

## Coin Cell EIS Test

### Purpose

This test is to demonstrate coin cell battery's EIS test. You can use this application note for your battery's EIS test.

### Preparation

- ZIVE SP/MP electrochemical workstation
- 3V Li ion Coin cell
- Coin Cell holder

### Cell Connection

+ electrode(Green lead & Blue lead)

- electrode(White lead & Red lead)

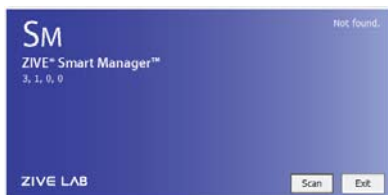


### Procedure

1. Turn the Power switch on the ZIVE SP/MP electrochemical workstation
2. Open the SM software by clicking the SM icon. The following progress box will appear, and will show the progress of checking instrument configuration and communication between ZIVE SP/MP electrochemical workstation and PC.



If the link is successfully connected, Click "OK" button on the box then the progress box will automatically disappear and SM software will appear. If the link failed, The following progress box will display then click the "Retry" button.

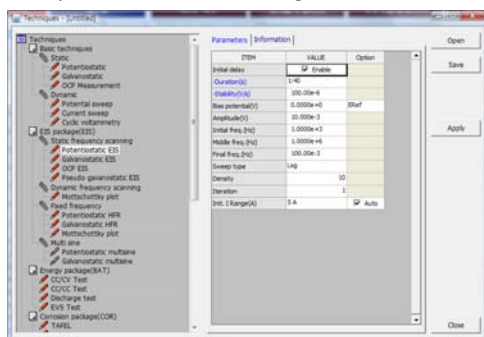


If the link failed again after clicking “Retry” button, you need to check USB cable connection.



3. Click Technique function icon (or select Technique function on Experiment menu)

Then you can see the following menu



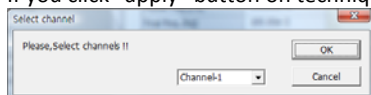
4. Select Potentiostatic EIS at left technique selection region. The parameter editing region is located at right.

Input figure for parameter setting as the follows.

ITEM	VALUE	Option
Initial delay	<input type="checkbox"/> Enable	
-Duration(s)	1:40	
-Stability(V/s)	100.00e-6	
Bias potential(V)	0.0000e+0	ERef
Amplitude(V)	10.0000e-3	
Initial freq. (Hz)	1.0000e+6	
Middle freq. (Hz)	1.0000e+6	
Final freq. (Hz)	100.00e-3	
Sweep type	Log	
Density	10	
Iteration	1	
Init. I Range(A)	5 A	<input checked="" type="checkbox"/> Auto

5. Click “Save” button to save the technique file which contains the above parameter and setting file name.
6. You can assign this technique file to channel(s) which you want by click “APPLY” button or select schedule file using file selection on “Single channel control/monitor” or “multi channel control/monitor”

If you click “apply” button on technique menu, You can see the following channel selection menu.



Select channel and click OK then this technique file will be assigned on the channel.

Click “Close” button or minimize technique window.

7. If you want control ZIVE SP/MP electrochemical workstation using “Single channel control/monitor”, you can see following windows.





To start experiment, click Start button

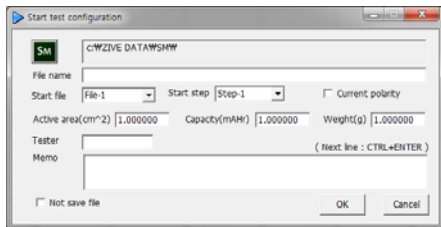



If you want control ZIVE SP/MP multichannel, you can see the following window



To start experiment for specific channel, click Start button  on the channel. If you want to start experiment for multiple channel, click on Group column which you want to start and click Start button  at bottom side.

8. After click start button, you can see the following box.



The data file name is automatically determined as default value but if you want to change data file folder then click  icon



You can make new folder which you want to save.

- ◆ If you want use your file name, input your file name on “File name”
- ◆ If you did not make file name manually, new data folder which named as sequence file name or technique file name under data folder and it’s subfolder will be created with name as date. The data file will be saved in this folder. The data file name will be determined automatically as string with sequence file name or technique file name and hour and minute and second, finally channel number will be added.

example) If you used sequence file for test and its file name is testabc.zsc and channel number is 1 and test date is 2000 year January 1<sup>st</sup> time is 15:30: 1 then the data file will be saved as

C:\Zive data\sm\data\testabc.zsc\2000010115\3001\_01.sdo (If data file have DC data only)

Or

C:\Zive data\sm\data\testabc.zsc\2000010115\3001\_01.sde (If data file have DC data and EIS data)

Or

C:\Zive data\sm\data\testabc.zsc\2000010115\3001\_01.seo (If data file have EIS data only)

e.g.) schedule file name with extension\yearmonthdayhour\minutesecond\_channel number

If you input file name as “tommy” then

C:\Zive data\sm\data\testabc.zsc\2000010115\tommy3001\_01.sdo (sde,seo)

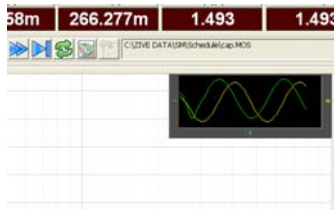
- ① Start Step: If your sequence file has several steps, you can select starting step.
  - ② Start file: If batch file is loaded, select file number
  - ③ Current polarity: If you want reverse polarity for measured current, check on this box.
  - ④ Active area: For calculation of current density
  - ⑤ Capacity: For C-rate value calculation
  - ⑥ Weight: For specific capacity calculation
  - ⑦ Tester: Operator name
  - ⑧ Memo: Text information for test (For line change, use CTRL+ENTER)
- No Save file: If you click this check box, the data will NOT be saved.

If you are ready to test, click OK button then experiment will be started..

You can see real time plot as the following.

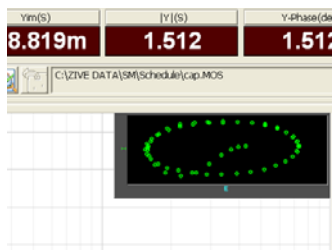



Real time EIS graph shows sub window at right upper side. This window display sine wave or E vs. I graph to check data quality. Default display is sine wave.



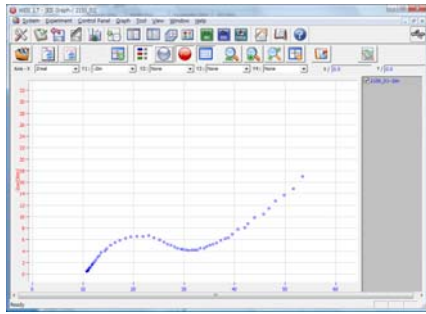
This shows two sine wave graphs. One is for current (green line) and the other is for voltage (Yellow line).

If you switch this graph to I vs E, double click on the graph then graph format will be changed.

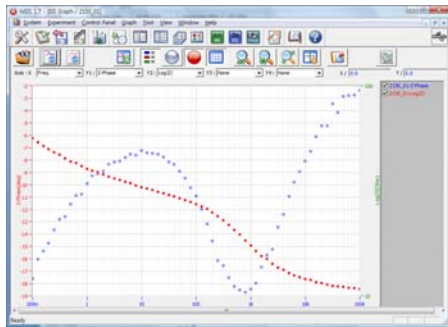


9. You can display graphic by clicking button  on tool bar

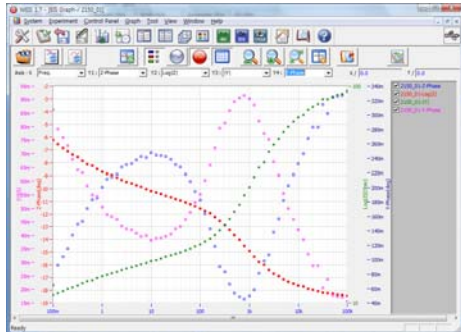
Click "Open data file" icon and select data file which you run the experiment.



You can select Bode plot by clicking  icon or Nyquist plot by clicking  icon.



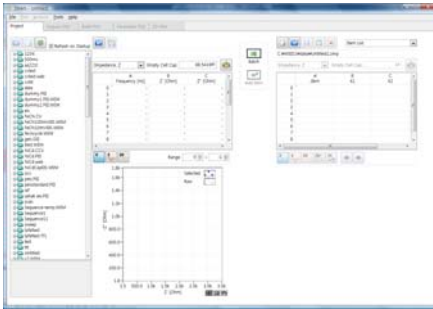
For user defined graphic, you can select X axis and Max 4 Y axis parameter as you wanted.



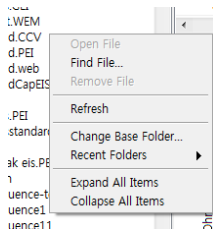
## Data Analysis

### Plot

1. Open "ZMAN" by clicking ZMAN icon. ZMAN program is located c:\program files\zivelab\zman2.2 folder.
2. You can see the following window.



3. Click Right button of mouse

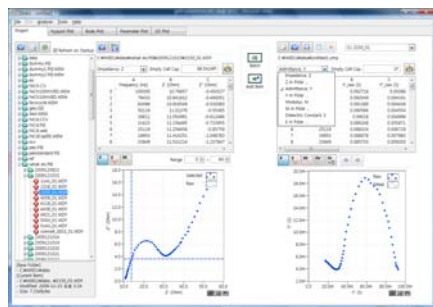


Select Change Base folder and select the folder which contain SM data.

4. Select data file by double clicking

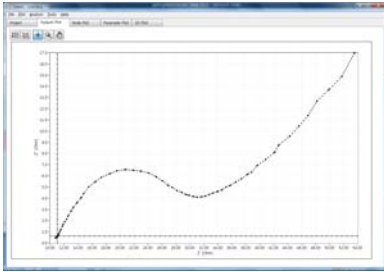


5. Upload data set to project for analysis by clicking "add item" button.
6. You can see Impedance, Admittance, Modulus, Dielectric

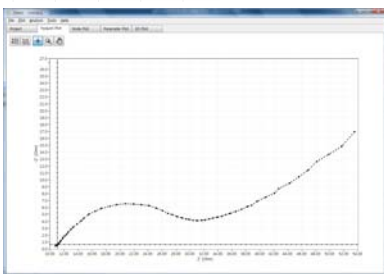
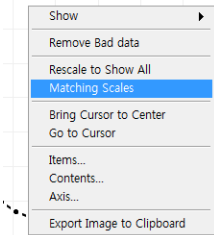


Select Impedance, Z in polar, Admittance, Y in Polar, Modulus, M in polar, Dielectric Constant, E in polar. (in polar = in Polar Coordinate)

7. Click 2D nyquist plot

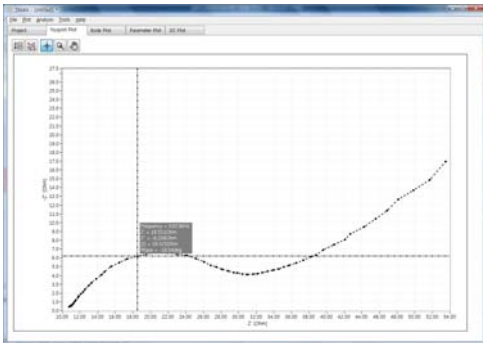
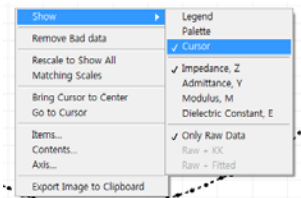


You can see “matching scale” by clicking right button of mouse and select “matching scale”



Matching scale is X axis scale and Y axis scale on graph is same.

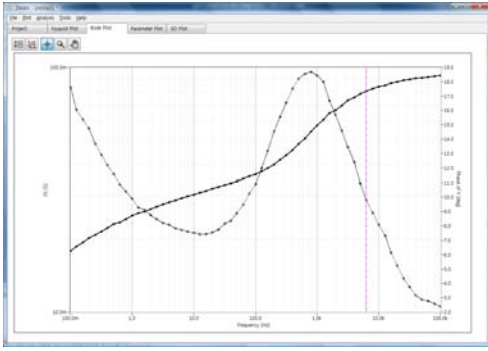
You can check each data value by selecting “cursor” with clicking right button of mouse .



You can move the point by dragging the mouse or using keyboard arrow key after clicking



8. Click 2D Bode





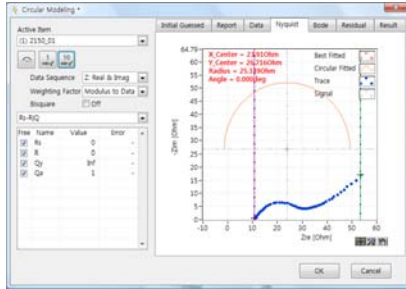
# EIS Analysis

You can select fitting method by your purpose Circular fit or Modeling & fitting

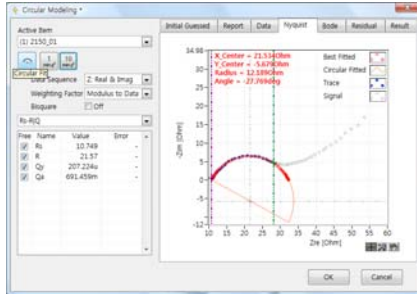
## A. Circular fit-Modeling process

### ➤ Circular fit

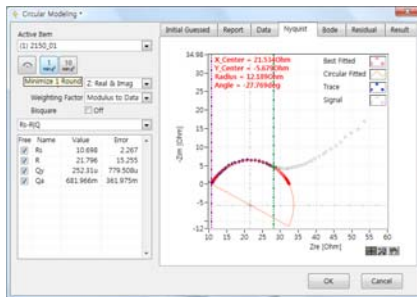
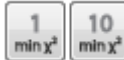
1. Select circular fit on Analysis menu



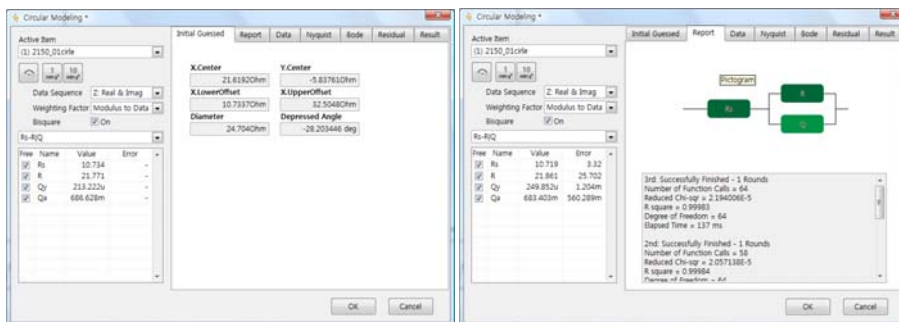
2. Move right cursor(olive color) into circle region as the above and click Initial guessing icon

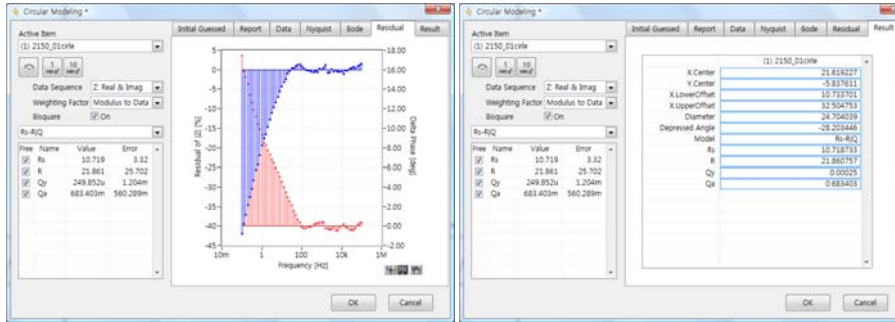
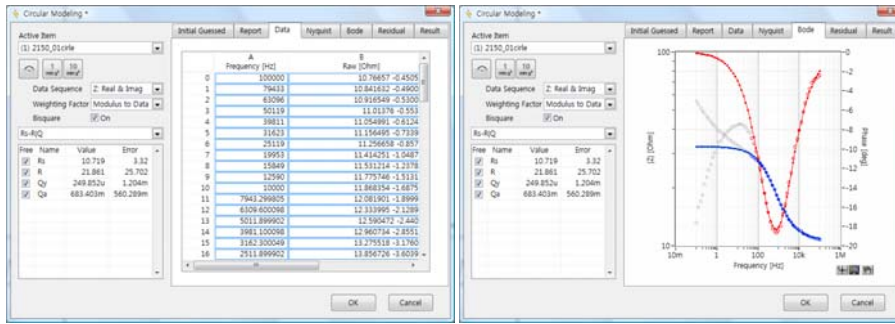


3. Click fitting icon 1time or 10 time fitting



4. You can see data list , Report, Initial Guess information, Result, Residual, Bode as the follows.

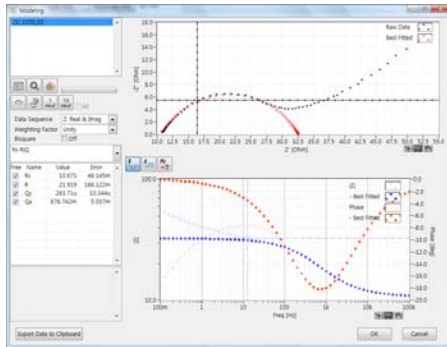




5. Click accept button if you want use this parameters

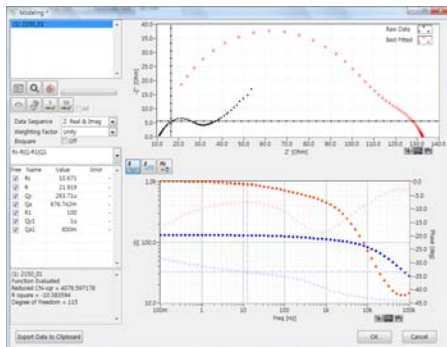
➤ **Modeling**

1. Select Modeling on Analysis



Circular fitting result was transferred to modeling automatically

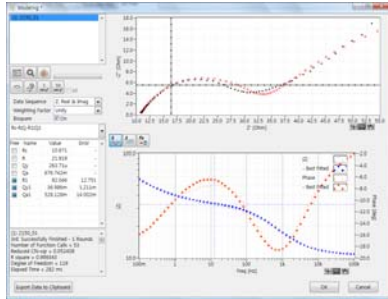
2. Guess that this data includes two circles and input circuit symbol directly as Rs-R/Q-R1|Q1 and press enter key.



3. Make parameters which came from circular fit as lock and new parameters as positive only.

Free	Name	Value	Error
<input type="checkbox"/>	Rs	10.671	-
<input type="checkbox"/>	R	21.919	-
<input type="checkbox"/>	Qy	263.71u	-
<input type="checkbox"/>	Qa	676.742m	-
<input checked="" type="checkbox"/>	R1	100	-
<input checked="" type="checkbox"/>	Qy1	1u	-
<input checked="" type="checkbox"/>	Qa1	800m	-

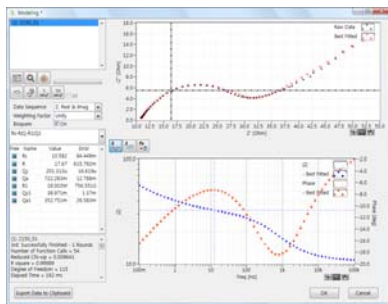
4. Click fitting.



5. Check free as positive only for locked parameters.

Free	Name	Value	Error
<input checked="" type="checkbox"/>	Rs	10.671	-
<input checked="" type="checkbox"/>	R	21.919	-
<input checked="" type="checkbox"/>	Qy	263.71u	-
<input checked="" type="checkbox"/>	Qa	676.742m	-
<input checked="" type="checkbox"/>	R1	92.046	-
<input checked="" type="checkbox"/>	Qy1	36.906m	-
<input checked="" type="checkbox"/>	Qa1	528.128m	-

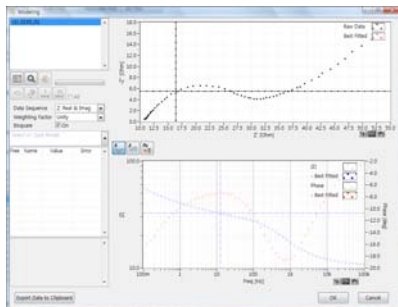
6. Click fitting



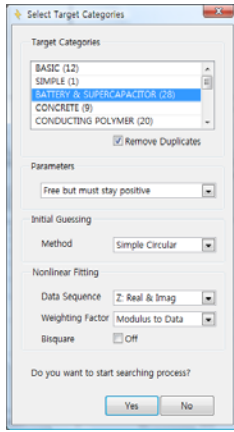
7. Click OK to accept fitting result.

## B. Automatic model searching & fitting.

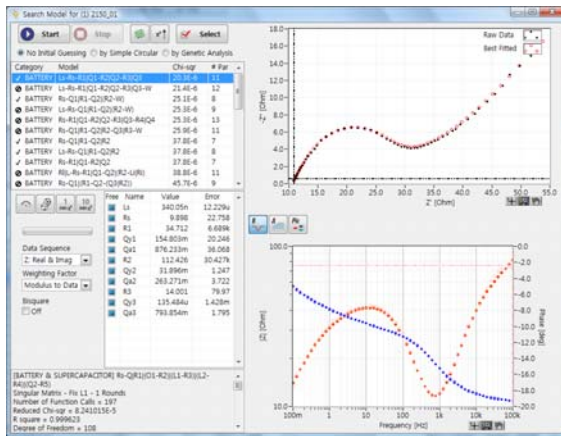
1. Select modeling on analysis



2. Search Model by clicking “search” button

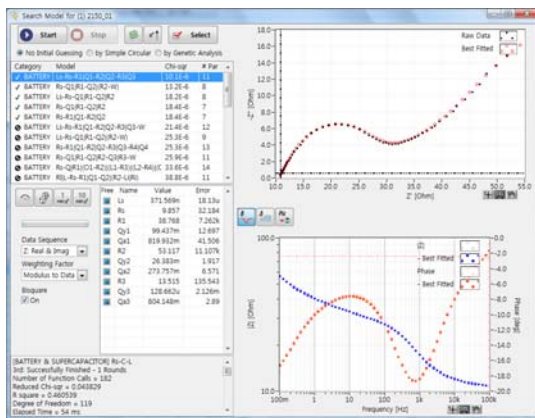


3. Select Battery & Supercapacitor in Target category
4. Select Parameters range as Free but must stay positive
5. Select initial guessing method as simple circular
6. Select data sequence as Zreal & Zimg
7. Select weight factor as modulus
8. Click Yes button then automatic model searching will be done



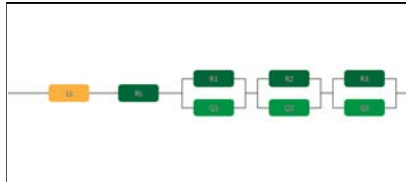
Result was rearranged by chi square value order.

9. Check on Bisquare for more accurate searching.
10. Click Start button and press stop button about 10<sup>th</sup> model searching finished or until end of similar fitting overlay plot on Nyquist & Bode..

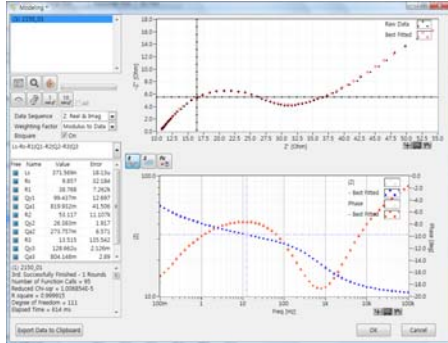


searching result will be rearranged by chi square value and it may be different from previous result.

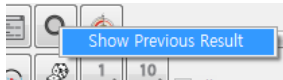
Suggested 1<sup>st</sup> model by automatic model searching is Ls-Rs-R1|Q1-R2|Q2-R3|Q3



11. Click select button to take this model
12. You can get this result or do fitting again by clicking fitting button.



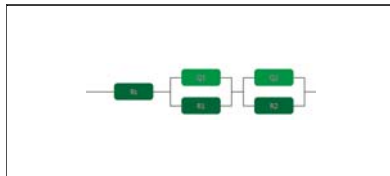
13. If you want to accept this result, click OK button
14. If you want to choose other model, click right mouse on searching button



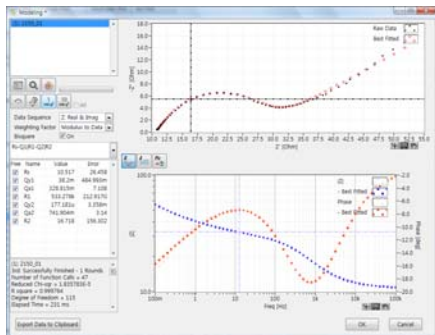
15. Click Show previous result pop up menu

Category	Model	Chi-sqr	# Par
<input checked="" type="checkbox"/>	BATTERY Ls-Rs-R1 Q1-R2 Q2-R3 Q3	10.1E-6	11
<input checked="" type="checkbox"/>	BATTERY Rs-Q1 R1-Q2 (R2-W)	13.2E-6	8
<input checked="" type="checkbox"/>	BATTERY Ls-Rs-Q1 R1-Q2 R2	18.2E-6	8
<input checked="" type="checkbox"/>	BATTERY Rs-Q1 R1-Q2 R2	18.4E-6	7
<input checked="" type="checkbox"/>	BATTERY Rs-R1 Q1-R2 Q2	18.4E-6	7
<input type="checkbox"/>	BATTERY Ls-Rs-R1 Q1-R2 Q2-R3 Q3-W	21.4E-6	12
<input type="checkbox"/>	BATTERY Ls-Rs-Q1 R1-Q2 (R2-W)	25.3E-6	9
<input type="checkbox"/>	BATTERY Rs-R1 Q1-R2 Q2-R3 Q3-R4 Q4	25.3E-6	13
<input type="checkbox"/>	BATTERY Rs-Q1 R1-Q2 R2-Q3 R3-W	25.9E-6	11
<input type="checkbox"/>	BATTERY Rs-Q1 R1-Q2 R2-Q3 R3-W	25.9E-6	11
<input type="checkbox"/>	BATTERY Rs-Q1 R1-Q2 R2-Q3 R3-W	33.6E-6	14
<input type="checkbox"/>	BATTERY R L-Rs-R1 Q1-Q2 (R2-L) R3	38.8E-6	11

16. Select Minimum parameters on the top list. It is Rs-Q1|R1-R2|R2



17. Check on Bisquare option and click fitting button

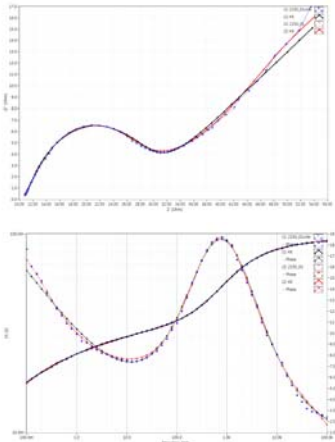


18. If you accept this result, click OK button

19. If you want overlay raw data and fitted data, Plot detail in Plot menu



20. You can see Nyquist or Bode data with fitted data



blue line : raw data,

red line : fitted data (Ls-Rs-R1|Q1-R2|Q2-R3|Q3)

black line : fitted data (Rs-R1|Q1-R2|Q2)

21. 3D graph

