

# Getting Started with EC-Lab<sup>®</sup>: Zfit: EIS data analysis

The aim of this presentation is to guide the user to use Zfit in the most efficient way.

**NOTE:**

Tutorials on impedance theory are available on request. No theoretical background will be discussed in this getting started.

1. Open EIS data
2. Open Zfit
3. Set the appropriate Equivalent Circuit
4. Set the fit
5. Minimize
6. Copy/save EIS data fit

**NOTE:**

Only good quality data can be fitted to provide relevant information. How to optimized the EIS measurement is discussed in the getting started on EIS techniques (“Getting Started with EC-Lab<sup>®</sup>:EIS: Electrochemical Impedance Spectroscopy”).

# 1- Open EIS data

- In the “Experiment” Menu, select “Load Data File” (or Ctrl+O).

- The “Open” window appears,

- Browse through the “Open” window to find the file of interest (when selected the file is highlighted in blue).

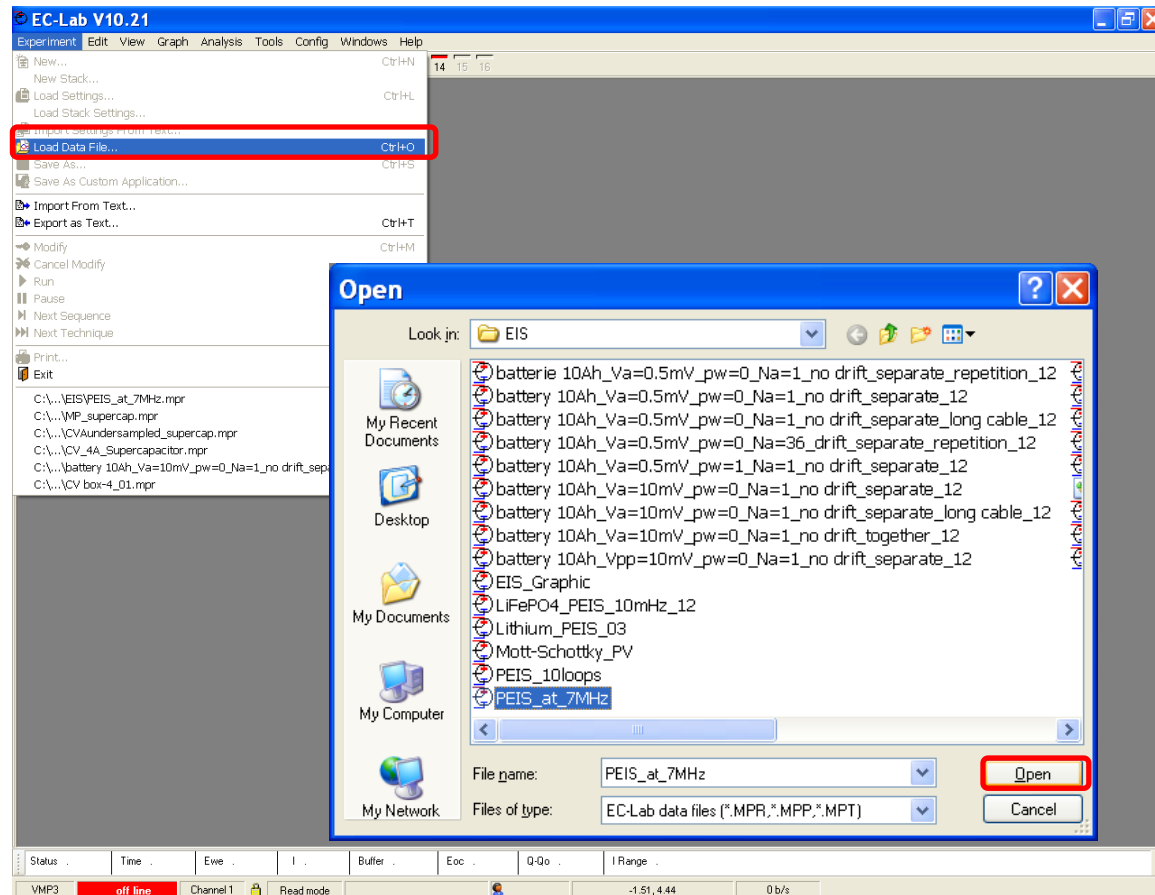
Here: it is “PEIS\_at\_7MHz.mpr” file.

- Click on the “Open” button

**TIP:**

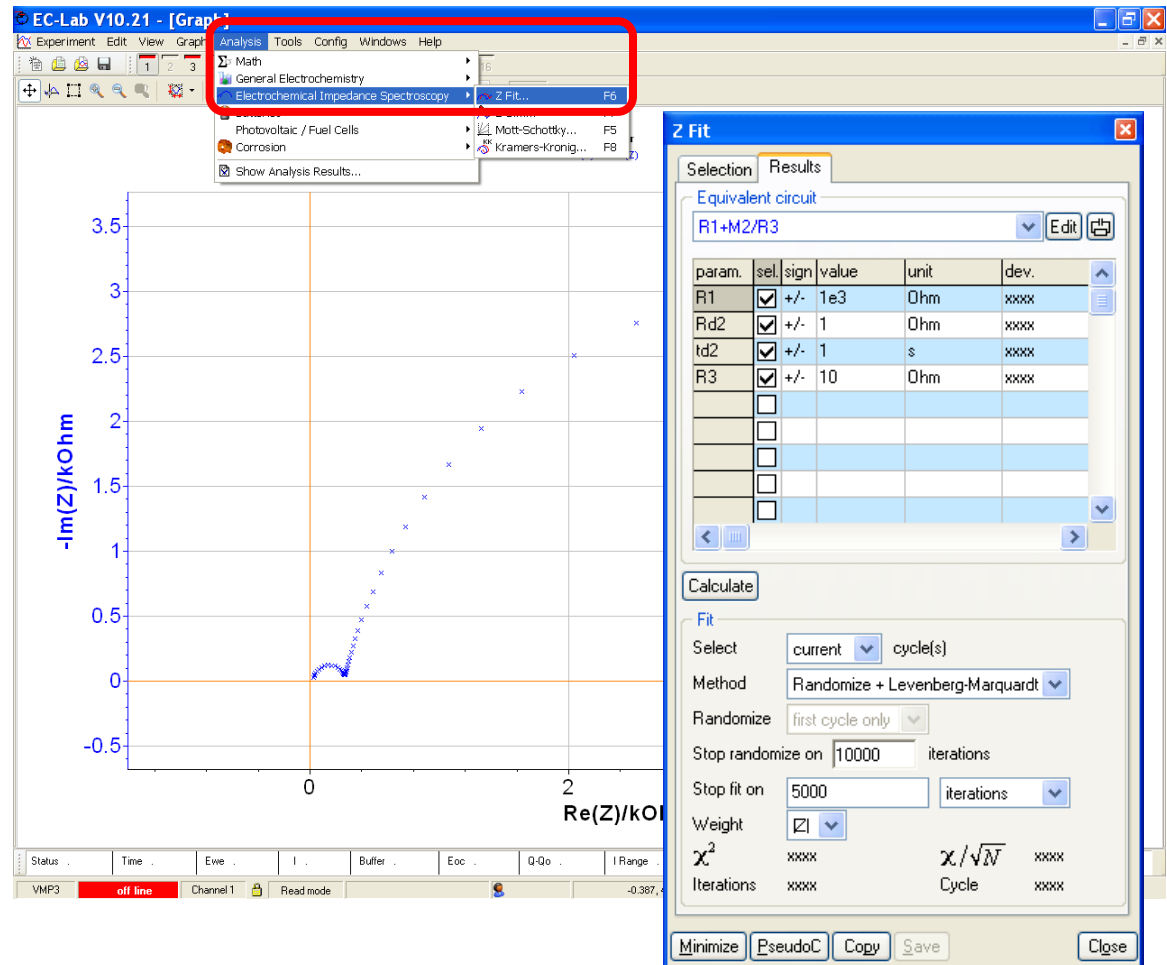
It is possible to open .mpr file but also every text file. To perform Zfit, the text file has to have the following information:

- Frequencies
- Re(Z)
- -Im(Z). Zfit cannot work with Im(Z), so if the file contains Im(Z), Im(Z) has to be converted to -Im(Z).



- In the “Analysis” Menu, go into the “Electrochemical Impedance Spectroscopy” subfolder and then select “Zfit” (or F6 as keyboard shortcut).

- The “ZFit” window is displayed,



The screenshot shows the EC-Lab V10.21 software interface. The main window displays an EIS plot with the y-axis labeled  $-\text{Im}(Z)/\text{k}\Omega\text{hm}$  and the x-axis labeled  $\text{Re}(Z)/\text{k}\Omega$ . The plot shows a series of blue 'x' markers forming a semi-circular arc starting from the origin. A blue dashed line represents the fit to the data. The 'Analysis' menu is open, and 'Z Fit...' is selected. The 'Z Fit' dialog box is open, showing the equivalent circuit 'R1+M2/R3' and a table of parameters.

param.	sel.	sign	value	unit	dev.
R1	<input checked="" type="checkbox"/>	+/-	1e3	Ohm	xxxx
Rd2	<input checked="" type="checkbox"/>	+/-	1	Ohm	xxxx
td2	<input checked="" type="checkbox"/>	+/-	1	s	xxxx
R3	<input checked="" type="checkbox"/>	+/-	10	Ohm	xxxx
	<input type="checkbox"/>				
	<input type="checkbox"/>				
	<input type="checkbox"/>				
	<input type="checkbox"/>				

The 'Calculate' section of the dialog box shows the following settings:

- Fit: current cycle(s)
- Method: Randomize + Levenberg-Marquardt
- Randomize: first cycle only
- Stop randomize on: 10000 iterations
- Stop fit on: 5000 iterations
- Weight:  $|Z|$
- $\chi^2$ : xxxx,  $\chi/\sqrt{N}$ : xxxx
- Iterations: xxxx, Cycle: xxxx

# 3- Set the equivalent circuit

- Click on the “Edit” button, the “Equivalent Circuit Edition” window is displayed,

- Select the equivalent circuit of interest (highlighted in blue).

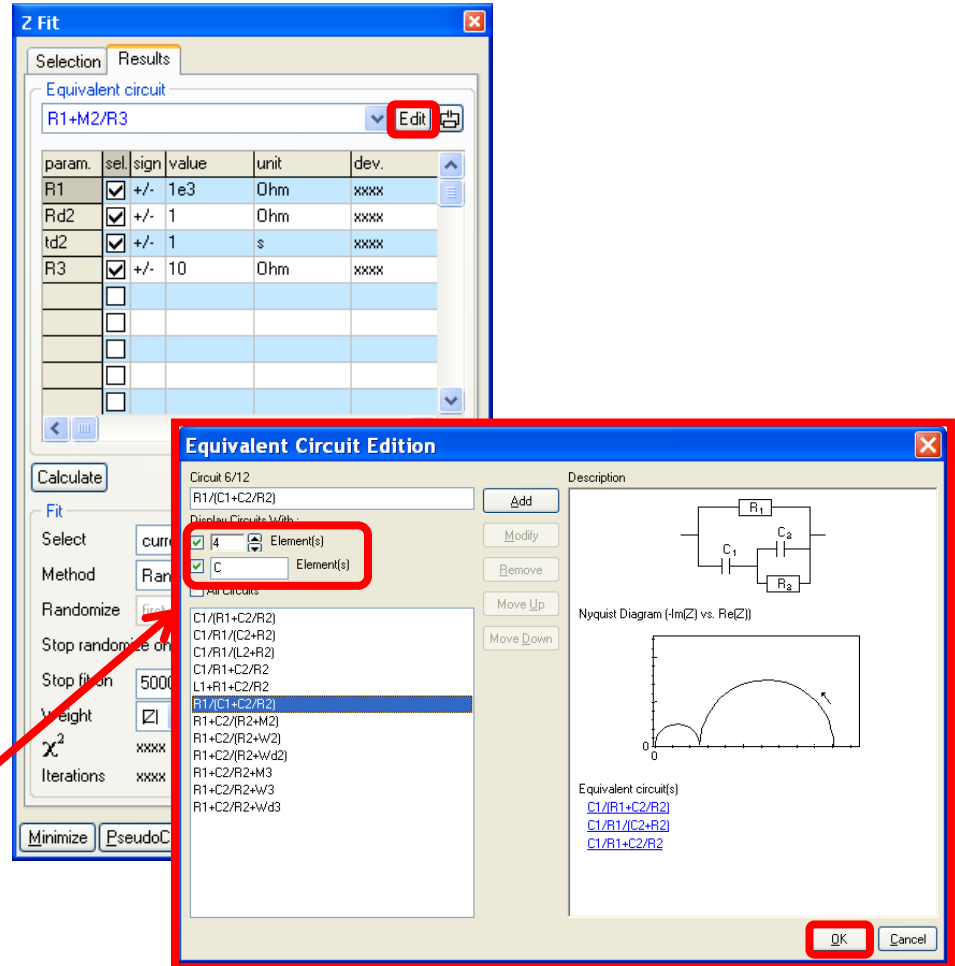
Here:  $R1/(C1+C2/R2)$

If you don't find the equivalent circuit, it is possible to design a new one. This will be shown in the next slide.

- Click on the “OK” button.

**TIP:**

Two parameters can be used to sort out some equivalent circuits among all circuits offered in the Zfit library: the type and the number of elements.



The screenshot shows the 'Z Fit' software interface. The 'Equivalent Circuit Edition' dialog box is open, displaying a list of circuit options. The selected circuit is  $R1/(C1+C2/R2)$ . The 'Element(s)' column shows '4' and 'C' checked, indicating the number of elements and their types. A red box highlights these elements, and a red arrow points from the 'TIP' text to this area. The 'OK' button is also highlighted with a red box.

param.	sel	sign	value	unit	dev.
R1	<input checked="" type="checkbox"/>	+/-	1e3	Ohm	xxxx
Rd2	<input checked="" type="checkbox"/>	+/-	1	Ohm	xxxx
td2	<input checked="" type="checkbox"/>	+/-	1	s	xxxx
R3	<input checked="" type="checkbox"/>	+/-	10	Ohm	xxxx

Equivalent Circuit Edition

Circuit 6/12  
R1/(C1+C2/R2)

Element(s)

- 4
- C

Description

Nyquist Diagram (-Im(Z) vs. Re(Z))

Equivalent circuit(s)

- [C1/\(R1+C2/R2\)](#)
- [C1/\(R1/\(C2+R2\)\)](#)
- [C1/\(R1+C2/R2\)](#)

## Create your own equivalent circuit

- In the edit box, write the new equivalent circuit according to a specific syntax (see below).
- Click the « Add » button. The equivalent circuit will be displayed in blue in the list afterwards.

### SYNTAX:

1- For elements in series, use the sign “+”.

For example for  $R$  in series with  $C$  the equivalent circuit will be “ $R1+C1$ ”.

2- For elements in parallel, use the sign “/”.

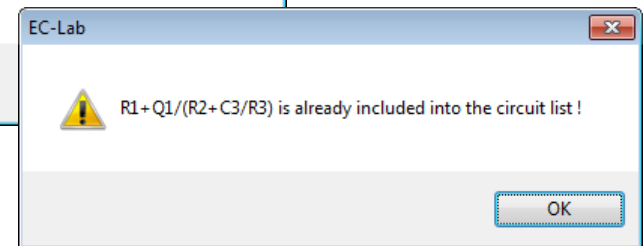
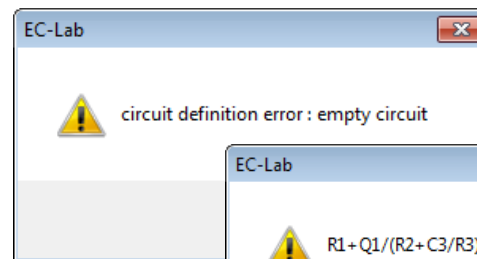
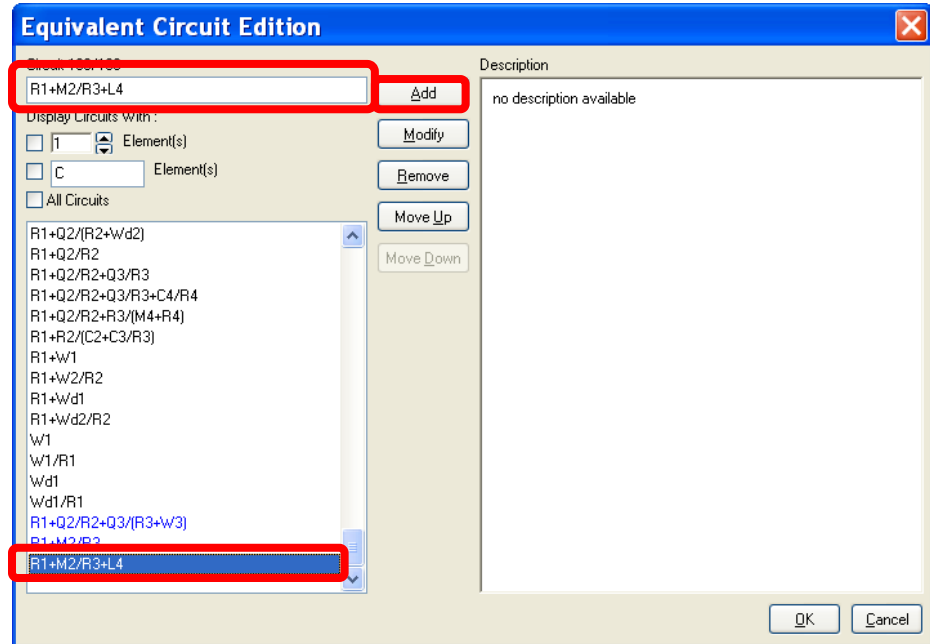
For example for  $R$  in parallel with  $C$  the equivalent circuit will be “ $R1/C1$ ”.

3- If several elements are in series or in parallel with each other, then the considered elements must be set between brackets “()”.

For example for  $R2$  and  $C2$  in series together and in parallel with  $R1$ , the equivalent circuit will be “ $R1/(R2+C2)$ ”.

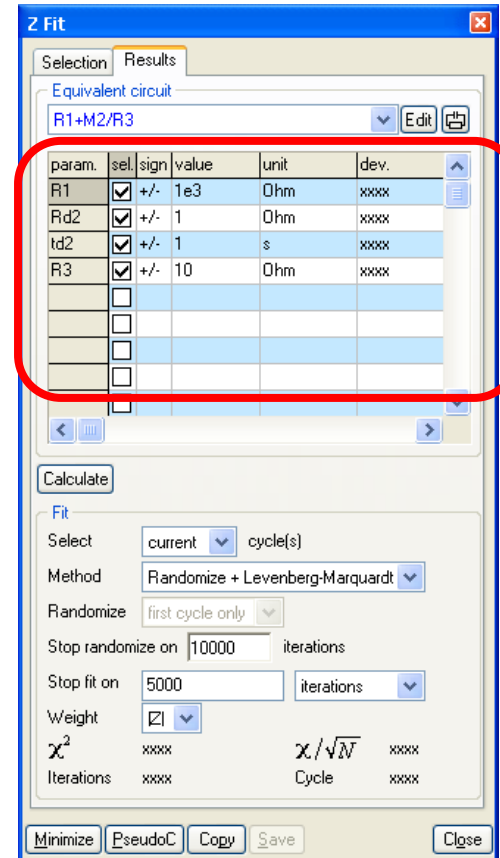
### NOTE:

When you click on the “Add” button, the equivalent circuit is checked. If the syntax is not correct or if the circuit already exists in the list the following error messages show up.



# 4- Set the fit

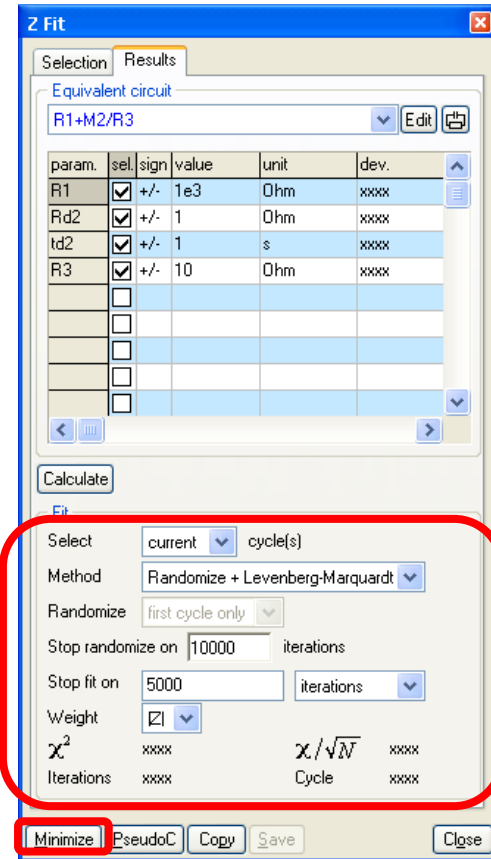
- If the box of the “sel.” column is checked the value will be minimized during the fit. If not checked, the value is used as is in the fit process *i.e.* not minimized.
- It is possible to force positive/negative value by clicking on the sign box.
- Possible to calculate (no fitting process) to get the impedance data obtained using the parameters entered in the table by clicking on the « calculate » button.



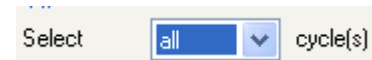


- Select the method used for the fit, there are three kinds of method. It is possible to stop the fit after a certain number of iterations. Randomize is used to find the initial values for the fit. Otherwise, the value in the table are used.
- Click on the « Minimize » button.

**NOTE:**  
 «  $\chi^2$  » is the error on the fit whereas « dev » is the standard deviation of the value of each parameters of the fit.



It is possible to fit several cycles in the meantime. If « all » Cycles is set in the box. A « XXX.mpp » file will be created with all the values fitted for each cycle.



- It is possible to save the EIS data file by two means:
  - Copy the parameters and values of the fit, in editable format (\*.doc file for example). For this click on the “Copy” button and then paste in a document.
  - Create a “\*.fit” file. For this click on the “Save” button. Then a text file with the parameters is automatically created in the folder where is the original mpr file.

