

For an easier evaluation of Cole-Cole plot data measured with a Hioki BT4560, this little tool might be helpful to you...

Measuring the impedance of a battery usually leads to a lot of data which then needs to be evaluated afterwards. When using a HIOKI BT4560 you can export a .csv file containing the data in a standardized format. That file is then loaded on this website my colleagues made:

<http://www.circuitfitting.net/multiplot>

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Multi-plot (Beta)

With this web application, you can plot Cole-Cole and Bode plots for multiple impedance data simultaneously. Just upload CSV files one by one and get the result.

+ Add impedance data
Reset

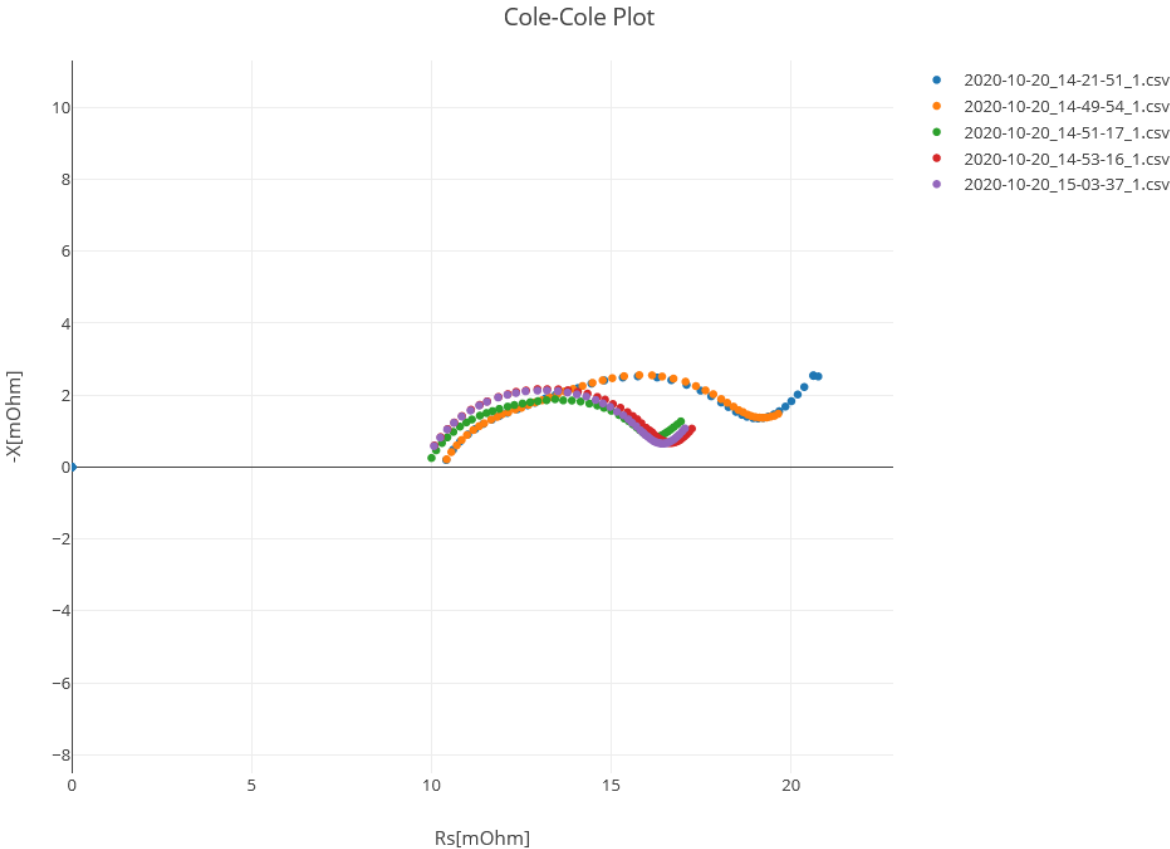
Requirements for the input CSV file format:

- Column names for frequency, real part of impedance and imaginary part of impedance should include the words "FREQUENCY(Hz)", "R", and "X", respectively.
- Comma-separated CSV format and semicolon-separated CSV format are supported.
- ZView-like CSV format is also available.
- Download sample input files from here:
[comma.csv](#) , [semicolon.csv](#) , [comma_z.csv](#) , [semicolon_z.csv](#)

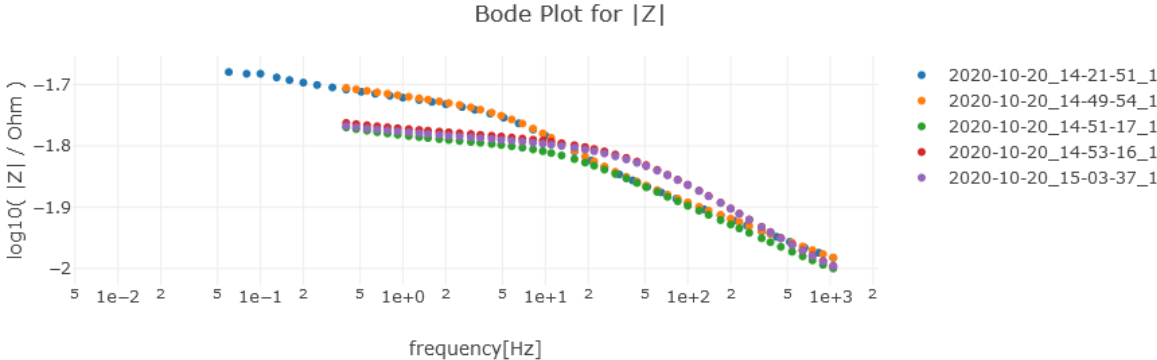
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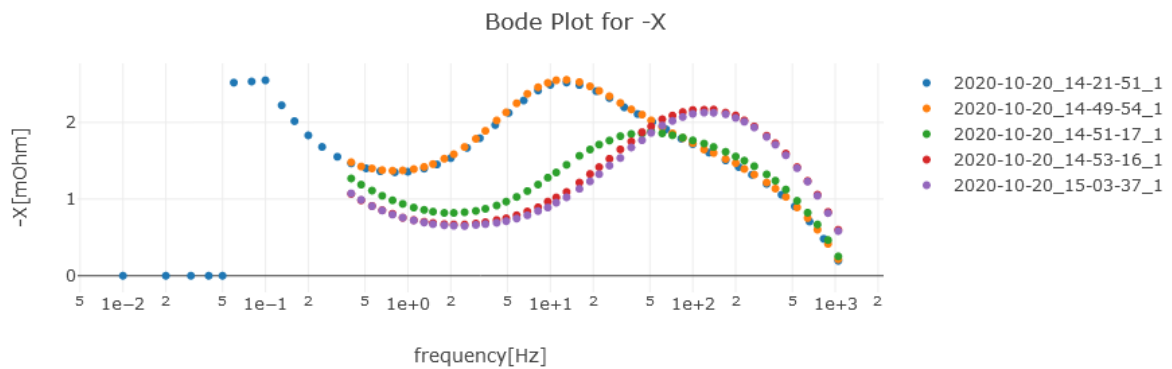
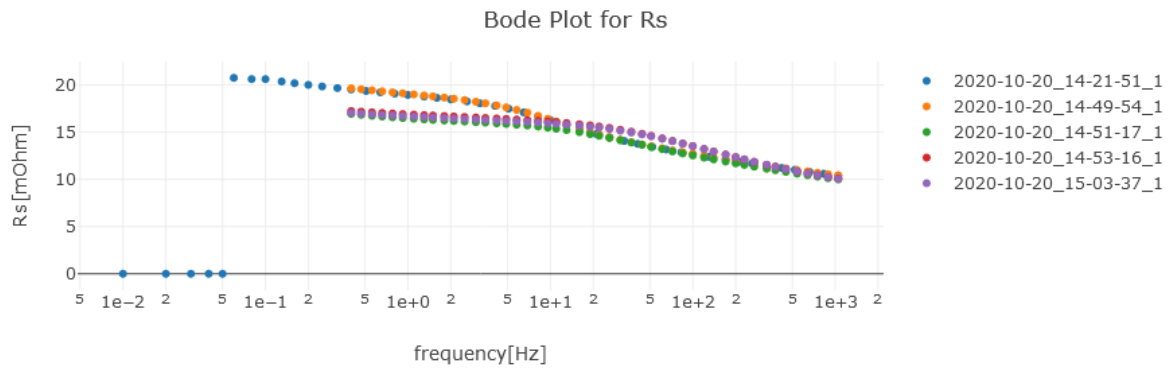
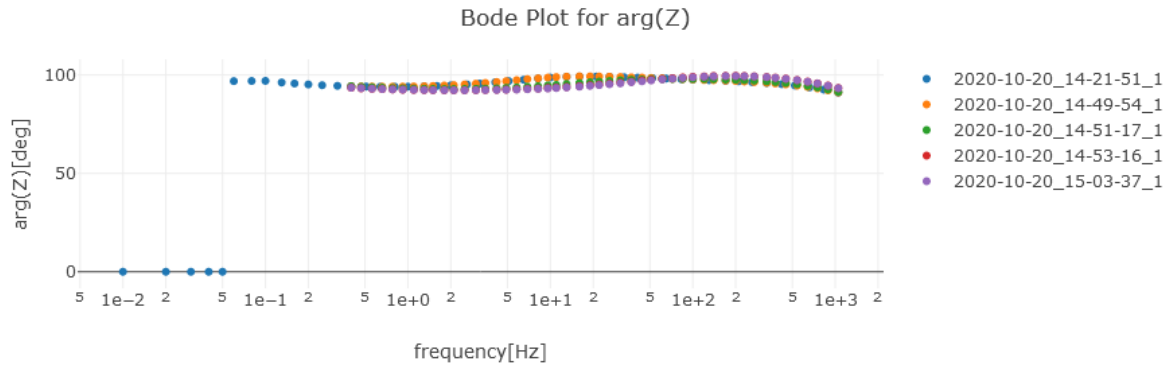
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By clicking on "Add impedance data" you can chose the .csv file and load it. When comparing the results of several batteries you can repeat those steps and load the data from one battery to another. The output is the Cole-Cole plot like this:



And those four Bode plots:





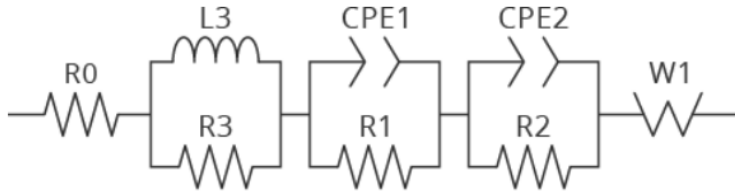
Giving you a quick method to create graphs of your measurements for reports and presentations without manually loading them into an Excel sheet.

If that didn't convince you to give this website a try you should check out the fitting function which is also provided:



Equivalent Circuit Fitting (Beta)

Automatically analyze battery impedance data with the pre-defined model shown below. Just upload a CSV file and get the fitting result.



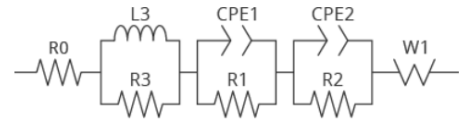
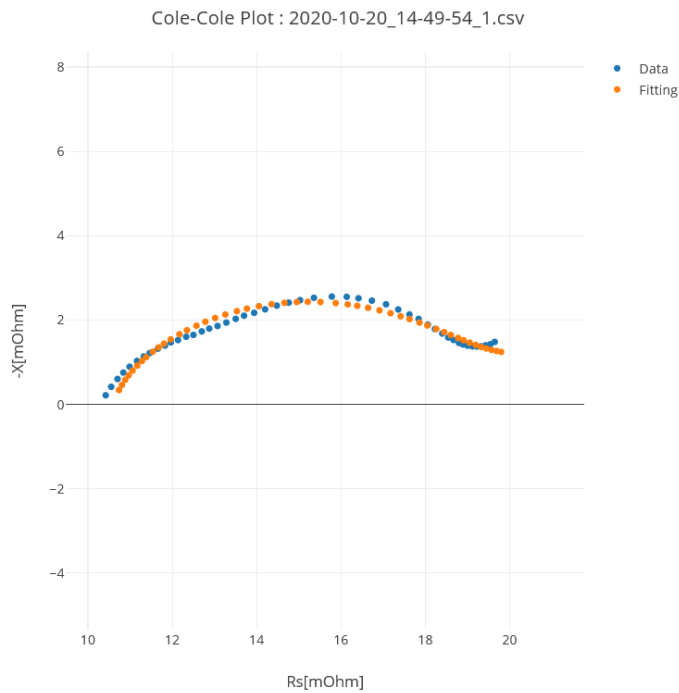
Select impedance data

Reset

Requirements for the input CSV file format:

- Column names for frequency, real part of impedance and imaginary part of impedance should include the words "FREQUENCY(Hz)", "R", and "X", respectively.
- Comma-separated CSV format and semicolon-separated CSV format are supported.
- You can simply use HIOKI [BT4560](#) CSV format.
- As an exception, you can also use ZView-like CSV format.
- Download sample input files from here:
[comma.csv](#) , [semicolon.csv](#) , [comma_z.csv](#) , [semicolon_z.csv](#)

It's as easy as it gets: click on "Select impedance data" and chose the file to load. The website then fits the equivalent circuit shown on the right of the graph to the measured data from the chosen .csv file and gives out the respective results:



$$Z_{CPE} = \frac{1}{(j2\pi f)^{pQ}}$$

$$Z_W = \frac{R}{\sqrt{j2\pi fT}} \coth \sqrt{j2\pi fT}$$

[Download the fitting result](#)

Model : R0-(L3//R3)-(CPE1//R1)-(CPE2//R2)-W1

rmse_score[Ohm] : 1.81e-4

R0[Ohm] : 9.74e-3

L3[H] : 6.11e-8

R3[Ohm] : 9.22e+0

CPE1_Q[Ohm^-1 sec^p] : 6.39e+0

CPE1_p[] : 5.74e-1

R1[Ohm] : 9.60e-3

CPE2_Q[Ohm^-1 sec^p] : 7.71e+2

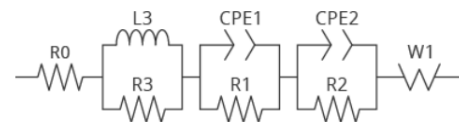
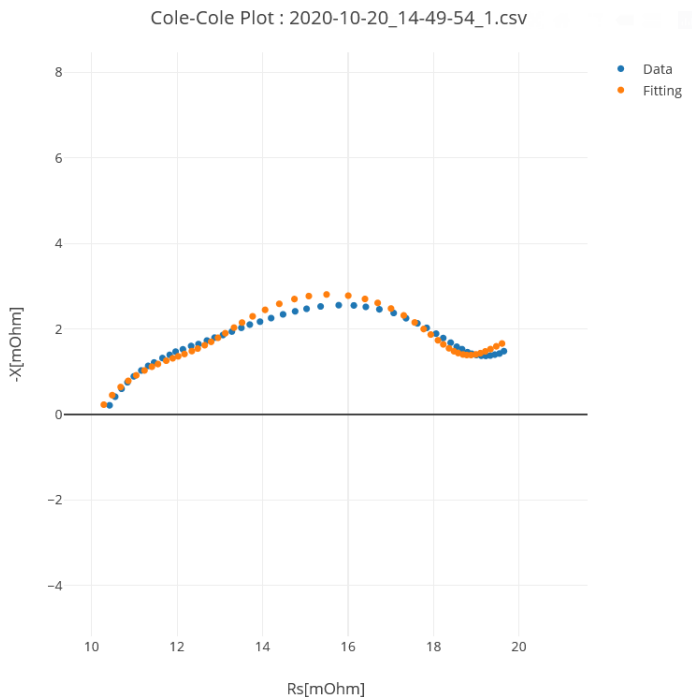
CPE2_p[] : 1.06e-1

R2[Ohm] : 1.10e-3

W1_R[Ohm] : 2.58e-3

W1_T[sec] : 5.00e+0

As the website and calculation model is still in its beta stage, please note that the fitted curve might not always match with the measured curve, as for example on the graph above. For that reason it might be worth giving it several tries. I tried three times in total and here's what I got on the second and third:



$$Z_{CPE} = \frac{1}{(j2\pi f)^{pQ}}$$

$$Z_W = \frac{R}{\sqrt{j2\pi fT}} \coth \sqrt{j2\pi fT}$$

[Download the fitting result](#)

Model : R0-(L3//R3)-(CPE1//R1)-(CPE2//R2)-W1

rmse_score[Ohm] : 1.79e-4

R0[Ohm] : 1.84e-4

L3[H] : 2.52e-7

R3[Ohm] : 1.00e+0

CPE1_Q[Ohm^-1 sec^p] : 1.30e+0

CPE1_p[] : 3.64e-1

R1[Ohm] : 1.44e-2

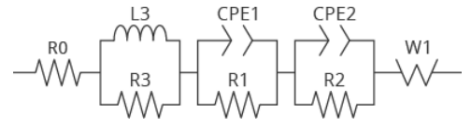
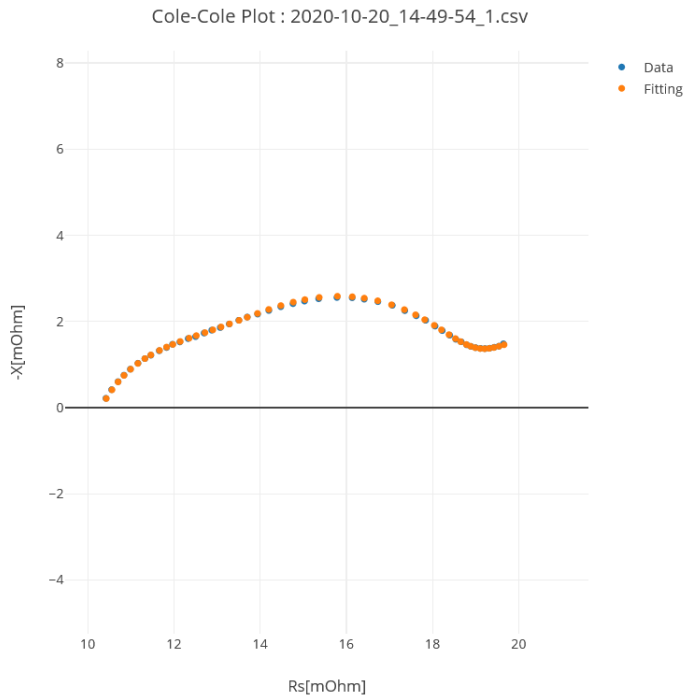
CPE2_Q[Ohm^-1 sec^p] : 2.73e+0

CPE2_p[] : 1.00e+0

R2[Ohm] : 3.90e-3

W1_R[Ohm] : 6.87e-3

W1_T[sec] : 5.00e+0



$$Z_{CPE} = \frac{1}{(j2\pi f)^{pQ}}$$

$$Z_W = \frac{R}{\sqrt{j2\pi fT}} \coth \sqrt{j2\pi fT}$$

[Download the fitting result](#)

Model : R0-(L3//R3)-(CPE1//R1)-(CPE2//R2)-W1

rmse_score[Ohm] : 1.96e-5

R0[Ohm] : 8.49e-3

L3[H] : 1.52e-7

R3[Ohm] : 5.19e+0

CPE1_Q[Ohm⁻¹ sec^p] : 4.50e+0

CPE1_p[] : 4.89e-1

R1[Ohm] : 6.77e-3

CPE2_Q[Ohm⁻¹ sec^p] : 5.66e+0

CPE2_p[] : 9.21e-1

R2[Ohm] : 3.55e-3

W1_R[Ohm] : 5.49e-3

W1_T[sec] : 5.00e+0

On the last one I got a quite good match. In general I had the impression it works quite well but sometimes you might not get the right results, even after several tries. In the latter case I recommend you to come back and try again after some time, as this website is still under development and is being continuously improved by my colleagues. For example I've heard of the plan to implement more equivalent circuits from which you can choose the one you think fits best to your particular application.

In any case, you're most welcome to share your ideas and requests regarding that website with me! Also your feedback regarding this article is appreciated!