such as start potential (E_i), scan rate (dE/dt), potential range (E_1 and E_2), and repeat time (nc)).



5. After you entered the designated parameters, click  on the left lower part to start testing.

6. You can have more freedom to input if you select cyclic voltammetry advanced

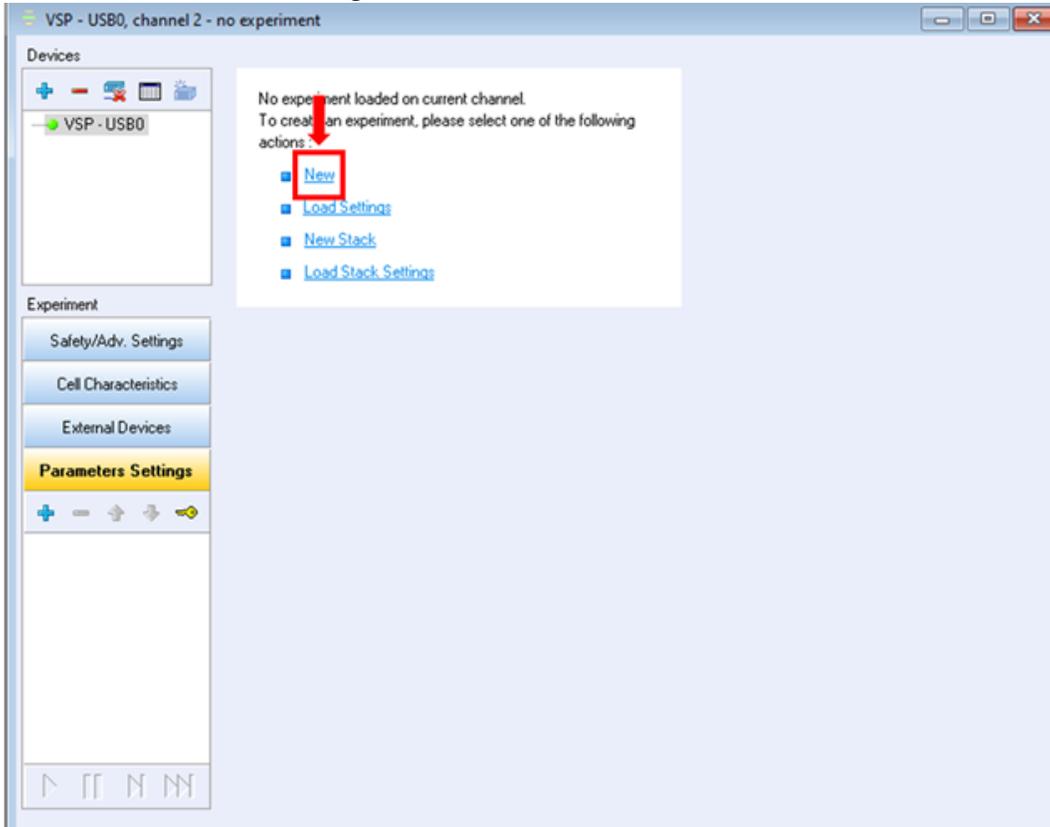
The screenshot displays the 'Cyclic Voltammetry Advanced' settings window. The interface is organized into several sections:

- Devices:** Shows 'VSP - USB0' connected.
- Experiment:** Includes 'Safety/Adv. Settings', 'Cell Characteristics', 'External Devices', and 'Parameters Settings' (highlighted).
- Parameters Settings:**
 - Set E_{we} to E_i = 0.000 V vs. Eoc** and **Hold E_i for t_i = 0 h 0 mn 10.0000 s** and record every dt_i = 1.0000 s.
 - Scan E_{we} with dE/dt = 100.000 mV/s** to vertex potential **E_1 = 1.000 V vs. Ref**. Hold E_1 for t_1 = 0 h 0 mn 0.0000 s and record every dt_1 = 0.1000 s. Measure <I> over the last 50% of the step duration, record <I> averaged over $N = 10$ voltage steps. E Range = -2.5 V; 2.5 V, I Range = Auto, Bandwidth = 5 - medium. Resolution = 100 μ V.
 - Reverse scan** towards vertex potential **E_2 = -1.000 V vs. Ref**. Hold E_2 for t_2 = 0 h 0 mn 0.0000 s and record every dt_2 = 0.1000 s.
 - Repeat n_c = 0 time(s) record the first cycle and every n_r = 1 cycle(s) (4000 points per cycle).
 - Reverse scan** towards **E_f = 0.000 V vs. Eoc**. Hold E_f for t_f = 0 h 0 mn 0.0000 s and record every dt_f = 0.1000 s.
- Annotations:** A note indicates $(dE/dt \sim 100 \mu V / 1 m)$ and $(dEN \sim 1.0 mV)$.
- Buttons:** 'Reverse', 'Force E1 / E2', and 'Hold E' are available.
- Data Table:**

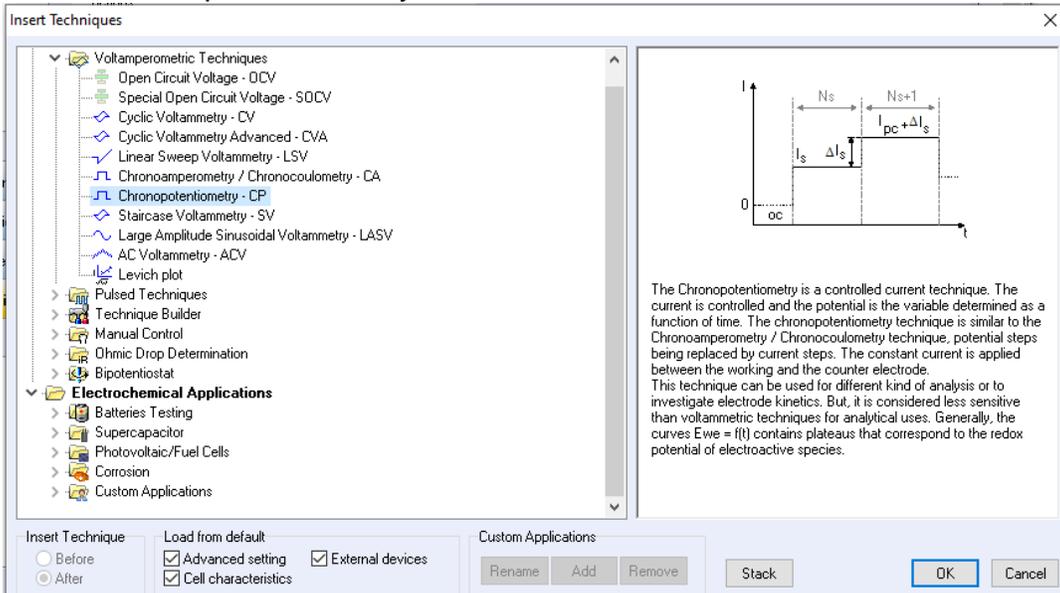
Ns	Ei (V)	vs.	ti (h:m:s)	dti (s)	dE/dt	dE/dt unit	E1 (V)	vs.	t1 (h:m:s)	dt1 (s)
0	0.000	Eoc	0:00:10.0000	1.0000	100.000	mV/s	1.000	Ref	0:00:0.0000	0.1000

Chronopotentiometry (CP)

1. Click new to start an experiment or loading setting if you have one, or click  under Parameters Setting



2. Select Chronopotentiometry – CP, and click ok



3. Enter the parameters you want and click  in the left lower part

VSP - USB0, channel 2 - experiment: <no name> - technique: Chronopotentiometry

Devices Turn to OCV between techniques

VSP - USB0

Experiment

- Safety/Adv. Settings
- Cell Characteristics
- External Devices
- Parameters Settings**

1 - CP

Apply $I_s = 50.000 \mu\text{A}$ vs. <None>

for $t_s = 0 \text{ h } 0 \text{ mn } 10.000 \text{ s}$

Limit E_{we} to $E_M = \text{pass V}$ and $|\Delta Q|$ to $\Delta Q_M = 138.889 \text{ nA.h}$

Record Ewe every $dE_s = 1.0 \text{ mV}$ and every $dt_s = 0.100 \text{ s}$

E Range = -2.5 V; 2.5 V ... I range = 100 μA

Resolution = 100 μV

Bandwidth = 5 - medium

Next sequence, or Goto sequence $N_s = 0$, for $n_c = 0$ time(s)

to N_s or N_s'

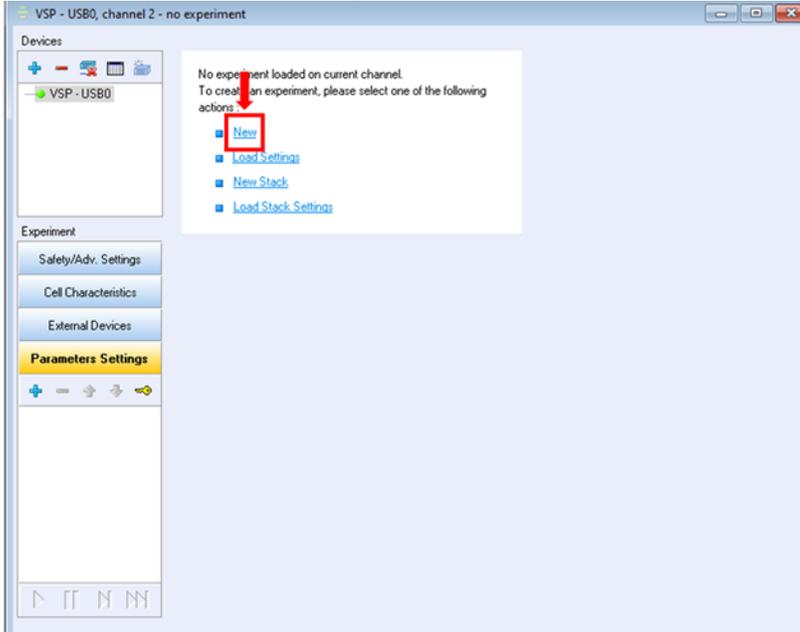
End $N_s' = 9999$

Ns

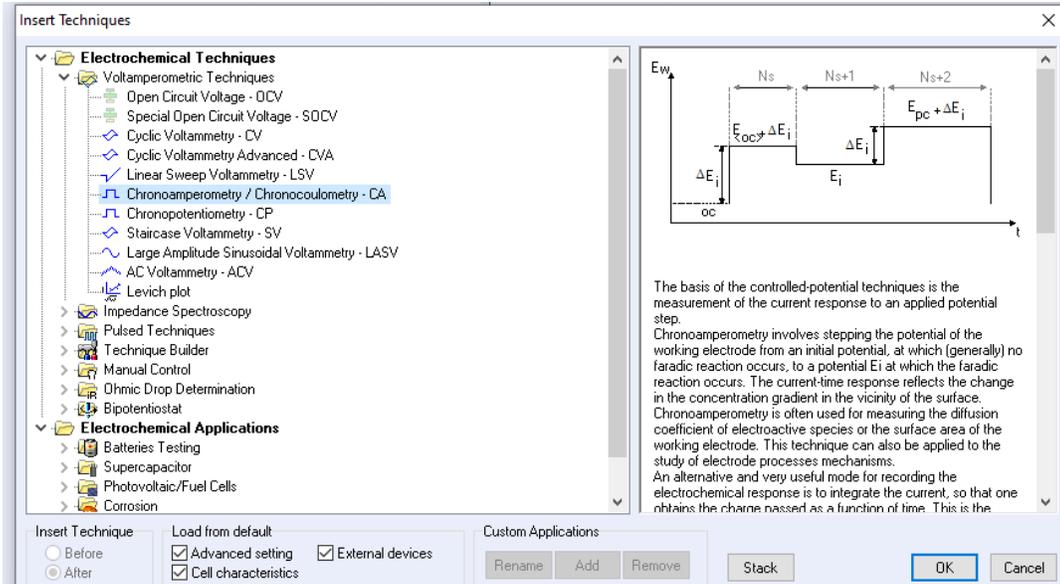
Ns	Is	unit Is	vs.	ts (h:m:s)	EM (V)	dQM	unit dQM	record	dEs (mV)	dts (s)
0	50.000	μA	<None>	0:00:10.0000	pass	138.889	nA.h	Ewe	1.00	0.1000

Chronoamperometry / Chronocoulometry (CA)

1. Click new to start an experiment or loading setting if you have one, or click  under Parameters Setting



2. Select Chronoamperometry / Chronocoulometry (CA), and click ok



3. You can set the parameters you want to like E_i and t_i .

EC-Lab V11.31
 Experiment Edit View Graph Analysis Tools Config Windows Help

VSP - USB0, channel 1 - experiment: <no name> - technique: Chronoamperometry / Chronocoulometry

Devices: VSP - USB0

Experiment: Safety/Adv. Settings, Cell Characteristics, External Devices, Parameters Settings

Parameters Settings: 1 - CA

Apply: $E_i = 0.350$ V vs. Ref for $t_i = 0$ h 0 min 10.000 s

Limit: $I_{max} = I_{min} = I_{pass}$ mA and $|\Delta Q| < \Delta Q_M = 0.000$ mA.h

Record: every $dt = 5.000$ μA , $dQ = 0.000$ mA.h and $dt = 0.1000$ s

E Range = -2.5 V; 2.5 V I Range = Auto Bandwidth = 5 - medium

Resolution = 100 μV

Next sequence, or Goto sequence $N_s = 0$, for $n_c = 0$ time(s)

to N_s+1 on limit to N_s or N_s End $N_s = 9999$

N_s	E_i (V)	vs.	t_i (h:m:s)	I_{max}	unit I_{max}	I_{min}	unit I_{min}	dQM	unit dQM	record
0	0.350	Ref	0:00:10.0000	pass	mA	pass	mA	0.000	mA.h	I

Status Stopped Time 0.0000 s Ewe -29.38 mV I 0 A Buffer 0 Eoc -29.38 mV Q-Qo 0 A.h I Range open Ns 0

VSP USB Channel1 Amplifier: None EIS Modify mode 0,0 16 972 b/s

4. Click

N_s	E_i (V)	vs.	t_i (h:m:s)	I_{max}	unit I_{max}	I_{min}	unit I_{min}	dQM	unit dQM	record
0	0.350	Ref	0:00:10.0000	pass	mA	pass	mA	0.000	mA.h	I

to

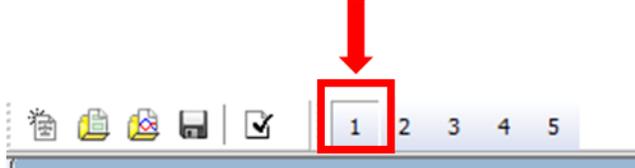
add more steps if you want to do so, set $E_i = 0$ vs. E_{oc} if you want to rest. Click

means deleting this step.

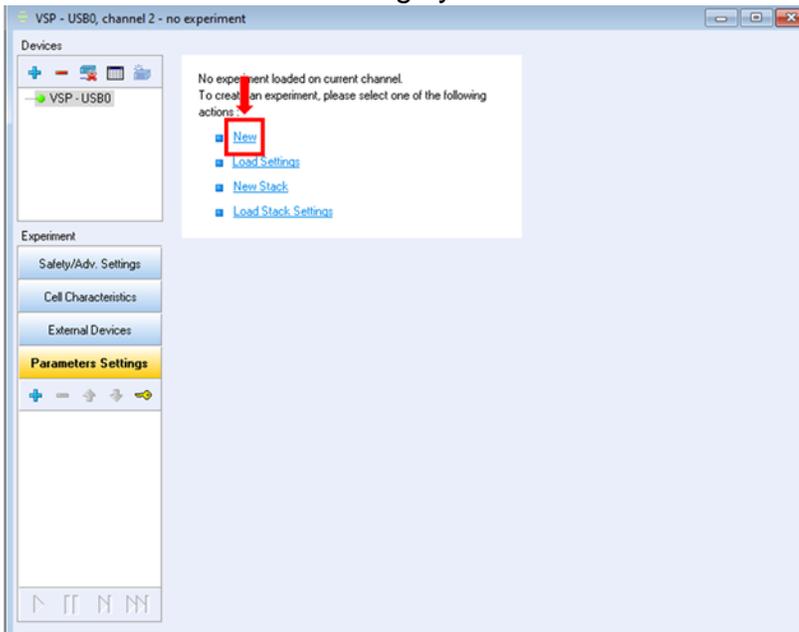
5. Click in the left lower part to start

Potential Electrochemical Impedance Spectroscopy (PEIS)

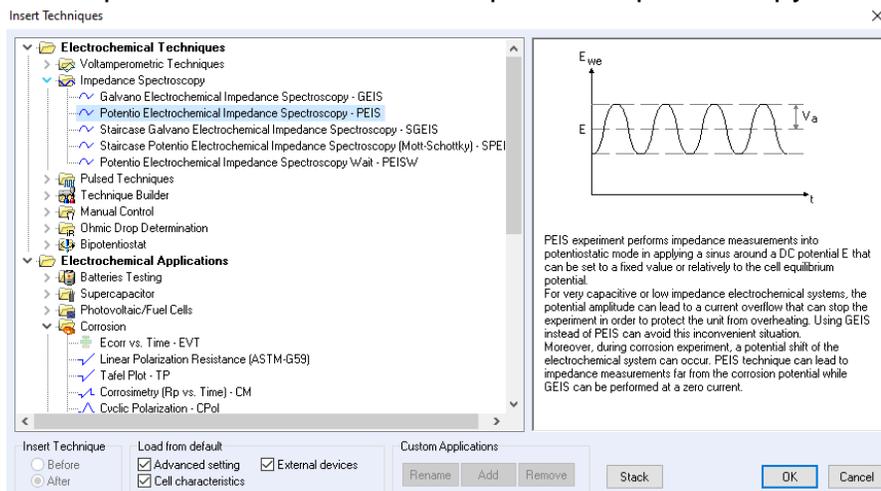
1. First thing of all, only channel 1 is capable for EIS measurement!



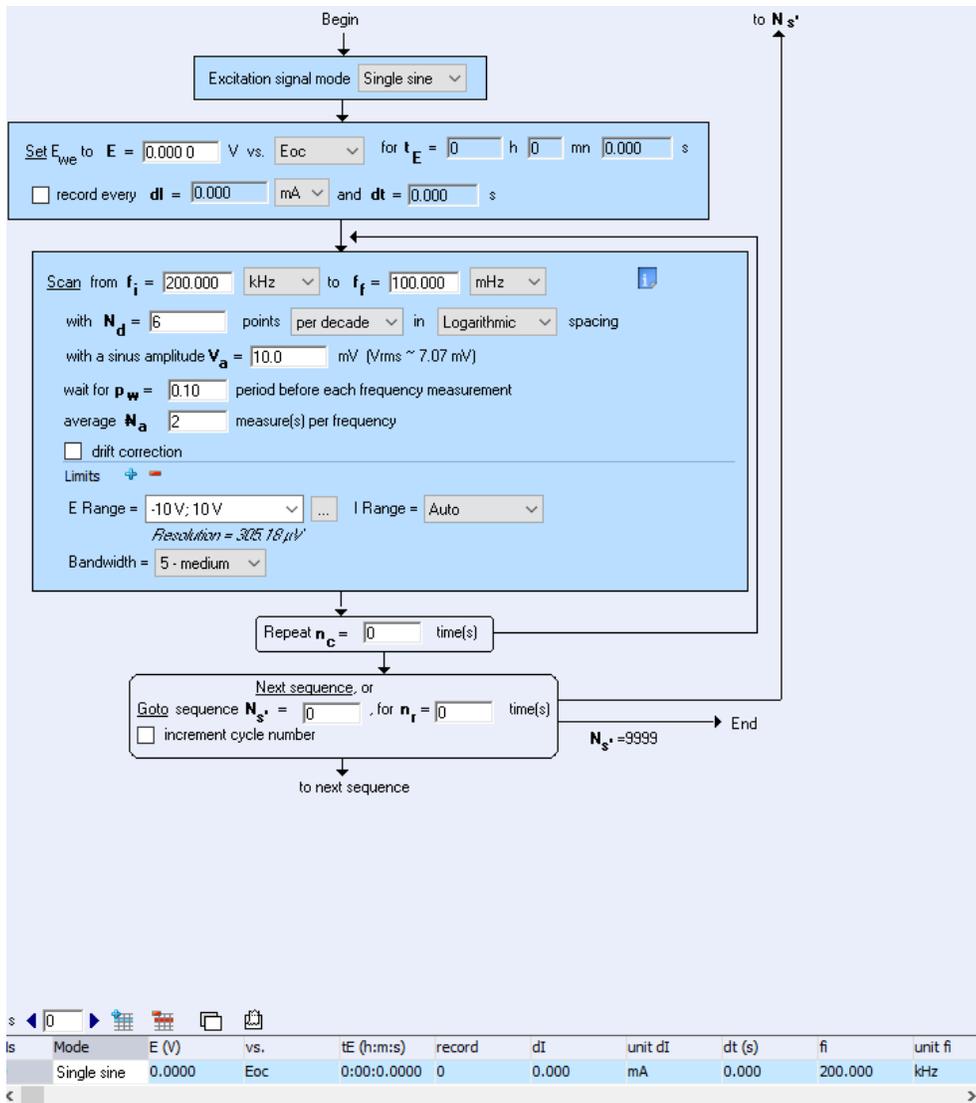
2. Click new to start an experiment or loading setting if you have one, or click  under Parameters Setting fly out



3. Select potential electrochemical impedance spectroscopy-PEIS

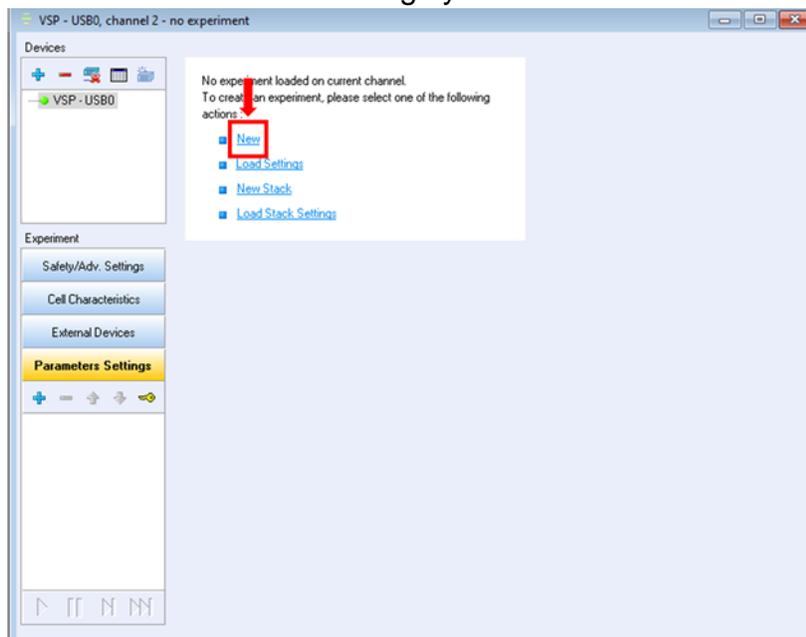


4. Enter the parameters you want and click 

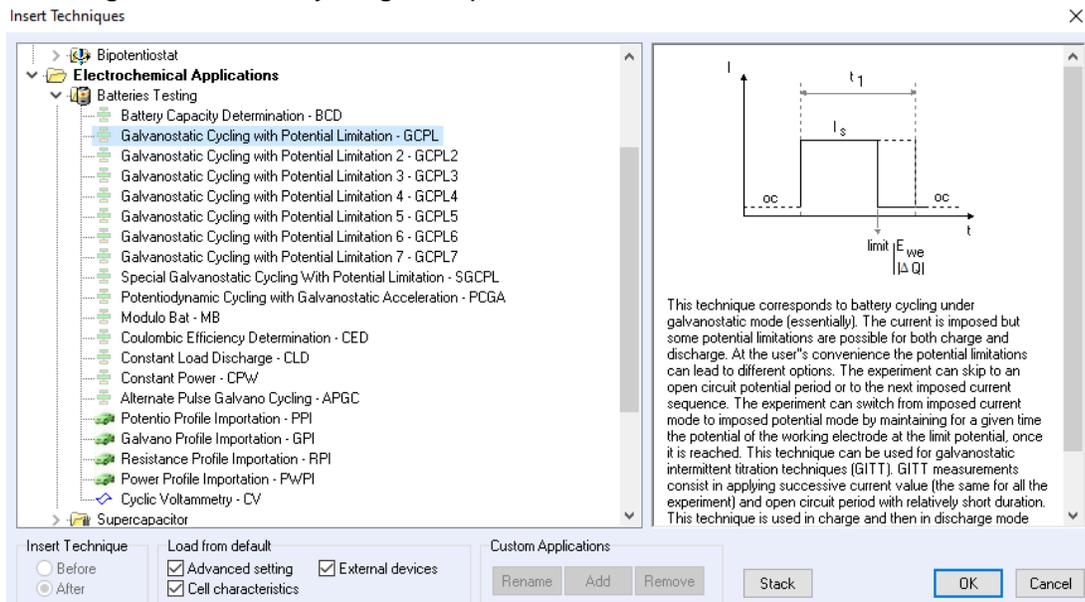


Charge and discharge (Galvanostatic cycling with Potential limitation – GCPL)

1. Click new to start an experiment or loading setting if you have one, or click  under Parameters Setting fly out



2. Select galvanostatic cycling with potential limitation – GCPL and click ok



3. You will see

Devices: Turn to OCV between techniques ✓

Experiment: Safety/Adv. Settings, Cell Characteristics, External Devices, Parameters Settings

1 - GCPL

Parameters Settings:

- Set I to $I_s = 0.000$ mA vs. <None>
- for at most $t_1 = 0$ h 0 mn $0.000\ 0$ s
- with I Range = 1 A and Bandwidth = 5 - medium
- Record E_{we} every $dE_1 = 0.0$ mV and at least every $dt_1 = 0.000\ 0$ s
- Limit $E_{we} < E_M = 0.000$ V
- and stand for $t_M = 0$ h 0 mn $0.000\ 0$ s
- or until $|| I_{Im} = 0.000$ mA or $|dI/dt| < dI/dt_I = 0.000$ mA/s
- with E Range = 0 V; 5 V Resolution = 100 μ V
- Record ΔQ every $dQ = 0.000$ A.h and at least every $dt_q = 0.000\ 0$ s
- Limit $|\Delta Q|$ to $\Delta Q_M = 0.000$ mA.h $\Leftrightarrow \Delta x_M = 0.000$

Flowchart:

- turn to Rest for $t_R = 0$ h 0 mn $10.000\ 0$ s
- or until $|dE_{we}/dt| < dE_R/dt = 0.0$ mV/h
- Record E_{we} every $dE_R = 0.0$ mV and at least every $dt_R = 1.000\ 0$ s
- Test $E_{we} > E_L = \text{pass}$ V
- yes: Next sequence, or Goto sequence $N_s = 0$ for $n_C = 0$ time(s)
- no: Loop back to start
- End: $N_s = 9999$

Ns	Set I/C	Is	unit Is	vs.	N	I sign	t1 (h:m:s)	I Range	Bandwidth	dE1 (mV)
0	I	0.000	mA	<None>	1.00	> 0	0:00:0.0000	1 A	5	0.00
1	I	130.000	mA	<None>	1.00	> 0	10:00:0.0000	1 A	5	0.00
2	I	-130.000	mA	<None>	1.00	> 0	10:00:0.0000	1 A	5	0.00

- In $N_s = 0$, you will set the rest time as shown in the above picture
- In $N_s = 1$, click blue arrow in $N_s \leftarrow 0$, or the region to activate the window, here you will set the parameters for first step charge or discharge. Use positive current values (I_s) of current for charge and negative I_s values for discharge. Set the parameters you want such as current value, cut-off voltage, hold at cut-off voltage time, record time, etc
- In $N_s = 2$, you can set the next step charge or discharge. In the case of charge first, you will set $N_s = 2$ in discharge mode by input negative I_s value. Change the parameters accordingly such as discharge cut-off voltage or so.
- Click

Ns	E1 (V)	vs.	ti (h:m:s)	Imax	unit Imax	Imin	unit Imin	dQM	unit dQM	record
0	0.350	Ref	0:00:10.0000	pass	mA	pass	mA	0.000	mA.h	I

to add more steps if you want.

8. After you set up all the parameters you want, click  to start
9. You can play with more freedom in GCPL2/3/4...

For any questions, feel free to contact Jiaqi Wang (jiaqi.wang@anl.gov).

HAVE FUN!