IVMAN ver1.2

User's Manual

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Contents

Overview **1**

A. Introduction of IVMan 1

B. What is New in IVMan 1

C. System Requirements 2

D. Installation and Setup 2

E. Licensing Note 4

F. Known Bug 4

G. Legal Information 4

H. END-USER LICENSE AGREEMENT 4

I. License Agreement 4

IVMAN Main program **6**

Chapter 1 File **7**

A. Open File 7

1. By data file source 8

2. File Selection 9

3. Cycle Selection 10

B. Close File 10

C. Convert Rfd to dmf 10

D. Save graph as image file 12

E. Generate HTML report 12

Chapter 2 View **14**

A. Information 14

B. Summary 14

C. Experiment Data 14

Chapter 3 Graph **16**

A. 3D graph 16

1. Projection 16

2. Autoscale 16

3. Invert Axis 17

4. View direction change 17

B. V,I,T vs. t 17
C. I vs. V graph 18
D. Integral of current 18
E. Derivative of current 19
F. Tafel graph 21
G. Linear Polarization graph 22
H. General graph 23
1. File selection for graph 24
2. X,Y axis parameter selection 24
3. axis setting 24
4. Axis label changing 24
I. Graph functions in IVMAN 26
• 2D Graph function 26
Chapter 4 Analysis 31
A. Simple Math 31
1. X-axis for calculation 31
2. Y1 axis for calculation 31
3. Operator selection 31
4. Y2 input 31
B. Peak search 32
1. Peak searching condition 32
2. Find peaks 33
C. Advanced peak search 35
1. Step1: Choose data set 35
2. Step2: Derivative 35
3. Step3: Baseline point 36
4. Step4: Peak find 36
5. Step5: Generate Base line 37
6. Result of peak search 37
D. Interpolation 38
E. Smoothing 40
1. Savitzy-Golay smoothing 40
2. Adjacent averaging 41
3. FFT filtering 41

F. Differentiation 42
G. Integral 42
H. Semi-Derivative, Integral 43
I. Tafel analysis 43
1. Determine tafel region 44
2. Initial guessing: 44
3. Fitting 44
4. Corrosion rate calculation 45
J. Linear Polarization analysis 46
K. Advanced Integral 47
Chapter 5 Example 49
A. Current density converting 49
IVMAN differential Analysis 53
A. File Open 53
B. Graph format 53
1. 2D Plot general function 54
2. Manual axis range setting 55
3. Graph option 55
C. Measured Data 58
D. Voltage Profile 58
E. Capacity plot 59
F. Differential Analysis 59
1. Differential Capacity (EVS) 59
2. Differential Voltage 60
3. Parameters for differential analysis 60
4. 3D graph 61
5. Projection Style 62
6. Graph Style 63
G. Export Data as CVS 64
IVMAN Extractor 66
IVMAN peak find module 69

Overview

A. Introduction of IVMan

IVMan is scientific software for time-voltage-current in DC mode.
This software package consists of IVMAN main program and IVMAN utilities which contains IVMAN differential analysis, IVMAN extractor and peak searching module

In IVMan main program, you can do analysis with time-voltage-current data set for peak search, smoothing, tafel analysis including mathematic data treatment etc.

For battery data analysis,
With IVMAN differential analysis function in IVMAN utilities, it can do electrochemical voltage spectroscopy using charging-discharging data set and display Voltage vs. capacity
With IVMAN extractor, you can divide the cycle file by cycle number or step number.

For voltammogram's peack searching, simple "peak searching module" may be used.

B. What is New in IVMan

Current IVMan1.1 version can load WonATech product's data set and BAS(Bioanalytical systems Inc)'s data set(*.dat). Also It can imported ASCII file set series if they can meet data series condition. These exiting features will help you manage and analyze your time voltage current data set in a more productive way than ever before.

- **History**
  - IVMan 1.0
  - Upgrade to IVMan 1.1
  - Upgrade to IVMan 1.2

C. System Requirements

In order to run IVMan, you must ensure that your computer meets the following minimum software and hardware requirements.

Operating System: Windows XP, 2K, Vista, Windows7
PC: PentiumIV, RAM: 512MB Display resolution: 1280 x 1024, LAN card.

D. Installation and Setup

Installation and setup can be easily made by continuously clicking "Yes" after running "setup.exe" in IVMan Package.
After installation, you can run IVMan Main program by clicking "IVMan.exe"

If you bought IVMan and did not activate IVMan, license, you need to send some information to WonATech in order to get the license by selecting "Activate" on left bar's "Help"

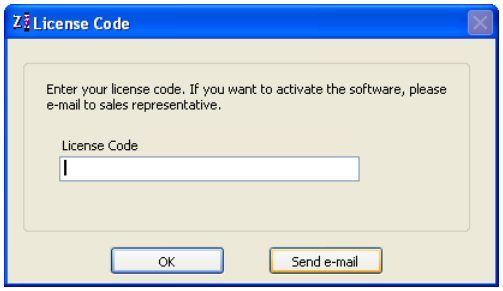

Figure 1.License Code

Click "send e-mail" button.

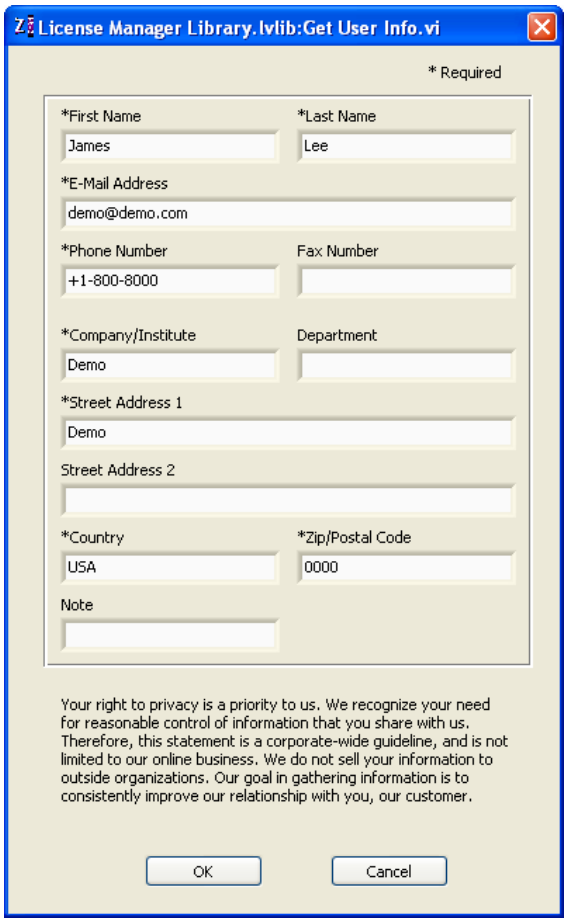

Figure 2. License code application form

If you did not buy IVMan and want to test this software for evaluation, click "cancel" button.
If you bought IVMan, then input information in blanks and click "OK" button

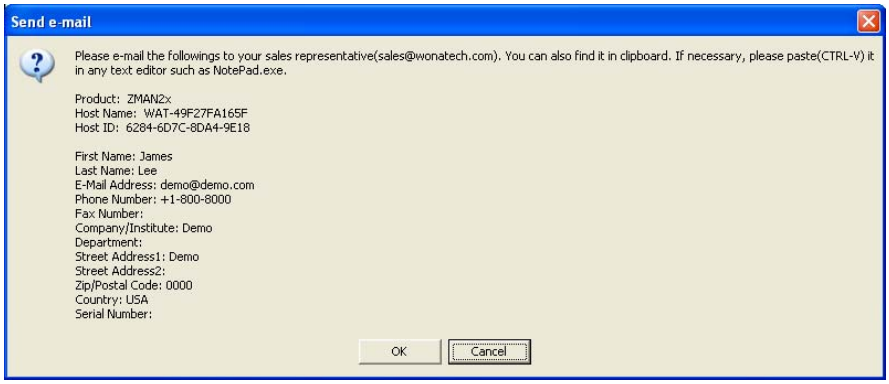

Figure 3.Send a mail

If you click "OK" button, The program bring default email software to send these information to WonATech to get license code. If your PC did not link internet, please paste (ctrl+v) these information into text editor and send this file to sales@wonatech.com by email. You can receive license code by email. Until receipt of license code, you can use IVMan for WonATech product's data formats (dmf,rfd,wdf,wif).

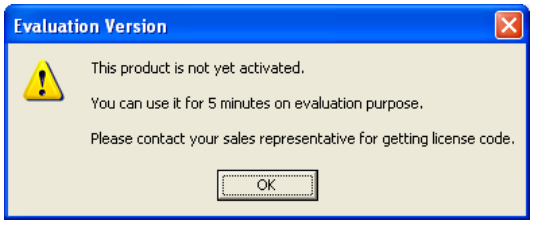

Figure 4.Notice for 5Minute operation

E. Licensing Note

IVMan license code is available per one PC. You must install IVMan into the PC which you want to use IVMan software.

F. Known Bug

IVMan uses Microsoft Common Control to open a file, however, the file open dialog is not loaded in some machines. It is caused from a licensing issue of the ActiveX control. The easiest way to fix it is to install Microsoft Visual Studio or Visual Basic.

G. Legal Information

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- Use in other PC

Term

This license is effective until terminated.

· If you have problems

Contact us at your earliest convenience.

We can be contacted via;

E-mail : service@wonatech.com

Fax : 82-2-576-2635

Phone : 82-2-578-6516

Address : WonATech Co., Ltd

8-6, WooMyun-Dong, SeoCho-Ku, Seoul 137-900, Korea

If you write to us about a problem, provide as much information as possible.

· Limited Warranty

WonATech Co., Ltd warrants to the original user of this product that it shall be free of defects resulting from faulty manufacture of the product.

WonATech Co., Ltd makes no warranties regarding either the satisfactory performance of IVMan package including the software encoded in this product or the fitness of the system for any particular purpose.

WonATech Co., Ltd reserves the right to make revisions to the system at any time without incurring any obligation to install same on systems previously purchased. All system specifications are subject to change without notice.

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IVMAN Main program

Chapter 1 File

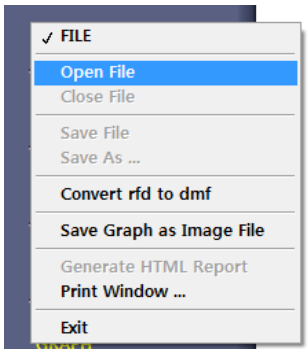


Figure 5. File Menu

A. Open File

In order to open the data file, click “File” on left side menu and select “Open file”

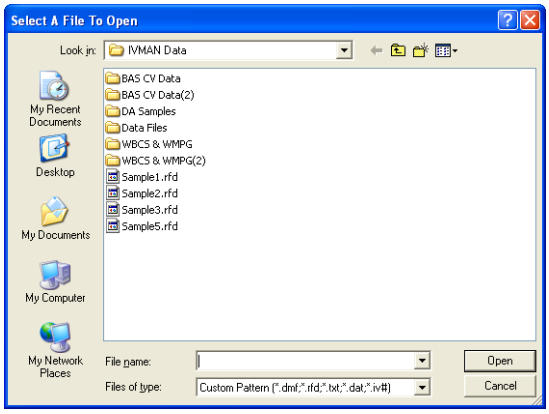


Figure 6. Select data file to open

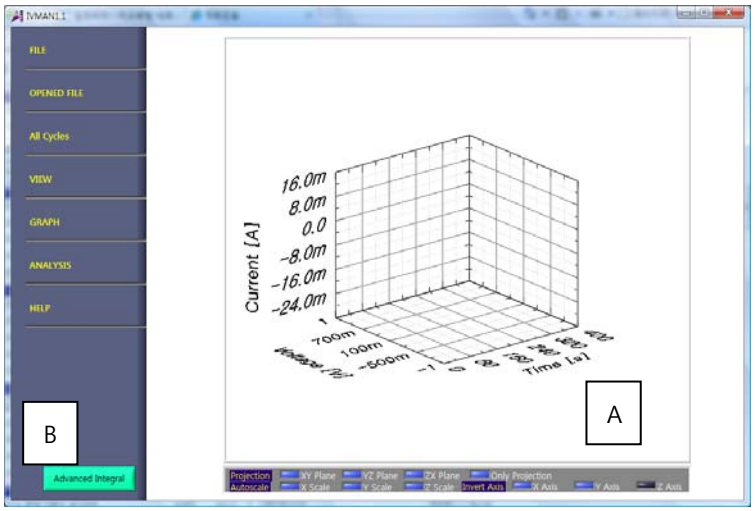


Figure 7. Main windows structure

You can select raw data then IVMan convert this file format into IVMan file format(*.dmf)

You can see 2 section as the above.

"A" section: Graphic section

"B" section: Menu section

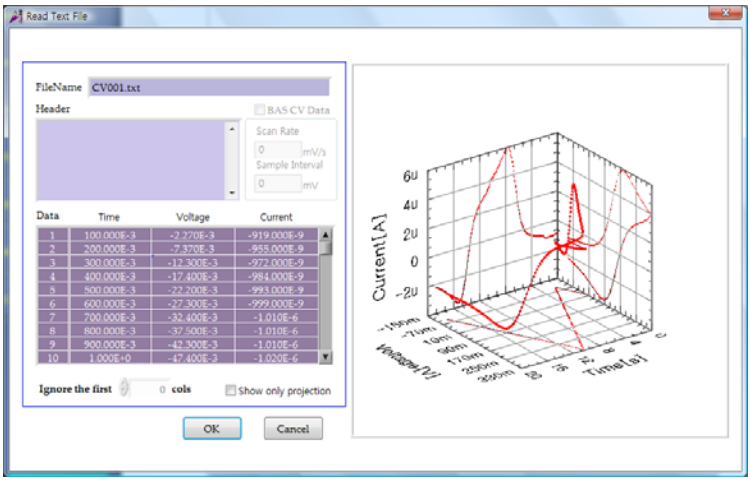
1. By data file source

There are three kind of open data file

1) Using 3rd parties ASCII file

If the data file come from 3rd parties' ascii file and the file consists series of data in order as time-voltage-current or or Bioanalytical System's Epsilon format (dat) then Once you select one data file, you may see the following window.

NOTE: each data must be numeric not text format. If data set is text format, IVMAN will treat them as note section.



a. Importing Ascii file

i. Press "**OK**".

ii. You can see following figure 11

2) Using registered data format

If you open registered data format(WonATech product's data format, then you can see the following messege box

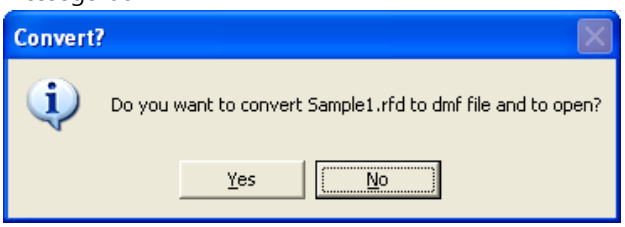


Figure 8. Converting file to IVman format

a. Press "**OK"**.

b. You can see following figure 11

3) IVMan file format

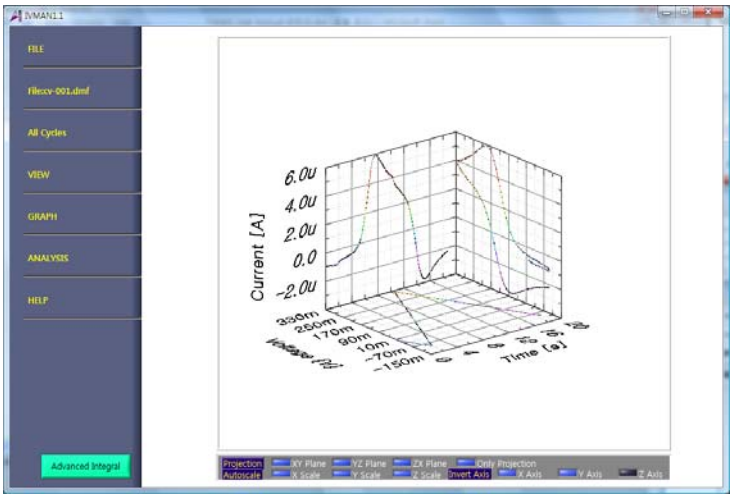


Figure 9. After loading data

2. File Selection

You can upload multiple files by the above process. The loaded data set will be located on memory so you can select uploaded file(s) by selecting it anytime.

Recent uploaded data file name is displayed at "OPENED FILE" section on left menu bar

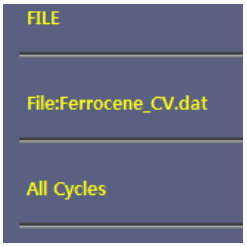


Figure 10. Display of recent uploaded file name

You can see file list by clicking uploaded file name

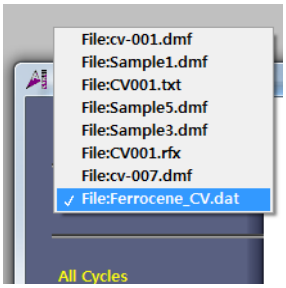


Figure 11. Uploaded File list

You can select file name to be activated for graphic and data analysis.

When you select file, you can see graph preview on 3D format at right side(section A)-Figure 8

3. Cycle Selection

If data file contains cycle information (multiple cycle), you can select "all cycle" or any of cycles for displaying and data analysis

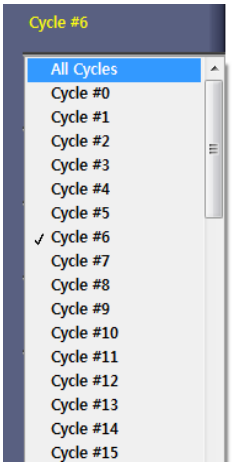


Figure 12. Cycle selection

B. Close File

If you want close recent open file or active file, select "Close" file in File menu at left side menu bar.

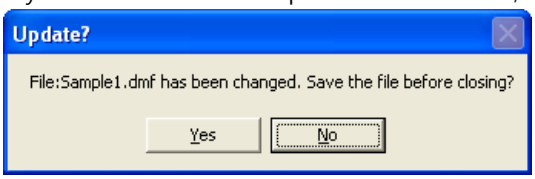


Figure 13. Confirmation message

C. Convert Rfd to dmf

If you want to convert rfd file(WonATech's WBCS,WMPG,WPG data file format) to IVMAN data file format(dmf), select this menu.

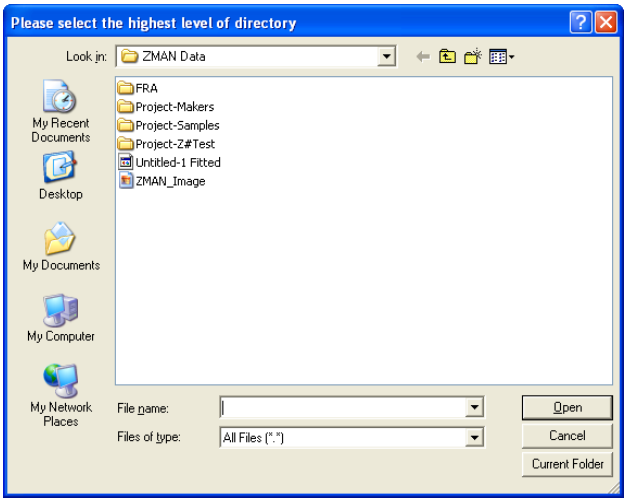


Figure 14. Select data file folder to be converted

You need to select folder which contains rfd data files and click "Current Folder"

Then you can see left side file select section. You can change this folder by clicking "change

directory" .

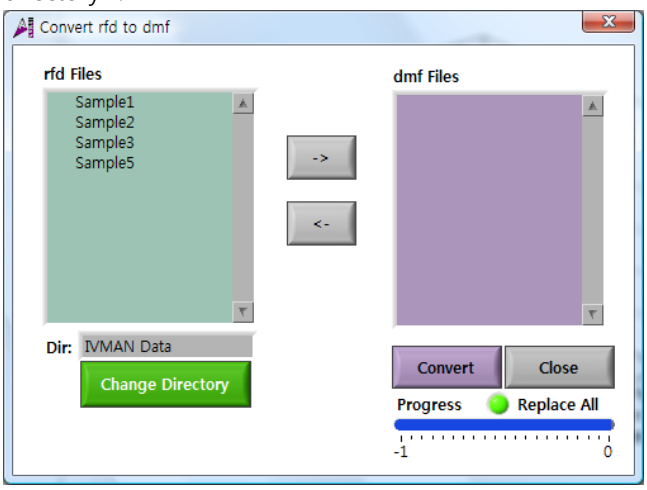


Figure 15. Select rfd folder

1. Select rfd file at left side for converting. You can select multiple files. To select multiple files, you can use ctrl+left mouse button click or dragging or shift+left mouse button click
2. Click -> button to move files to be converted.

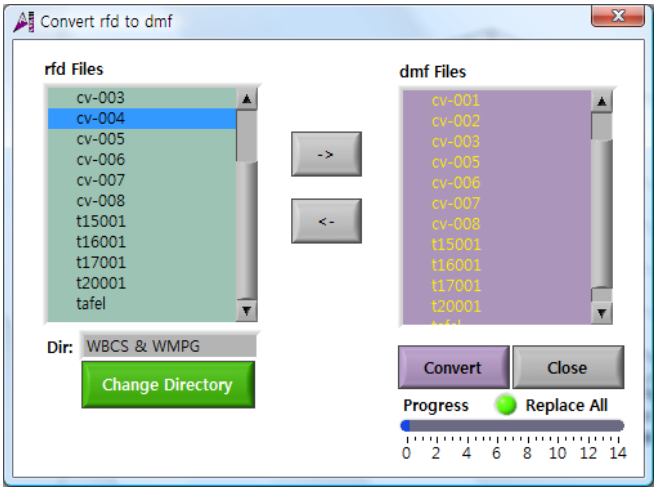


Figure 16. Multiple selection of rfd file to be converted

If you change your mind to convert some rfd file(s) which you located right side, select files to cancel and click <- button

When you ready to convert files, click "convert" button then rfd files will be converted to dmf files

If you do not want to overwrite them automatically to existing converted files, you can do turn off "Replace all" by clicking circle lest side of "Replace all". The color of this circle will be changed to grey.

After turn off "Replace all" and click "convert" button, if there is already converted file with same file name then you can see

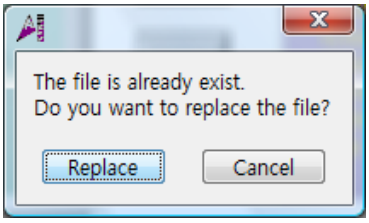


Figure 17. Overwrite confirmation

D. Save graph as image file

You can convert displayed graph at right side(section1) to jpeg file or bmp file format.

The displayed graph is different by graph menu selection, the converted image file is following this selection. If there is 3 graph on section1, the convertion will be done 3 times. (Each graph will be changed separately and have I.D(graph format name) after original file name.)

E. Generate HTML report

You can make report using this function. When you click this function you can see report name input window.

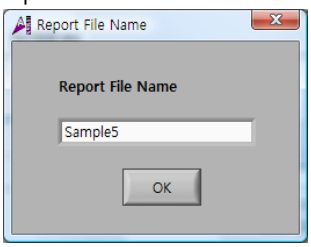


Figure 18. Report file name input window

Input the file name for report and click OK button then converting process will be done and the following window will be displayed.

Note: During converting process, You must wait till following display appears.

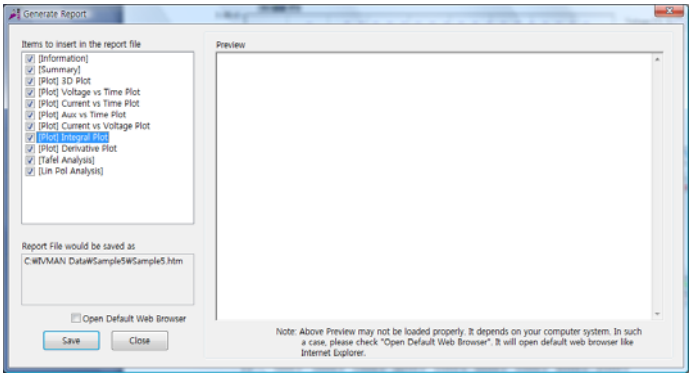


Figure 19. Report Items selection

1. Check items by **double clicking** which you want make your report.
2. If you want to see report after generating report, check on "open default web browser"
3. Click "Save" button then report file is generated same as on the above folder and files name(*.html).

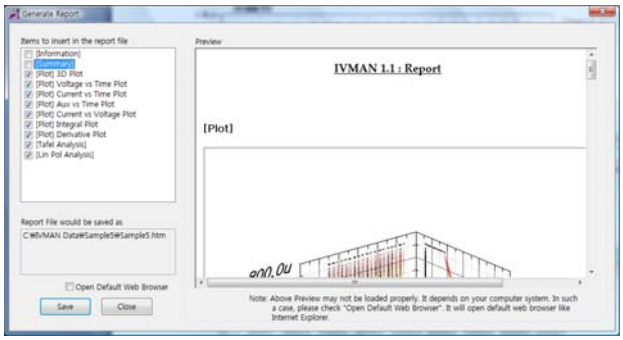


Figure 20. Preview of report after saving report file

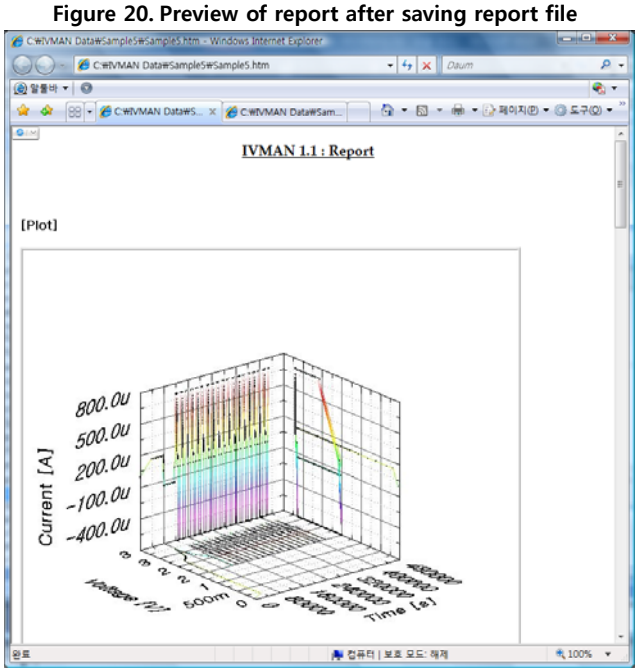


Figure 21. Report file Web browser view

Chapter 2 View

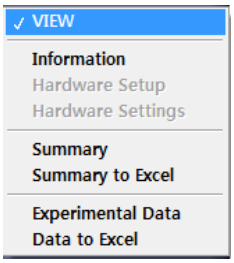


Figure 22. View menu

A. Information

If there is experiment information inside data file, This function shows this information.

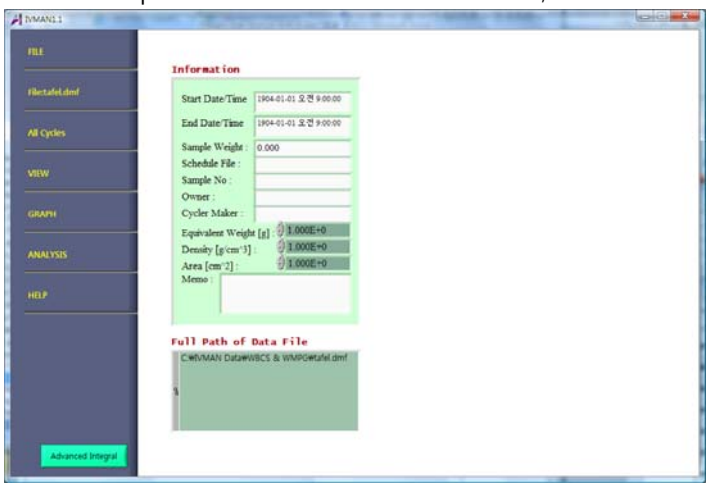


Figure 23. Experiment information display

B. Summary

Display experiment summary and you can export this data to excel format

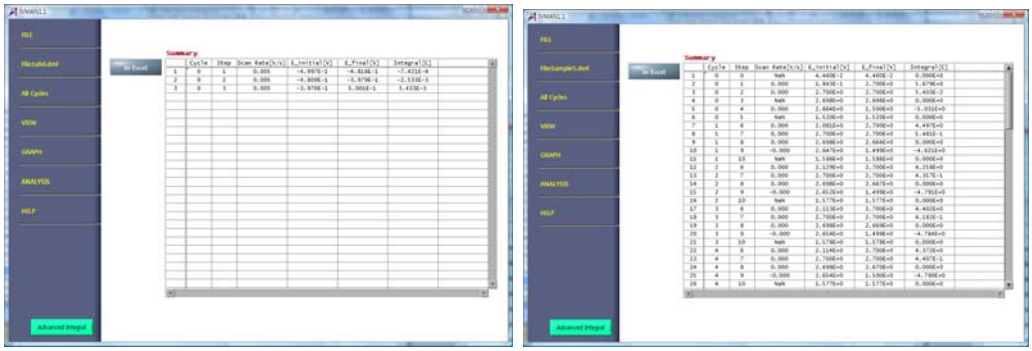


Figure 24. Display summary

C. Experiment Data

Display experiment data and you can export this data to excel format

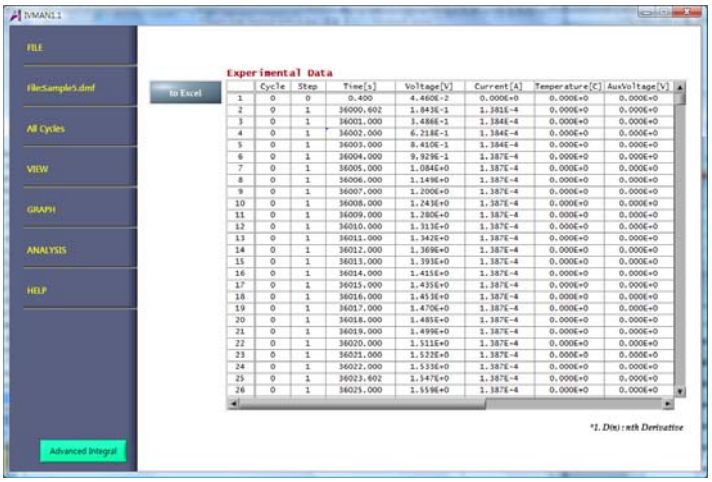


Figure 25. Experiment data display

You can see additional data information adding to original data; Semi integral, Integral, Semi derivative and *th derivative.

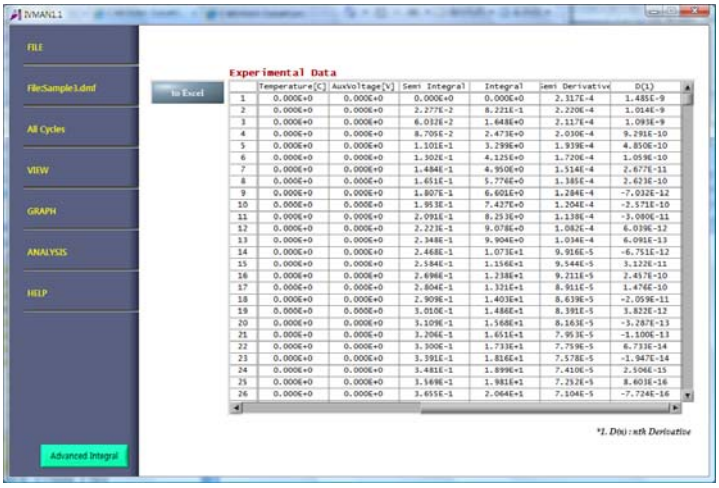


Figure 26. Additional data adding to original data

Chapter 3 Graph

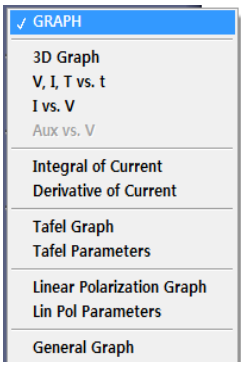


Figure 27. Graph menu

A. 3D graph

You can see 3D graph when you select this mode.

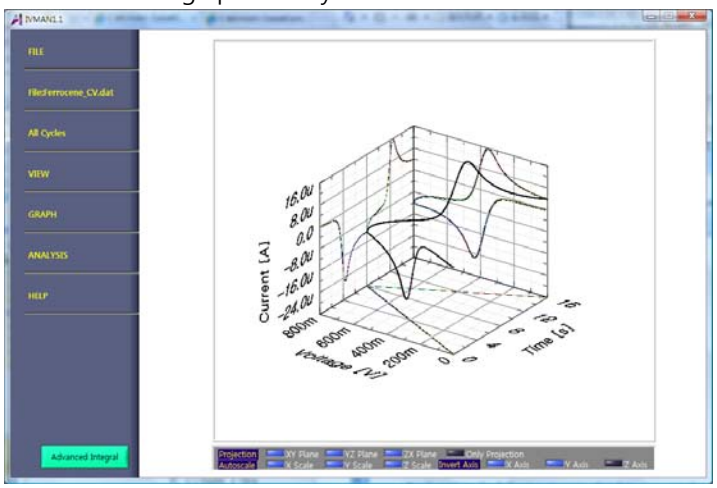


Figure 28. 3D graph

Figure 29. 3D graph menu

1. Projection

You can check on or check off each parameters to view or not.

- XY plane
- YZ plane
- ZX plane
- Only projection

2. Autoscale

This function makes autoscale function enable/disable

- Xscale
- Yscale

- Zscale

3. Invert Axis

- X-axis
- Y-axis
- Z-axis

4. View direction change

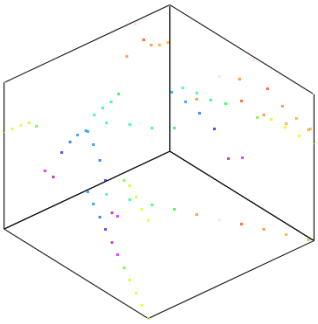


Figure 30. During dragging

You can change view angle by dragging on graph.

Note: In 3D graph, there is no submenu which describes in general graph function

B. V,I,T vs. t

This graph display 3 graphs versus time.

1) Voltage vs time
2) Current vs. time
3) Temperature vs. time

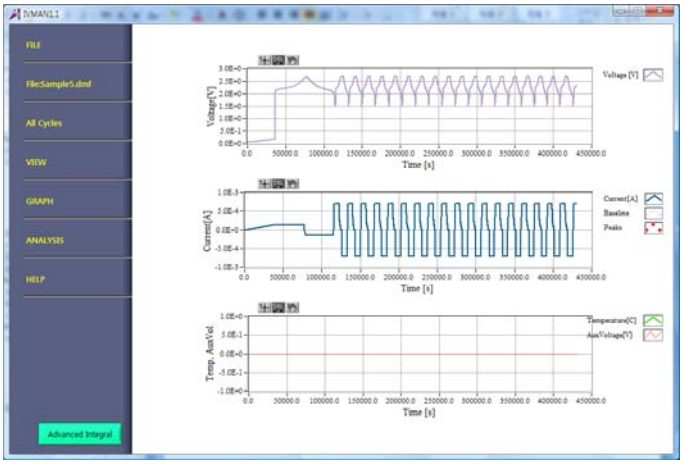


Figure 31. V,I,T vs. time graph

Note1): If there is no temperature data, temperature graph is blank.

Note2) Please refer to graph submenu for graphic function

C. I vs. V graph

This graph display Current vs. voltage.

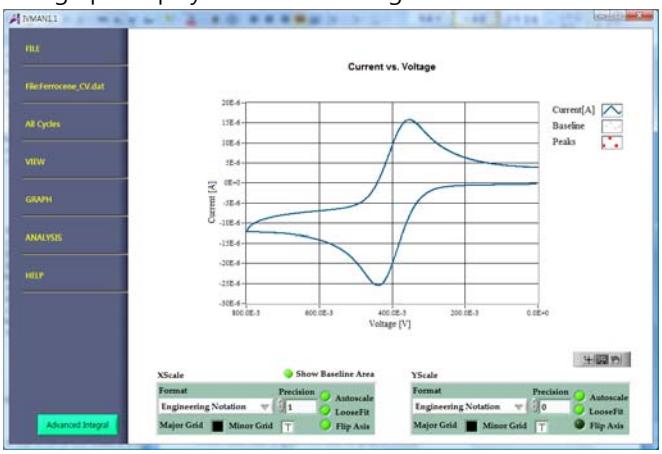


Figure 32. Current vs. Voltage graph

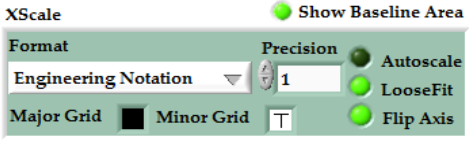


Figure 33. Graph axis menu

- Format: Axis value format selection
- Major grid, Minor grid: Grid color selection
- Precision: Valid numbers selection on axis
- Autoscale: On/off
- Loose fit: On/off

  If there are peaks by peak searching, using this function axis will fit the scale corresponding to peak height
- Flip axis: Opposite axis direction

D. Integral of current

This function makes integration of Current data versus time or voltage to get capacity(vs. time) or power(vs. voltage). You can select time or voltage at X axis selection.

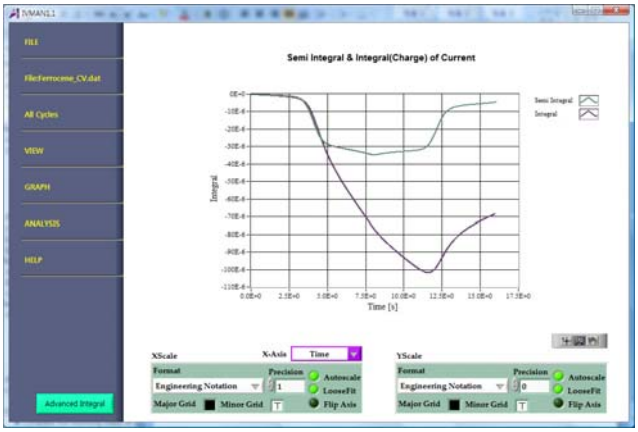


Figure 34. Current Integral vs. time graph

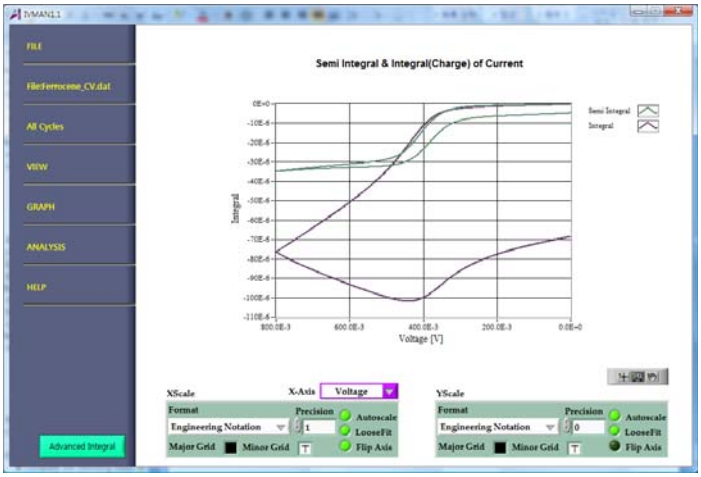


Figure 35. Current Integral vs. voltage graph

There are two line; One for Semi Integral and the other for Integral.

This graph will display calculated result by integral function on **analysis function.**

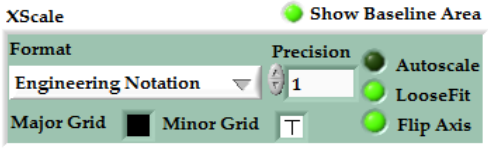


Figure 36. Graph axis menu

- Format: Axis value format selection
- Major grid, Minor grid: Grid color selection
- Precision: Valid numbers selection on axis
- Autoscale: On/off
- Loose fit: On/off

  If there are peaks by peak searching, using this function axis will fit the scale corresponding to peak height
- Flip axis: Opposite axis direction

Note: For analysis of battery charging discharging data, Use "advanced Integral" function.

E. Derivative of current

This function makes derivative of Current data versus time or voltage to get slope. You can select time or voltage at X axis selection.

This function makes integration of Current data versus time or voltage to get capacity(vs. time) or power(vs. voltage). You can select time or voltage at X axis selection.

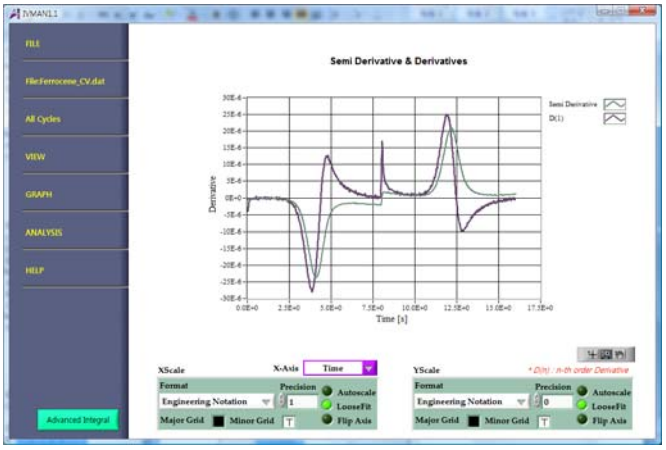


Figure 37. Derivative of Current vs. time

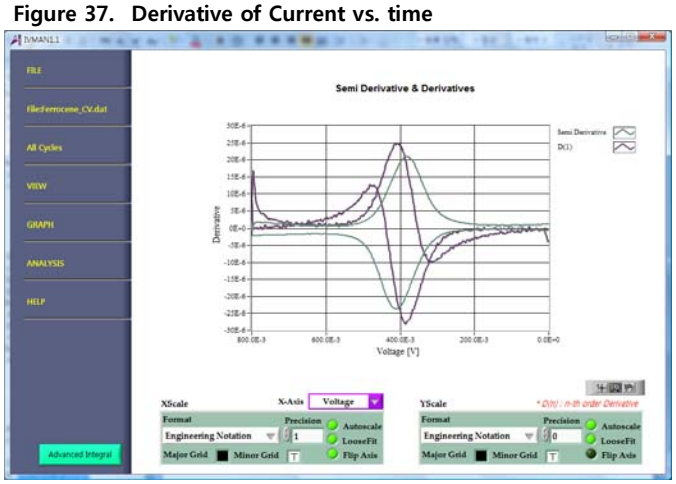


Figure 38. Derivative of current vs. voltage

This graph will display all calculated result by derivative function on **analysis function.**

If you did 2nd order, 3rd order derivative, the graph will show 2nd order derivative, 3rd order derivative as the following examples

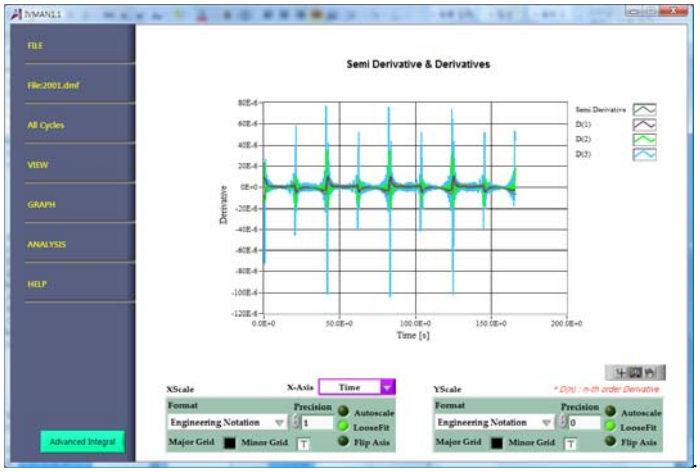


Figure 39. Semi derivative, 1st order derivative, 2nd order derivative, 3rd order derivative vs. time graph

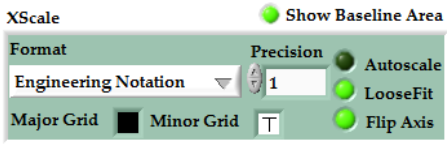


Figure 40. Graph axis menu

- Format: Axis value format selection
- Major grid, Minor grid: Grid color selection
- Precision: Valid numbers selection on axis
- Autoscale: On/off
- Loose fit: On/off
  If there are peaks by peak searching, using this function axis will fit the scale corresponding to peak height
- Flip axis: Opposite axis direction

F. Tafel graph

You can see Voltage vs. LogI in tafel graph. This graph will show the result from tafel analysis together.

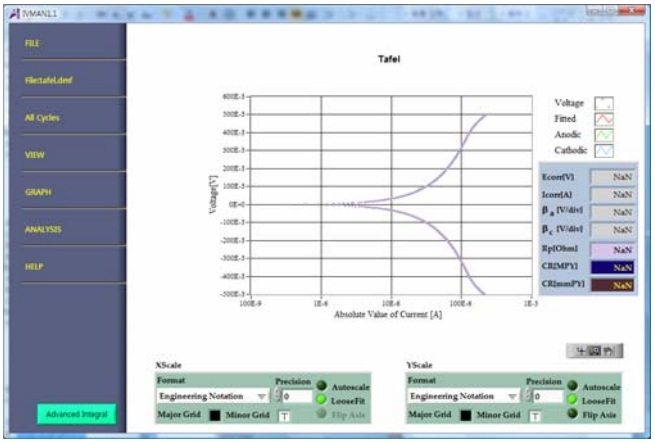


Figure 41. Tafel graph before analysis

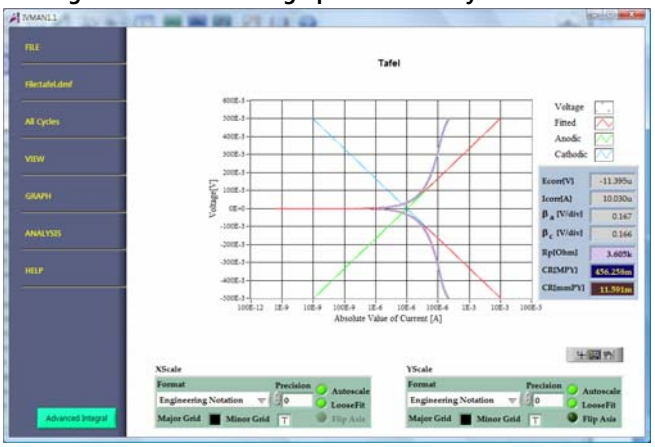


Figure 42. Tafel graph after analysis

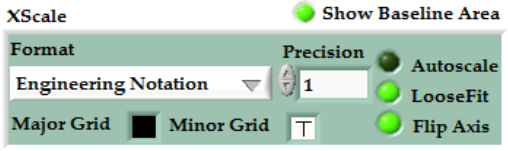


Figure 43. Graph axis menu

- Format: Axis value format selection

- Major grid, Minor grid: Grid color selection
- Precision: Valid numbers selection on axis
- Autoscale: On/off
- Loose fit: On/off

  If there are peaks by peak searching, using this function axis will fit the scale corresponding to peak height
- Flip axis: Opposite axis direction

See tafel analysis in analysis menu.

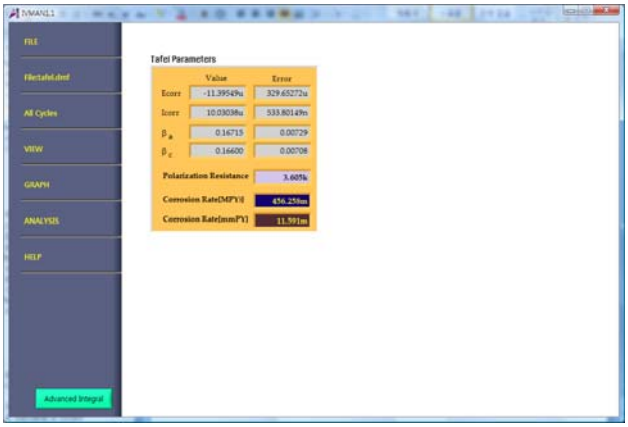


Figure 44. Tafel parameters viewer

G. Linear Polarization graph

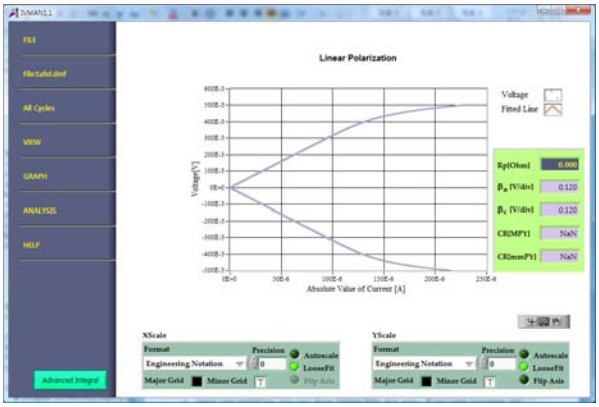


Figure 45. Linear polarization graph before analysis

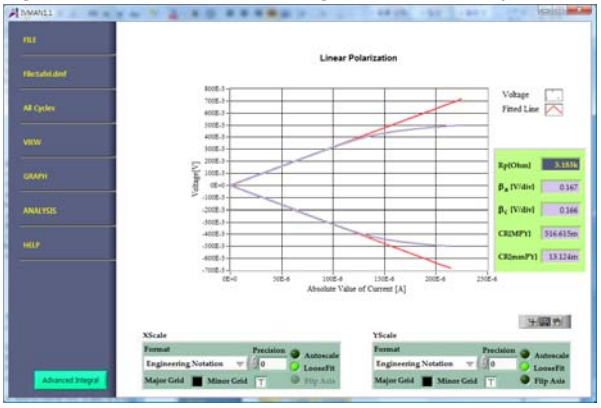


Figure 46. Linear polarization graph after analysis

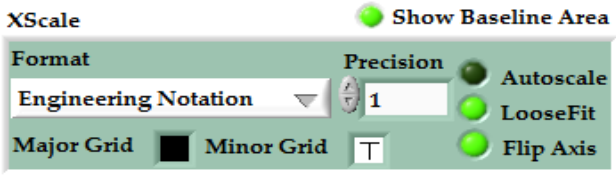


Figure 47. Graph axis menu

- Format: Axis value format selection
- Major grid, Minor grid: Grid color selection
- Precision: Valid numbers selection on axis
- Autoscale: On/off
- Loose fit: On/off

  If there are peaks by peak searching, using this function axis will fit the scale corresponding to peak height
- Flip axis: Opposite axis direction

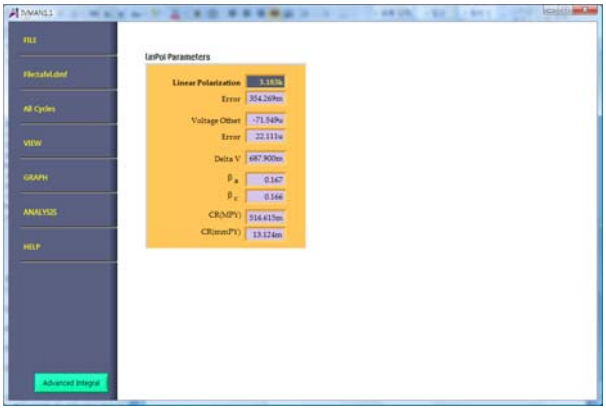


Figure 48. Linear polarization parameters

H. General graph

This function is for user selectable X,Y axis parameters.

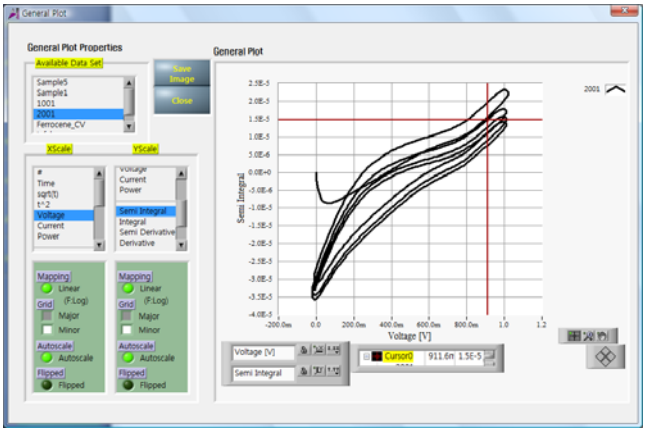


Figure 49. General graph

1. File selection for graph

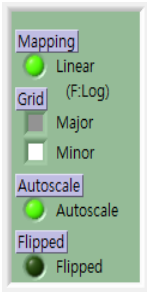
If you did upload multiple files, you can select multiple files to be activated for overlaying.
To select multiple files, you can use ctrl+left mouse button click or dragging or shift+left mouse button click in "Available data set".

2. X,Y axis parameter selection

You can freely select X and Y parameters. When you select parameter, graph will be changed following your selection

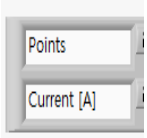
1) Point number
2) Time
3) Sqrt(t)
4) T^2
5) Voltage
6) Current
7) Power
8) Semi integral
9) Integral
10) Semi derivative
11) Derivative
12) Temperature
13) Auxiliary voltage

3. axis setting



- ✓ Mapping: Linear/Log selection
- ✓ Grid: Major/Minor grid color selection
- ✓ Autoscale: On/Off
- ✓ Flipped: Opposite axis direction

4. Axis label changing



You can change Label by typing inside the box then axis label will be changed.

Example) Tafel plot overlay

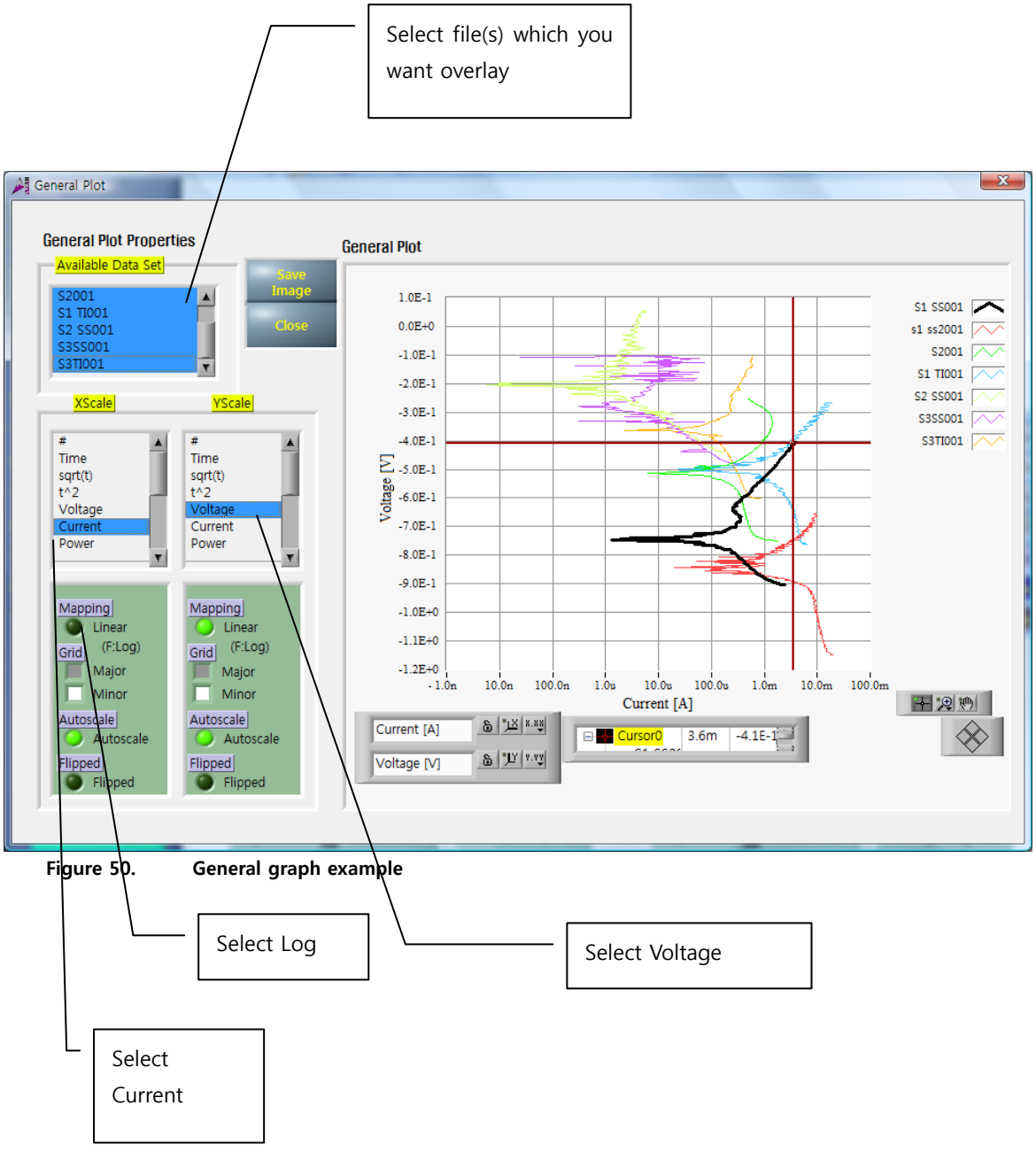


Figure 50. General graph example

I. Graph functions in IVMAN

• 2D Graph function

1) Zoom

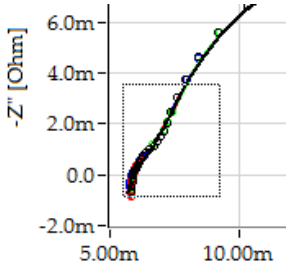


Figure 51. **Mouse dragging area for zoom up**

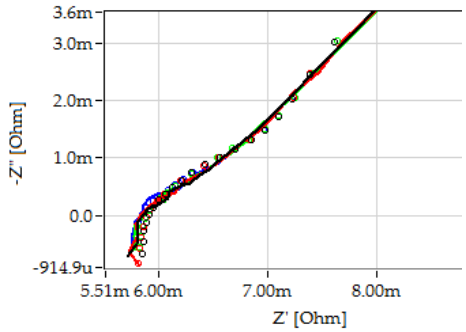


Figure 52. **Zoom up graph**

2) Axis scale

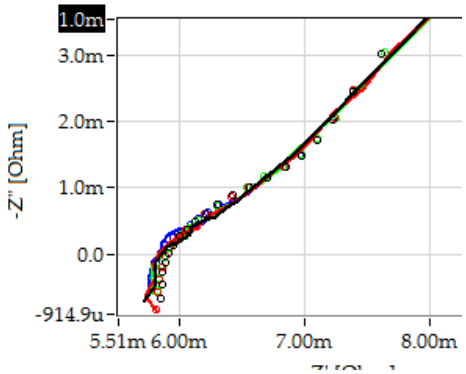


Figure 53. **Change maximum axis value by click on value**

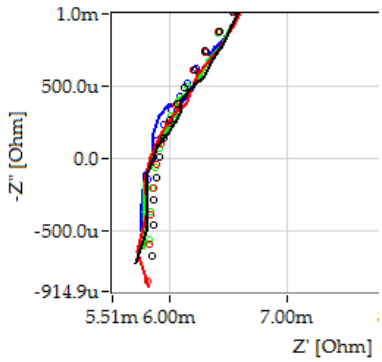


Figure 54. Zoom up graph

3) File name change on graph(Just displaying)

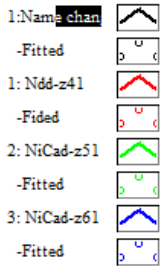


Figure 55. Click on file name and change it.

4) Graph internal function

Move cursor to inside of graph and click right button, then following sub menu will appear.

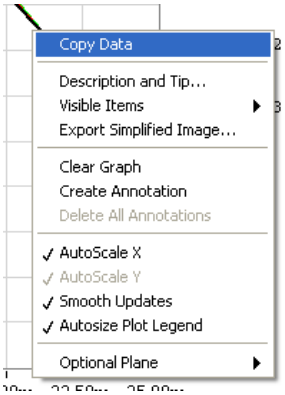


Figure 56. Graph submenu

a) Copy data: Copy graph to clipboard as following

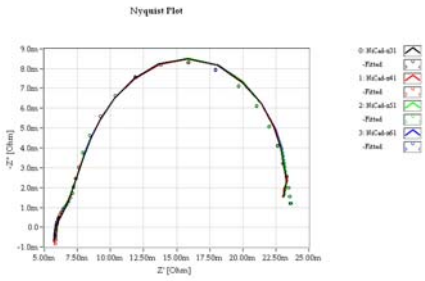


Figure 57. Copy data to clipboard

b) Visible Items

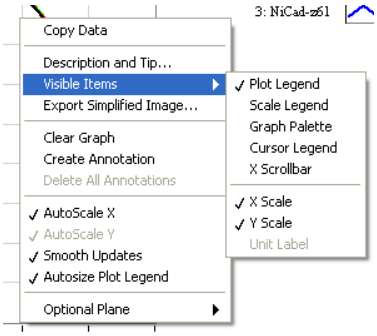


Figure 58. Visible item menu

b-1) Plot Legend On/Off

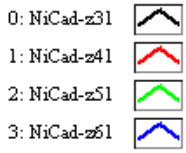


Figure 59. Legend on/off

b-2) Scale Legend On/Off

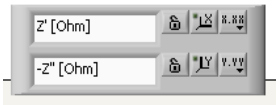


Figure 60. Scale legend

b-3) Graph Pallet

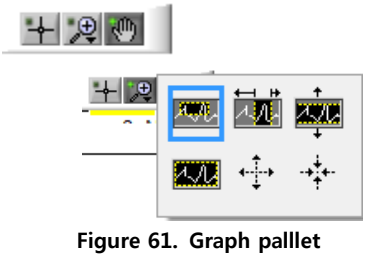


Figure 61. Graph palllet

b-4) Cursor Legend

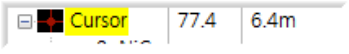


Figure 62. Cursor legend

c) Export simplified image

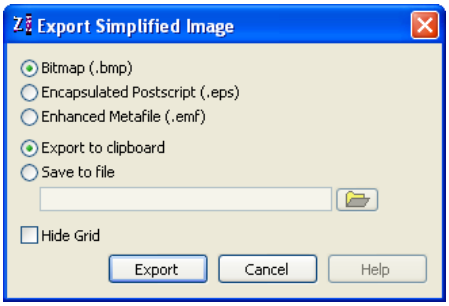


Figure 63. Export simplified image window

5) Side function of Graph

Move cursor to Legend and click on box right side of file name

a) Common plot

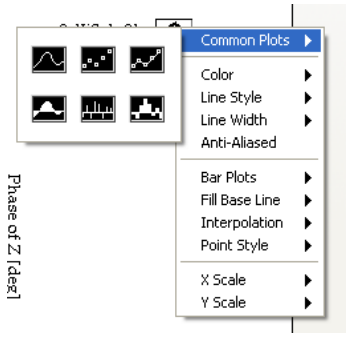


Figure 64. Plot menu

b) Line color

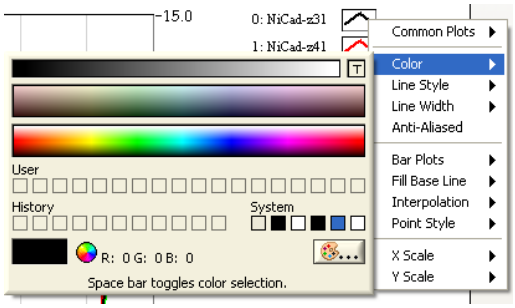


Figure 65. Line color

c) Line style

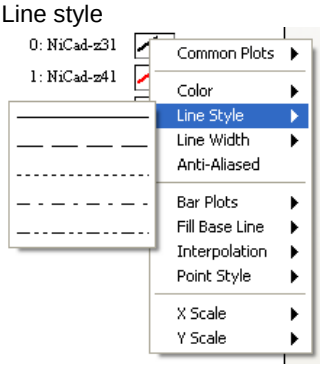


Figure 66. Line style

d) Line width

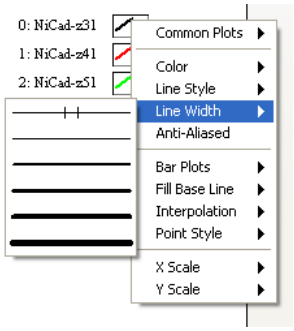


Figure 67. Line width

e) Bar plot

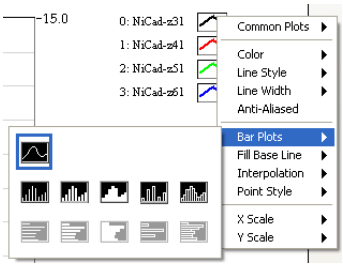


Figure 68. Bar plot

f) Interpolation

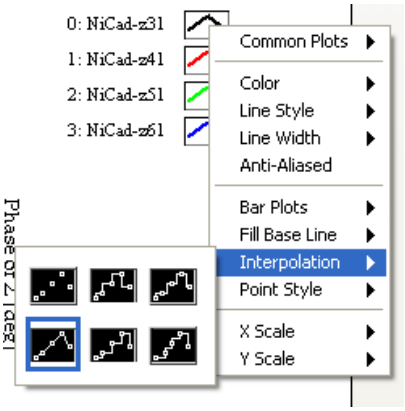


Figure 69. interpolation

g) Point Style

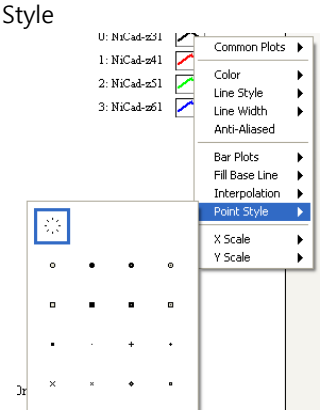


Figure 70. Point style

Chapter 4 Analysis

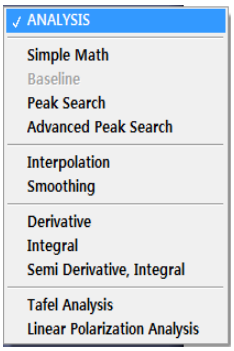
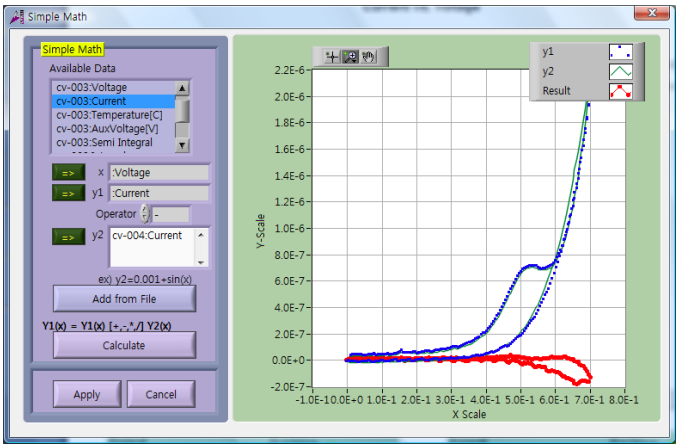


Figure 71. Analysis menu

A. Simple Math

This function will calculate the data by mathematical rule.

For example if you want blank subtraction, you can you this function.



1. X-axis for calculation

Select time or voltage on active data set for x-axis

2. Y1 axis for calculation

Target parameter on active data set to be used for calculation.

3. Operator selection

You can select +,-,x,/

4. Y2 input

You can input Y2 value to calculate.

Y2 value may be set as value or formula or external data set.

✧ Simple example

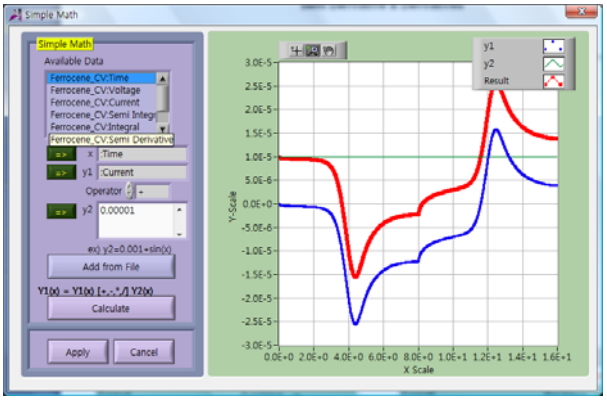


Figure 72. 10uA offset calculation(Blue line: original, green line: offset value(10uA), red line: calculated)

B. Peak search

This function is for searching peak on graph.

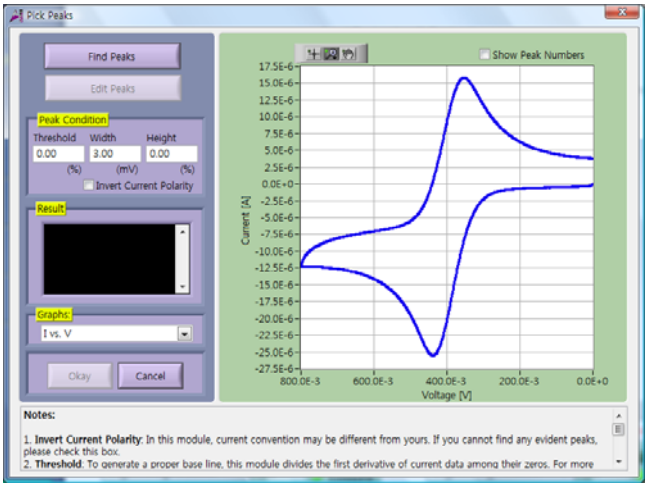


Figure 73. Peak search window

1. Peak searching condition

To find proper peak, you must set proper value

- Threshold: percent

  To generate a proper base line, this module divides the first derivative of current data among their zeros. For more details, please do "Advanced Peak Search" in main window.

- Width: x value width in x axis unit

  Width specifies the window size to use in the quadratic least squares fit. The value should be no more than about 1/2 of the half-width of the peaks and can be much smaller for noise-free data. Large widths can reduce the apparent amplitude of peaks and shift the apparent location. Ideally, width should be as small as possible but must be balanced against the possibility of false peak detection due to noise.

- Height: y value percent

  This module ignores any peak found with a amplitude that is less than Height above the base-line.

➢ Invert current polarity

In this module, current convention may be different from yours. If you cannot find any evident peaks, please check this box.

2. Find peaks

Click "Find peaks".

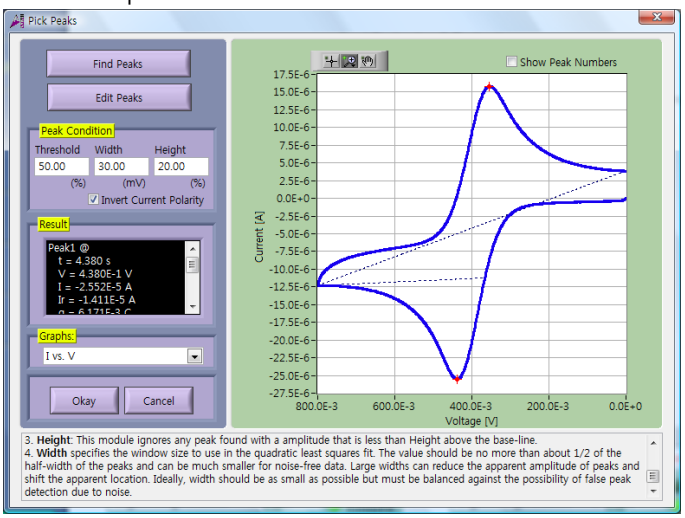


Figure 74. Peak find result in I vs. V graph

If you found peaks successful, you can see result data on Result section.

You can change graph format between I vs V or V,I vs time.

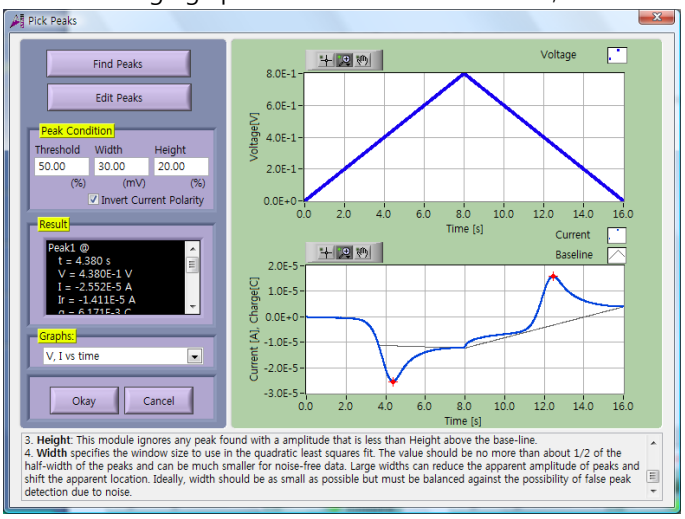


Figure 75. Peak find result in V,I vs time graph

If the searching parameters in peak condition is not proper, abnormal peak was found, you can re-adjust some parameters and try to find peaks again or you can edit some peak on peak editor.

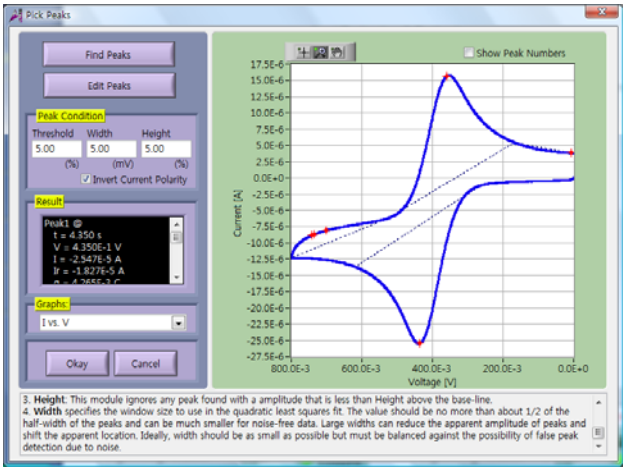


Figure 76. Abnormal peak searching result

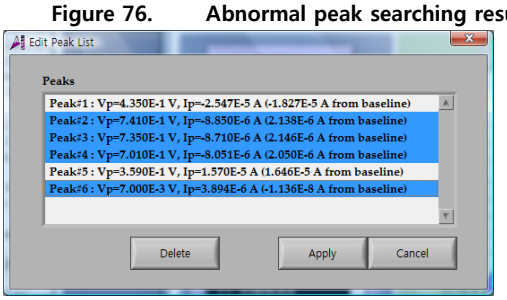


Figure 77. Edit peak list

- ✓ Select peaks to be deleted by click on the list (ctrl or shift key pressed). (blue list on above examples)
- ✓ Click delete button

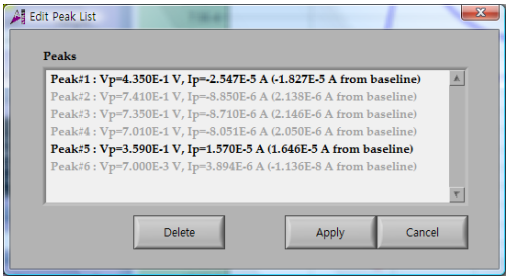


Figure 78. Peak deleted result

- ✓ Click apply button

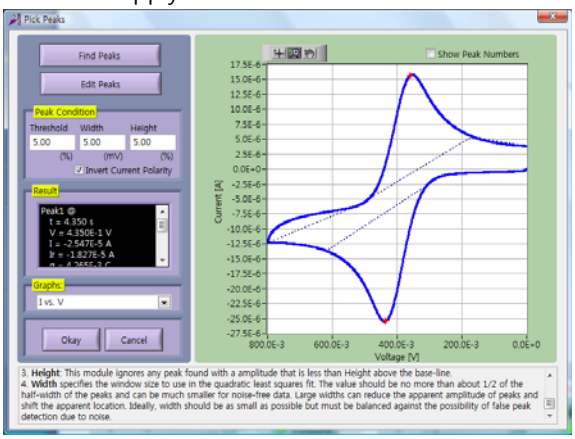


Figure 79. Peak edit result

C. Advanced peak search

This function is wizard function to find proper peaks.

1. Step1: Choose data set

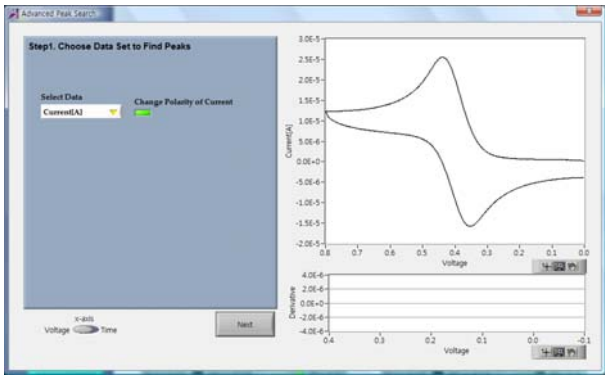


Figure 80. Advanced peak search front window

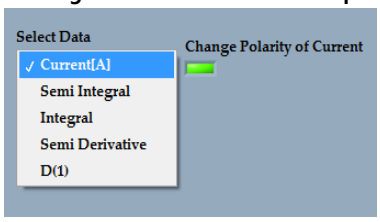


Figure 81. Target parameter selection for peak searching

- ✓ Select data and X axis parameters in time or voltage
- ✓ Click Next

2. Step2: Derivative

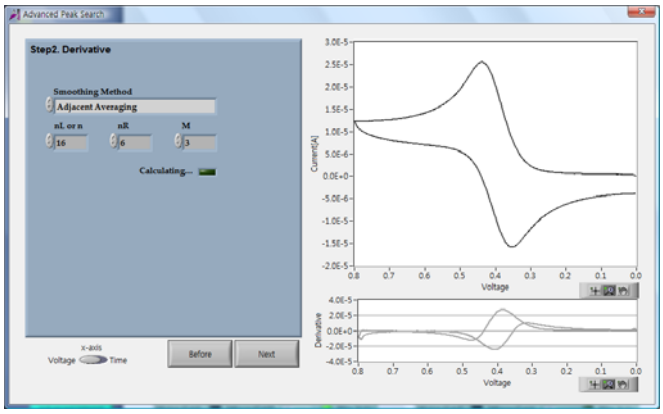


Figure 82. Smoothing method selection

Selecting Smoothing Method

- ✓ No smoothing
- ✓ Adjacent averaging
- ✓ Savitzky-Golay Smoothing Filter
- ✓ FFT filter

3. Step3: Baseline point

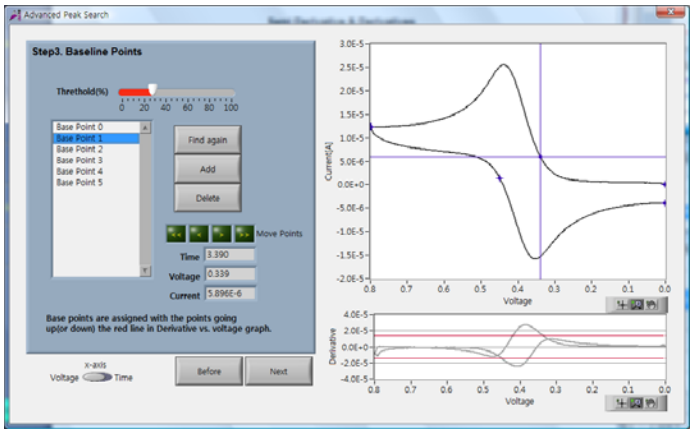


Figure 83. Baseline point determination

1) Move Threshold bar which you expected
2) Click "find again" button
3) If founded baseline points is not accurate, adjust Threshold value by moving threshold bar
4) Click :find again" button
5) You can "add" and/or "delete" base line point by clicking "add" button and/or "delete" button after selecting the point left side
6) Each selected point can move by click "move points" button

4. Step4: Peak find

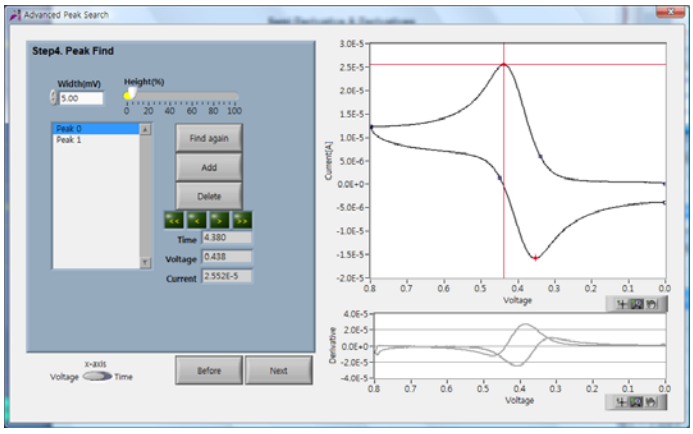
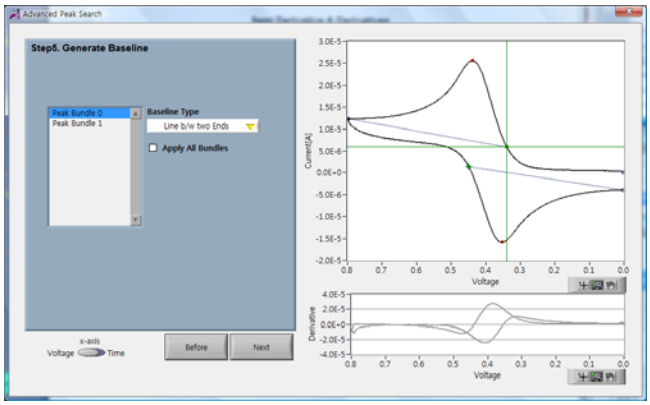


Figure 84. Peak find window

1) Select peak width and height
2) Click "find again"
3) If founded peak points is not accurate, adjust width and or height value by moving threshold bar
4) Click :find again" button
5) You can "add" and/or "delete" peak point by clicking "add" button and/or "delete" button after selecting the point left side
6) Each selected point can move by click "move points" button

5. Step5: Generate Base line



- ✓ Select base line type
  - o Constant
  - o Line with slope
  - o Line between two ends

6. Result of peak search

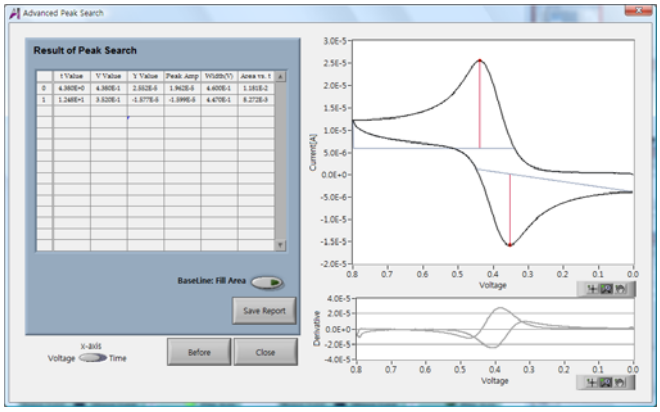


Figure 85. Result of peak search

You can generate report as html format by pressing "save report" button

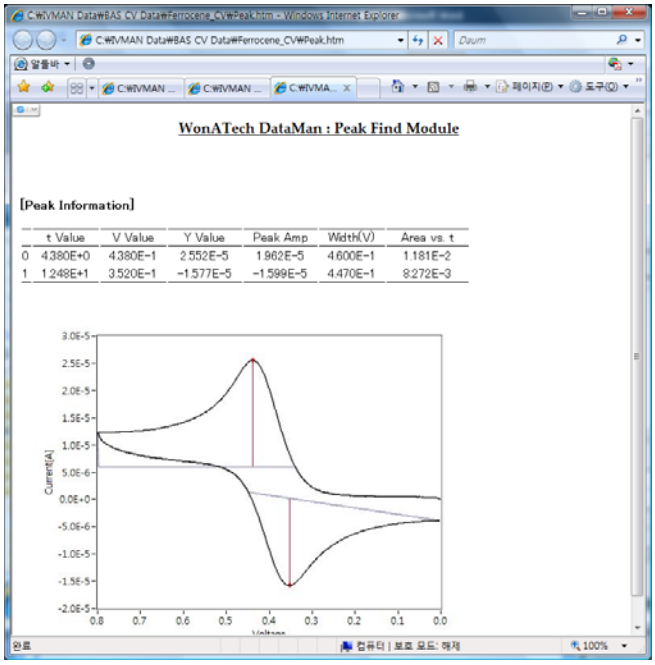


Figure 86. Peak find result report output

You can fill peak area by clicking "baseline fill area button"

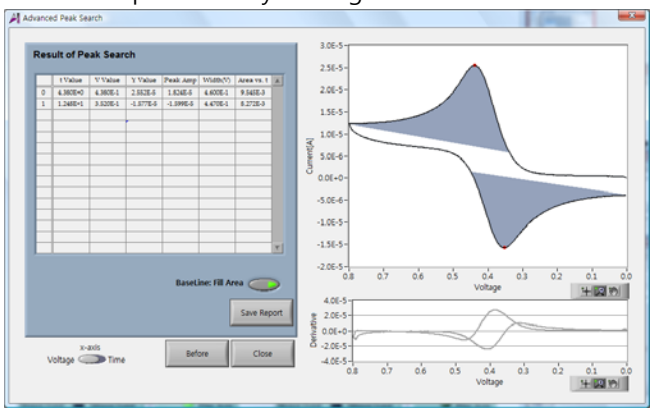


Figure 87. Baseline fill area

D. Interpolation

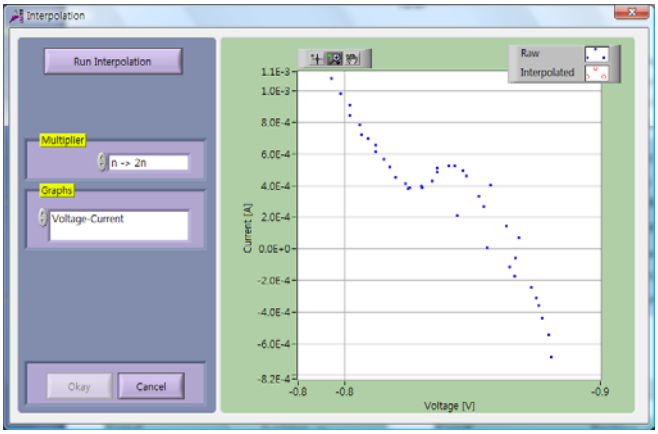


Figure 88. Interpolation window

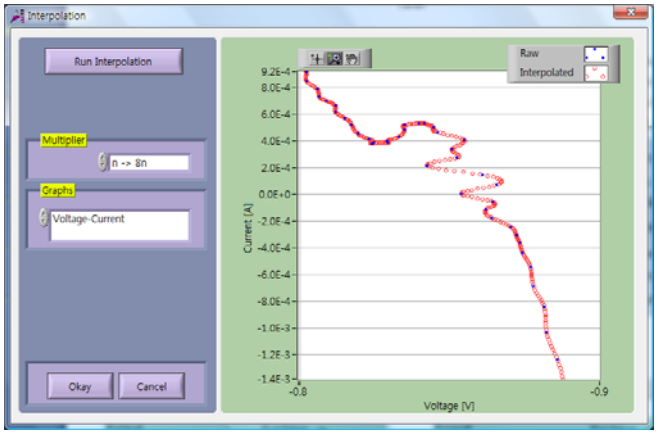


Figure 89. Interpolation result using n->8n

Interpolation*-(From Wikipedia)*

In the mathematical subfield of numerical analysis, ***interpolation*** *is a method of constructing new data points within the range of a discrete set of known data points.*

In engineering and science one often has a number of data points, as obtained by sampling or experimentation, and tries to construct a function which closely fits those data points. This is called curve fitting or regression analysis. Interpolation is a specific case of curve fitting, in which the function must go exactly through the data points.

A different problem which is closely related to interpolation is the approximation of a complicated function by a simple function. Suppose we know the function but it is too complex to evaluate efficiently. Then we could pick a few known data points from the complicated function, creating a lookup table, and try to interpolate those data points to construct a simpler function. Of course, when using the simple function to calculate new data points we usually do not receive the same result as when using the original function, but depending on the problem domain and the interpolation method used the gain in simplicity might offset the error.

It should be mentioned that there is another very different kind of interpolation in mathematics, namely the "interpolation of operators". The classical results about interpolation of operators are the Riesz-Thorin theorem and the Marcinkiewicz theorem. There also are many other subsequent results

Definition

From inter meaning between and pole, the points or nodes. Any means of calculating a new point between two or more existing data points is interpolation.

There are many methods for doing this, many of which involve fitting some sort of function to the data and evaluating that function at the desired point. This does not exclude other means such as statistical methods of calculating interpolated data.

One of the simplest forms of interpolation is to take the arithmetic mean of the value of two adjacent points to find the mid point. This will give the same result as a linear function evaluated at the midpoint.

Given a sequence of n distinct numbers x_k called ***nodes*** *and for each x_k a second number y_k, we are looking for a function f so that*

$$f(x_k) = y_k \ , \ k = 1, \ldots, n$$

A pair $x_k y_k$ is called a ***data point*** *and f is called an* ***interpolant*** *for the data points.*

When the numbers y_k are given by a known function f, we sometimes write f_k.

E. Smoothing

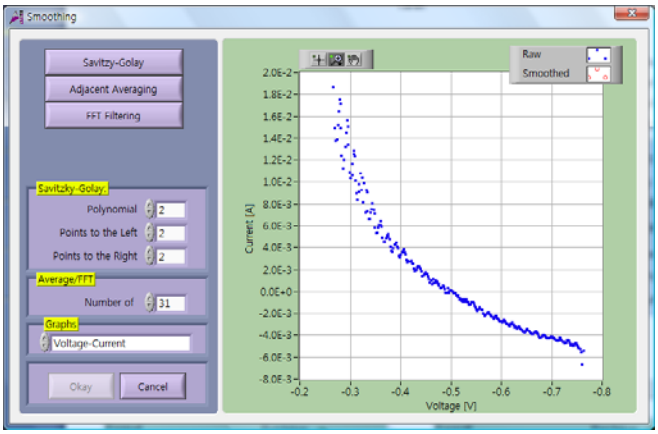


Figure 90. Smoothing window(voltage-current)

You can select graph format in voltage-current or time-voltage & time current or power spectrum.

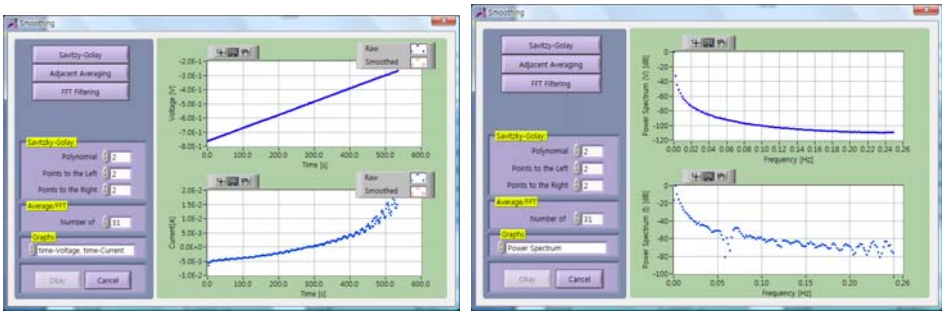


Figure 91. Time-voltage/time-current , power spectrum graph for smoothing

1. Savitzy-Golay smoothing

Input parameters for savitzy-golay smoothing.

Polynominal value, Points to the left, Points to the light

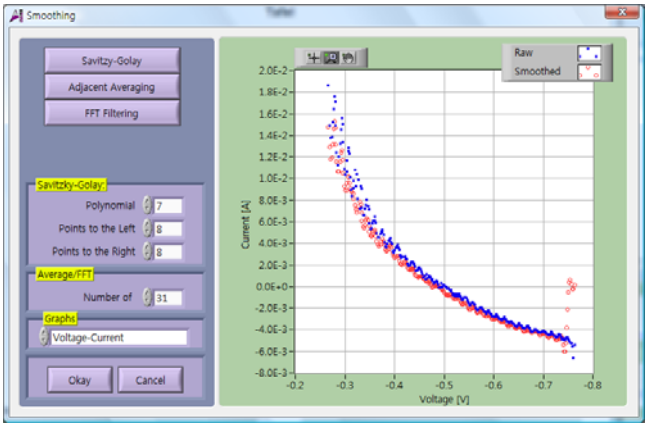


Figure 92. Savitzky-Golay smoothing

Savitzky–Golay smoothing *(From Wikipedia)*

The ***Savitzky–Golay smoothing filter*** *is a type of filter first described in 1964 by Abraham Savitzky and Marcel J. E. Golay. The Savitzky–Golay method essentially performs a local polynomial regression (of degree k) on a distribution (of at least k+1 equally spaced points) to determine the smoothed value for each point. Methods are also provided for calculating the first up to the fifth derivatives.*

The main advantage of this approach is that it tends to preserve features of the distribution such as relative

maxima, minima and width, which are usually 'flattened' by other adjacent averaging techniques (like moving averages, for example).

The paper that the filter appeared in is one of the most widely cited papers in the journal Analytical Chemistry and is classed by that journal as one of its "10 seminal papers" saying "it can be argued that the dawn of the computer-controlled analytical instrument can be traced to this article". Savitzky and Golay's original paper contained several typographical errors that were subsequently corrected by Steinier, Termonia, and Deltour

2. Adjacent averaging

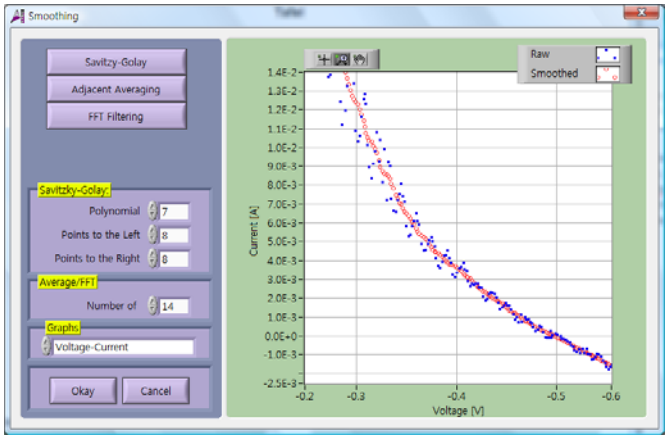


Figure 93. Adjacent averaging result

Select the point number for averaging

3. FFT filtering

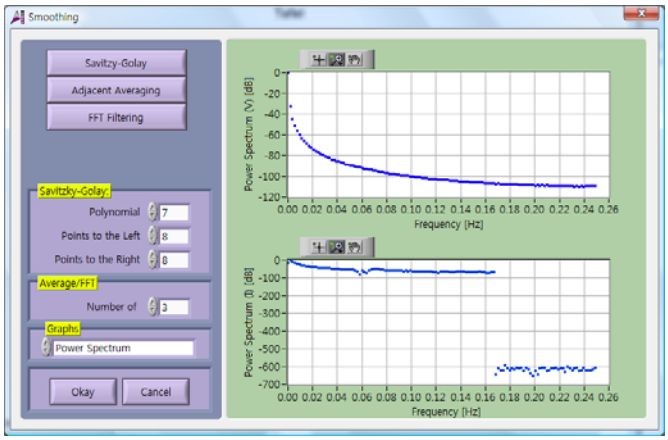


Figure 94. FFT filtering result

F. Differentiation

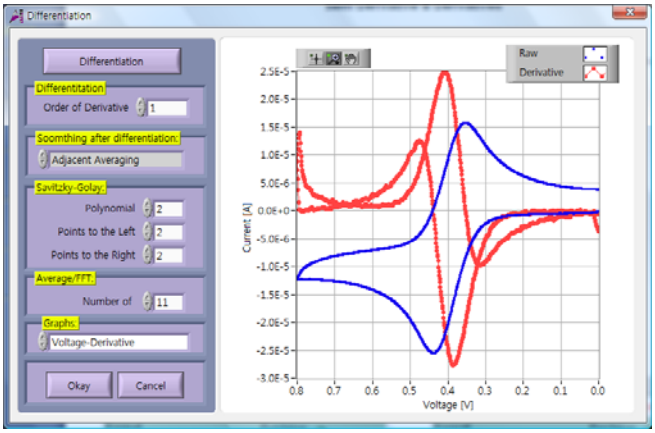


Figure 95. Differentiation window

1) Select derivative order

2) Select smoothing method after differentiation

3) Click "Differentiation" button

The result will display on the graph as overlay

G. Integral

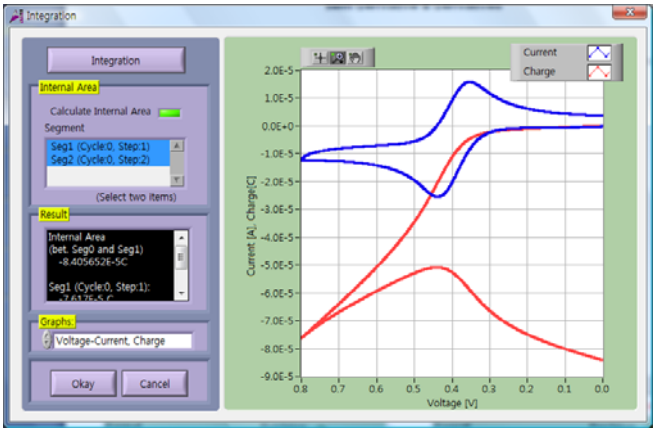


Figure 96. Integral window (current vs. voltage graph)

You can calculate internal area by check "calculate internal area"

Also you can see graph type with current vs. voltage or voltage vs.time current vs. time

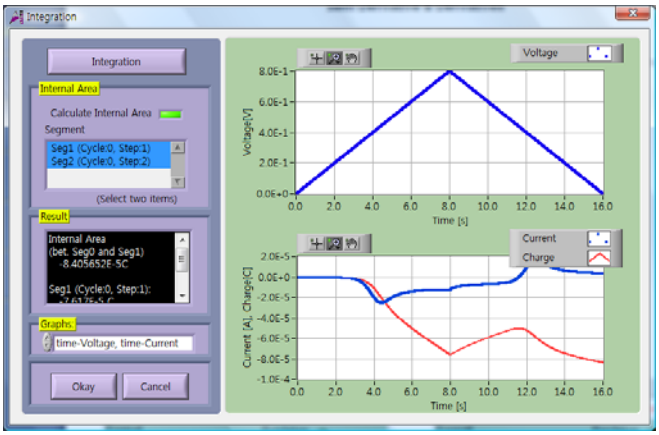


Figure 97. Integral window (voltage vs. time ,current vs. time graph)

H. Semi-Derivative, Integral

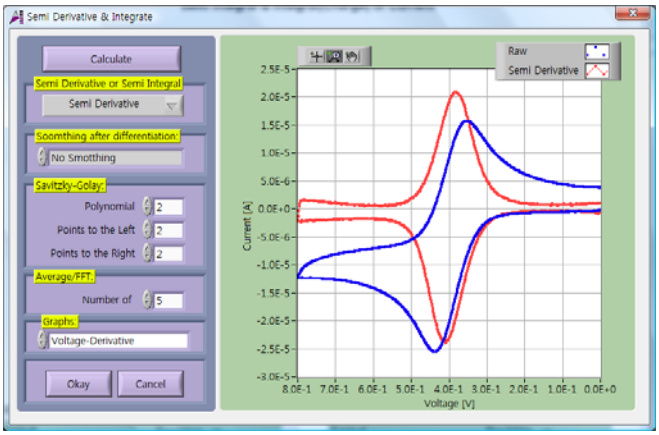


Figure 98. Semi derivative result

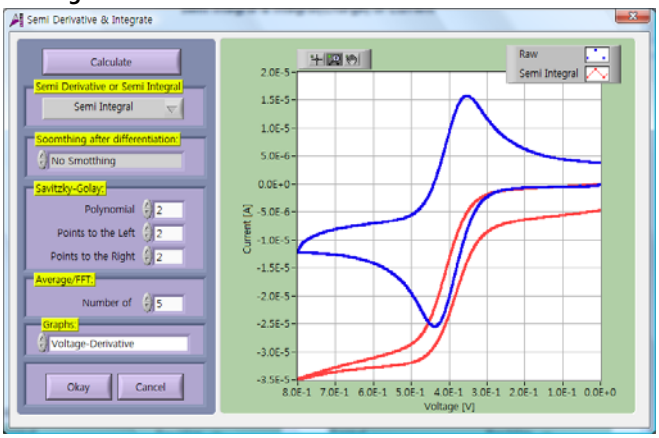


Figure 99. Semi integral result

1) Select Semi derivative or Semi integral

2) Select smoothing type after Semi derivative or integral

I. Tafel analysis

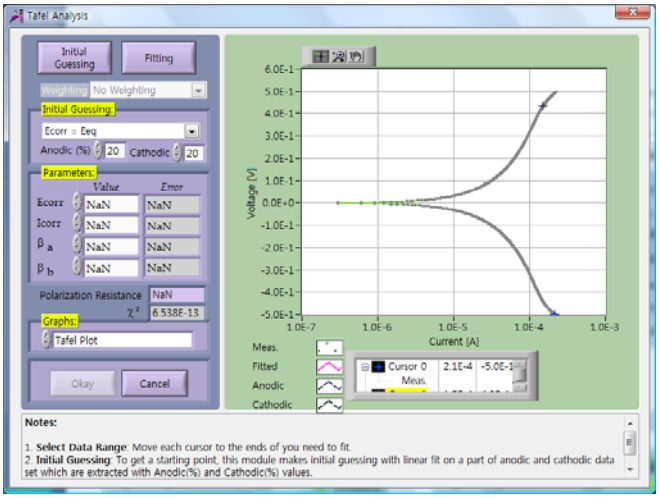


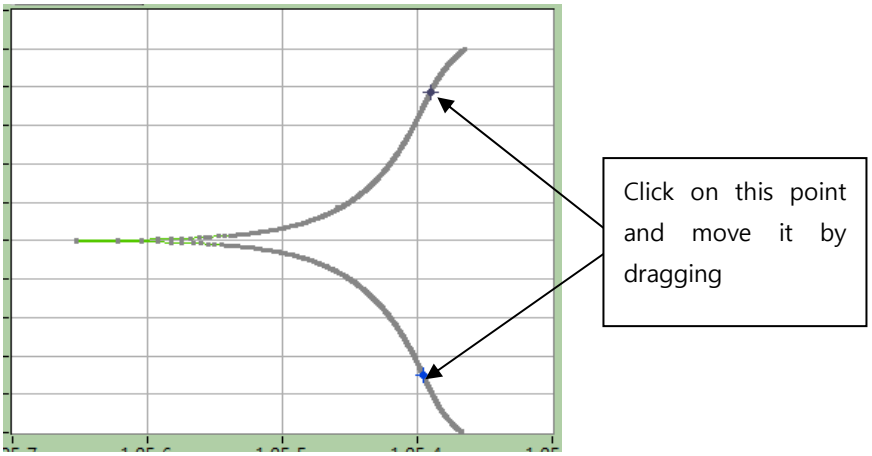
Figure 100. Tafel analysis window

Tafel analysis can get tafel coefficient and corrosion rate.

To get corrosion rate, You must provide equivalent weight and density and active area.

1. Determine tafel region

1) Select data range: Move two points at anodic region and cathodic region to proper points. IVMan will fit and calculate tafel coefficient using within this region. In order to set anodic limit point and cathodic limit point for tafel region, click point and drag it to the location.



2. Initial guessing:

To get a starting point, this module makes initial guessing with linear fit on a part of anodic and cathodic data set which are extracted with Anodic(%) and Cathodic(%) values. Also you can select Ecorr value as Ecorr=Eeq or (E,I)corr=Intersection point)

1) Click Initial guessing

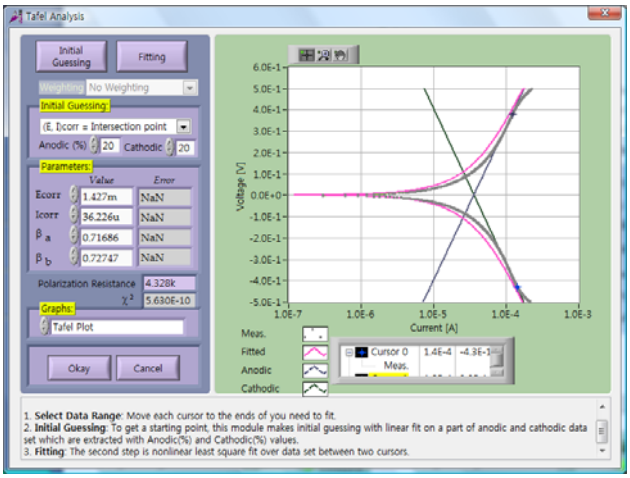


Figure 101. Initial guessing result

2) If initial guessing is not expected, goto 1) step and retry.

3. Fitting

1) If initial guessing result is satisfied, click fitting.

Fitting on this process is nonlinear least square fit over data set between two cursors.

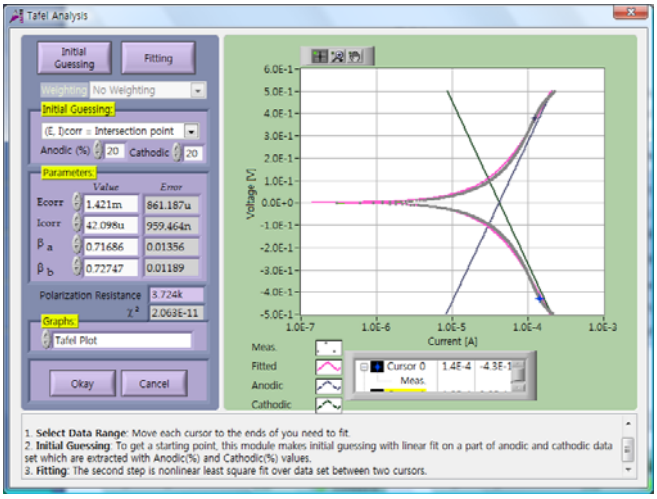


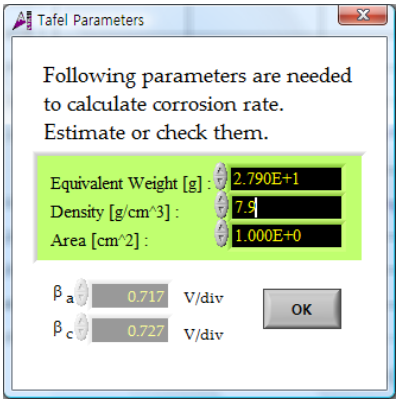
Figure 102. Fitting result

The fitting result is corrosion potential(Ecorr), Corrosion current(Icorr), Anodic Tafel coeffient(Ba), Cathodic tafel coefficient(Bc). Polarization resistance value is also calculated.

2) Click "Okay" button

4. Corrosion rate calculation

1) New input windows will appear



To get corrosion rate(mpy), you must input equivalent weight, density, and active area of your sample

2) Click "OK" button

You can see result as the follows

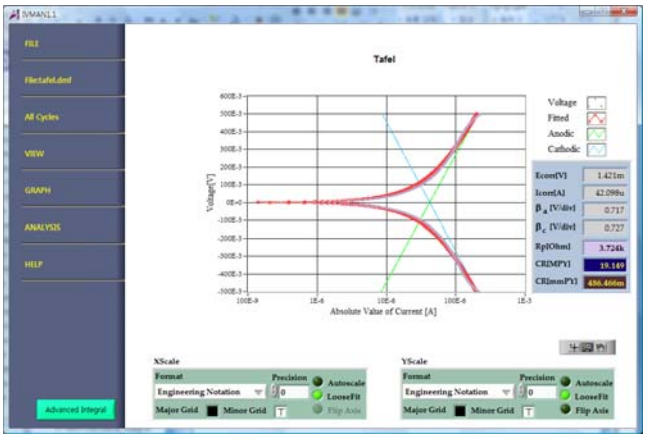


Figure 103. Tafel analysis result

J. Linear Polarization analysis

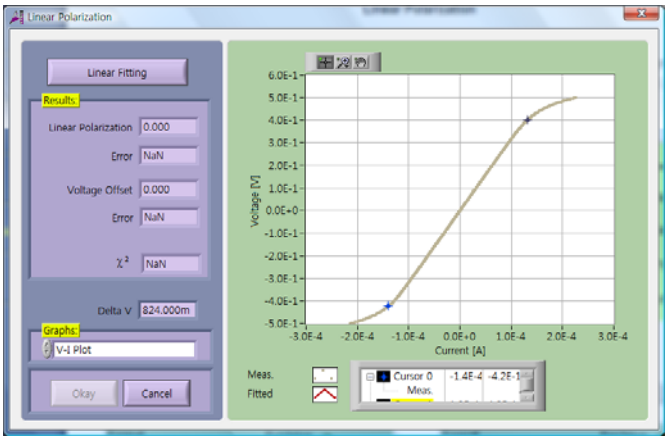


Figure 104. Linear polarization analysis window

1) Select data range: Move two points at anodic region and cathodic region to proper points. IVMan will fit and calculate polarization resistance using within this region. In order to set anodic limit point and cathodic limit point for linear polarization region, click point and drag it to the location.

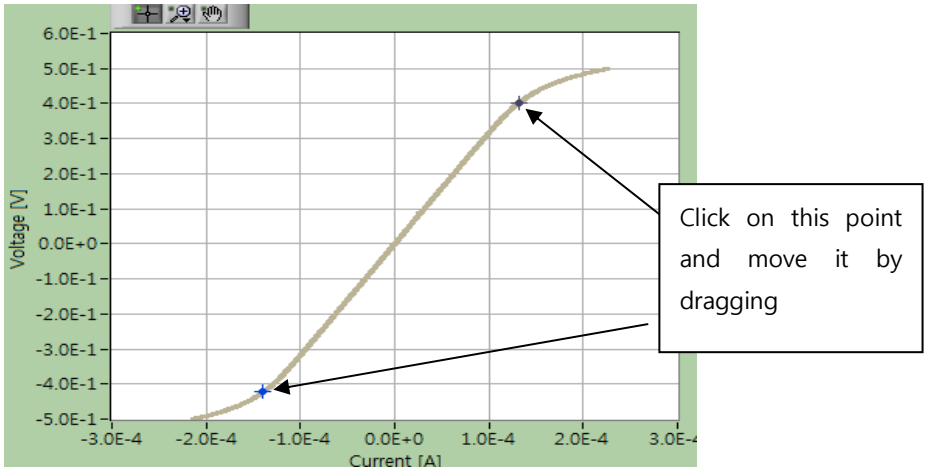


Figure 105. Select linear data region

2) click "linear fitting"

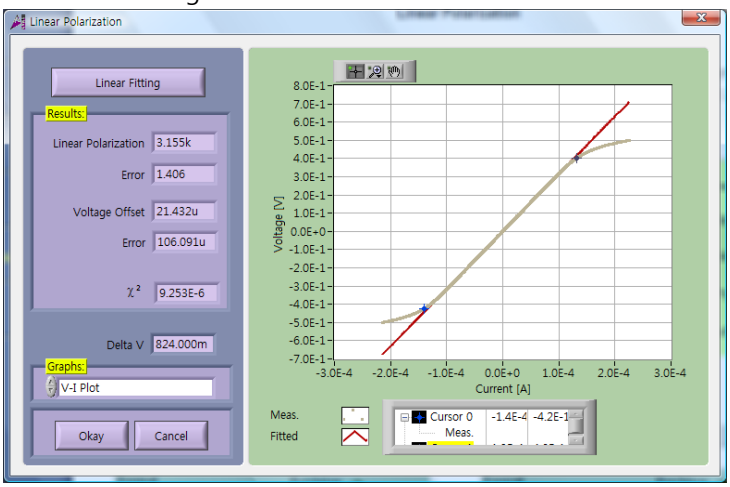


Figure 106. Fitting result

The fitting result is Polarization resistance.

3) Click "Okay" button

a. New input windows will appear

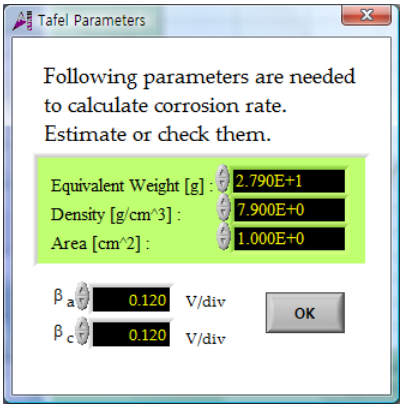


Figure 107. Parameter input

4) Click OK button

5) Linear polarization analysis result will be shown

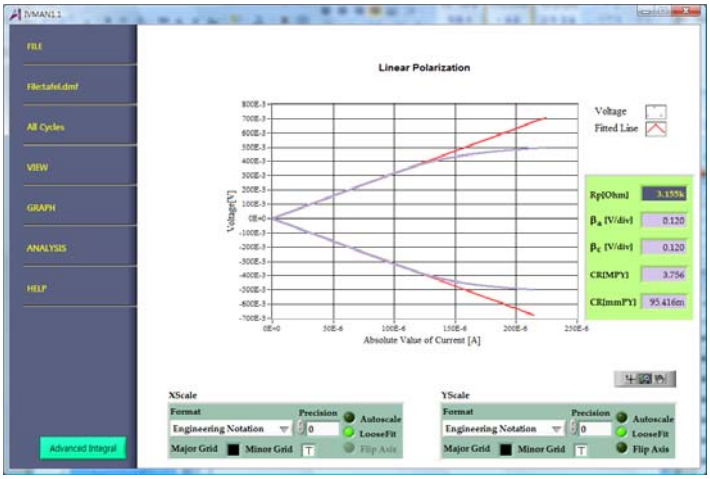


Figure 108. Linear polarization analysis result

K. Advanced Integral

This special function is for multiple cycle's capacity calculation by user setting base line and region. When you click advanced integral button at left bottom side, you can see following window.

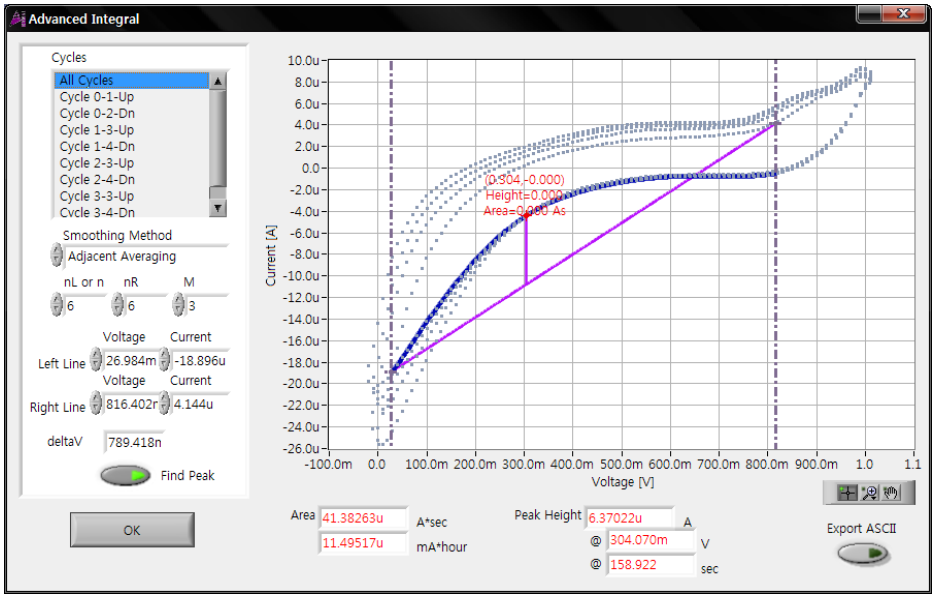


Figure 109. Advanced Integral menu

This function separate each cycle as positive scanning step and negative scanning step automatically. You can get the peak information (peak height current, voltage value and area value based on base line which you can defined by inputting the voltage and current value for region or dragging cursor bar to set region.

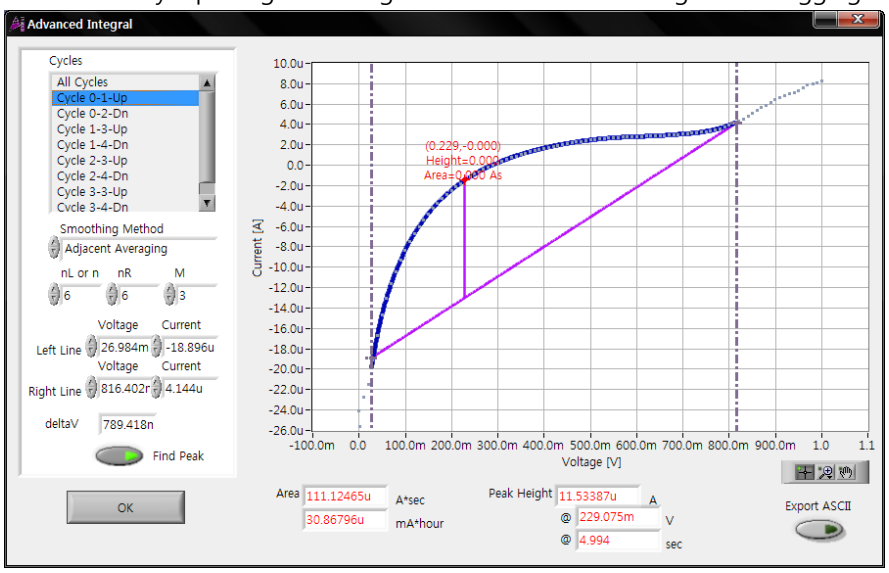


Figure 110. 1st Cycle's upper region's analysis result

You can select smoothing method as one of the following method

- Adjacent Averaging
- Savitzky-Golay Smoothing
- FFT filter

Chapter 5 Example

A. Current density converting

Open the data file

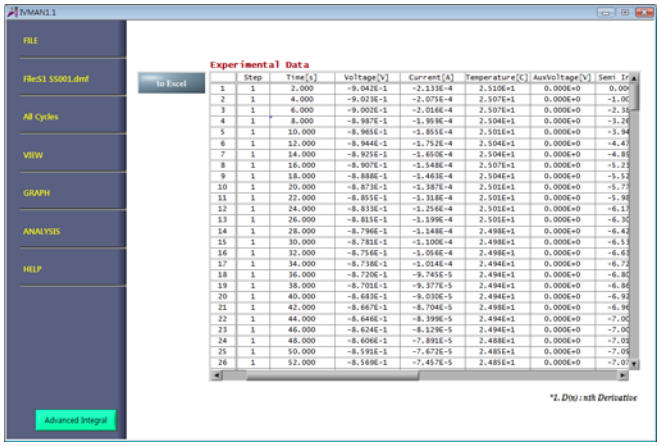


Figure 111. Source data

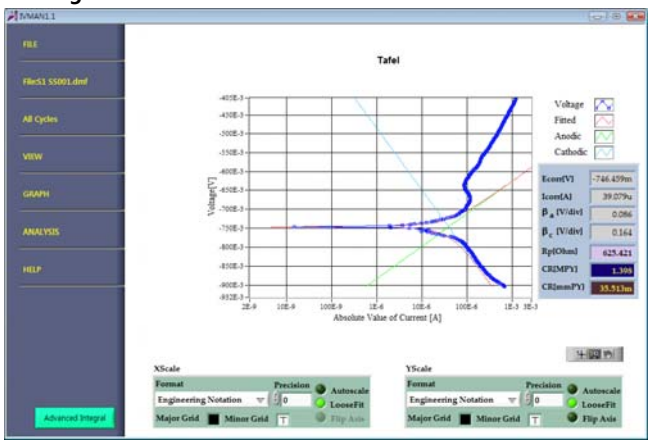


Figure 112. Tafel plot with source data

Go to analysis menu and select "simple math"

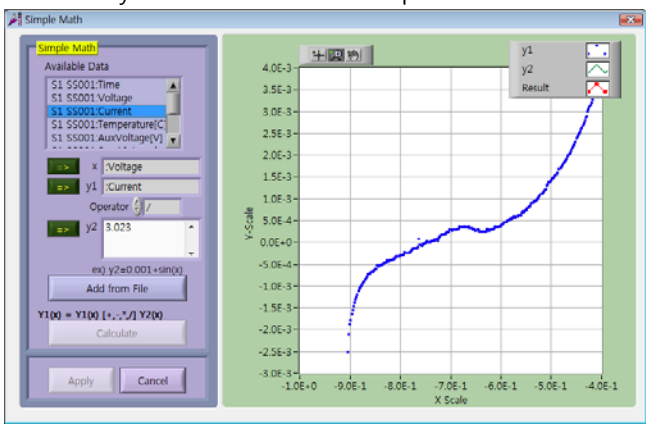


Figure 113. Simple Math1

If the sample active area is 3.023cm^2 then input the value as the above

Click "calculate"

Click "apply"

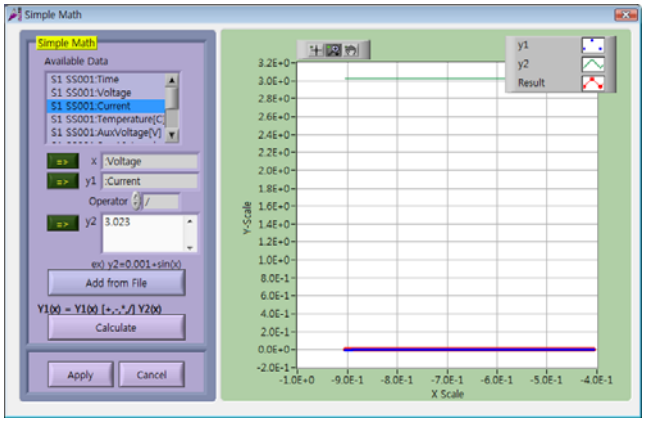


Figure 114. Simple Math2

Then the current data was converted as current density (A/cm^2)

You can see converted data on the graph.

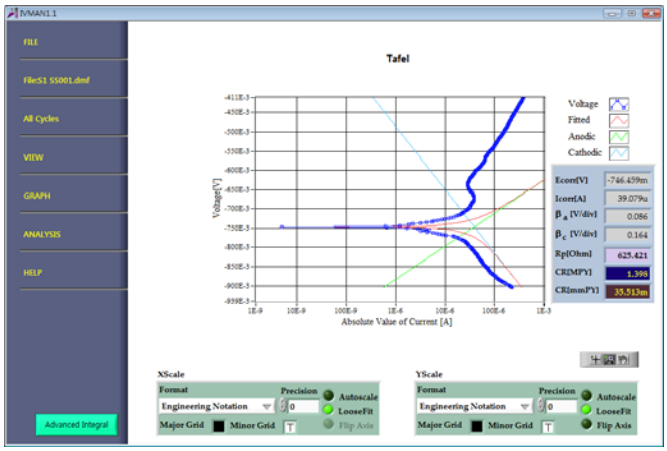


Figure 115. Tafel plot1 with current density

Graph X-axis label display is still not changed to current density

Click right button of mouse on the location of graph and select "visible items" and check on"scale legend"

Input the characters for x-axis label (example: Current density[A/cm^2]

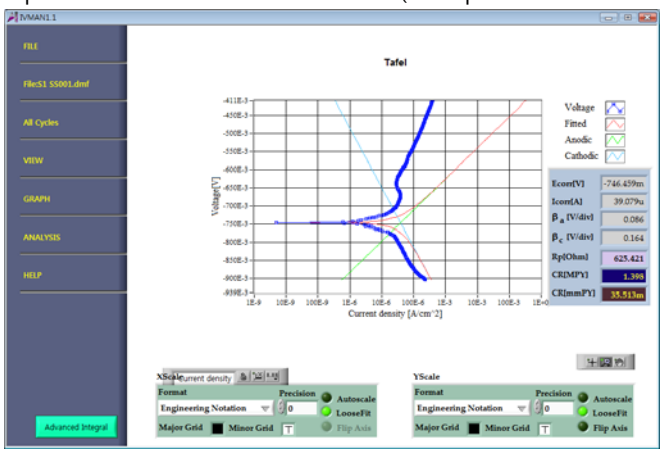


Figure 116. Tafel plot2 with current density

Check the current density value. The value was converted as current density as the follows.

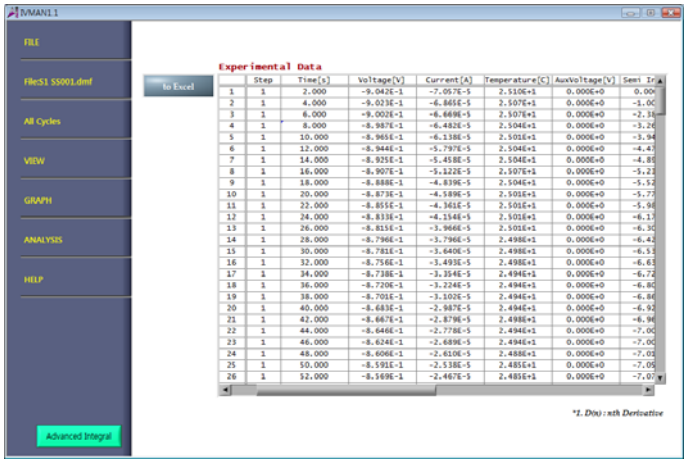


Figure 117. Converted data list

IVMAN differential Analysis

IV differential analysis program is utility program from IVMAN package in order to analysis of battery test data. This software utility is only for WonATech product's data format.

To run IV differential analysis, select IV differential analysis on IV untilities or Run "C:₩Program Files₩WonATech₩IVMANDA₩IVMAN Differential Analysis.exe"

A. File Open

Open your rfd or wdf file(This file came from your battery charging/discharging experiment using WonATech's WBCS, WMPG, WPG, WEIS instruments)

To do this, click Menu icon.

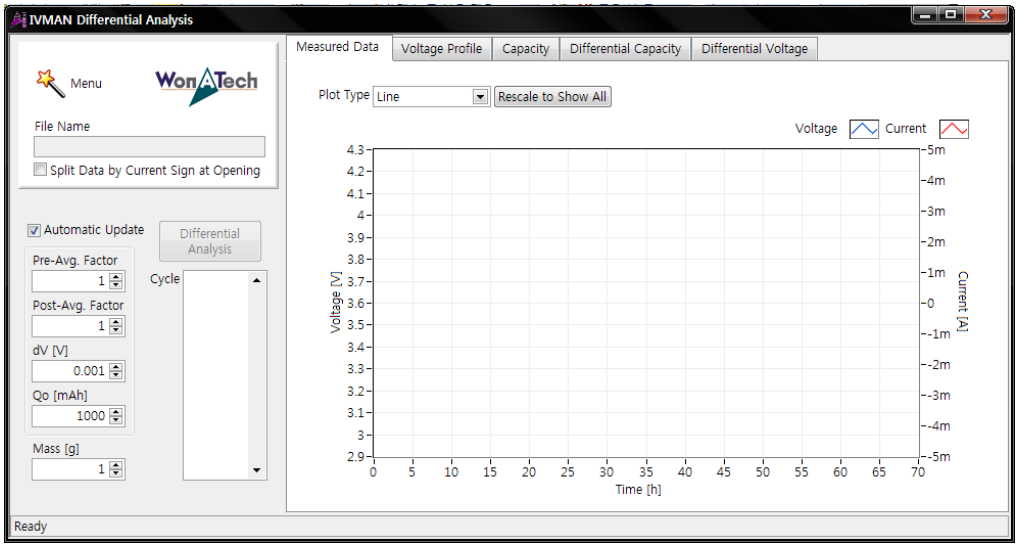


Figure 118. IVMAN differential analysis menu

Click "open file" and select battery test data file.

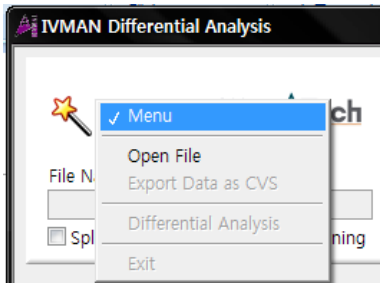


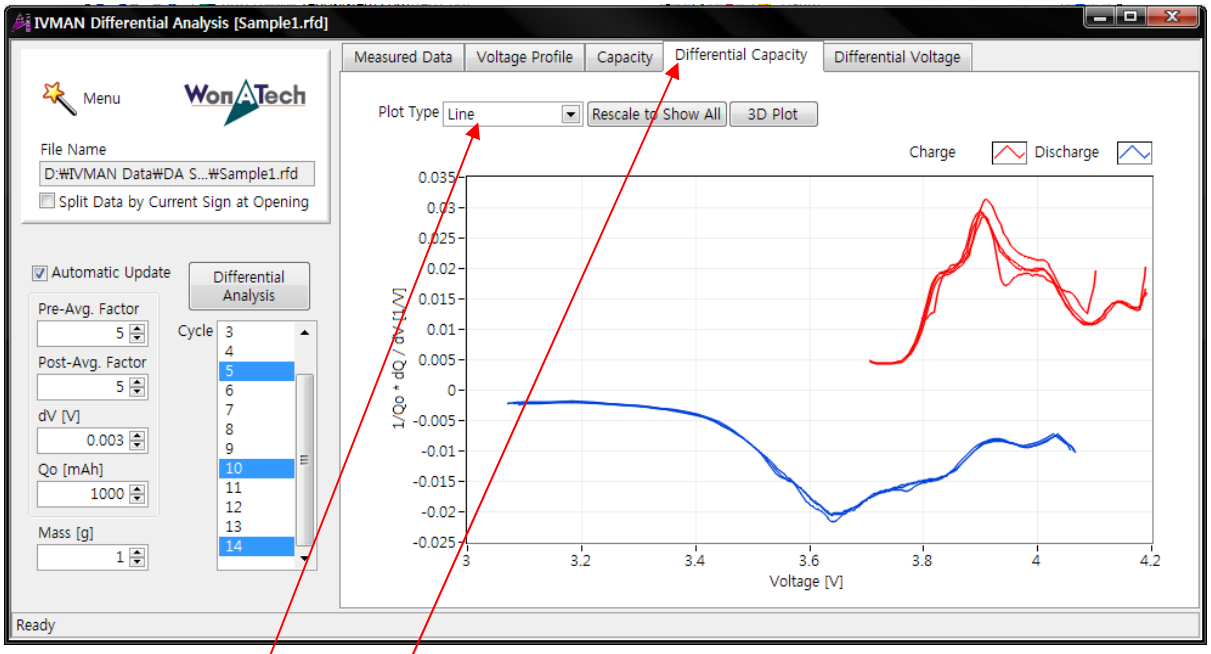
Figure 119. Menu icon pop up menu

B. Graph format

Using IVMAN differential analysis software, you can see the following graph formats.

- V,I vs time (Measured Data tab)
- Specific Capacity vs voltage (Voltage profile tab)
- Charging Capacity, Discharging capacity vs cycle number (Capacity tab)
- 1/Q0 * dQ/dV vs. voltage (Differential Capacity tab)
- 1/Q0*dV/dQ vs capacity (Differential voltage tab)

1. 2D Plot general function



Plots: You can select graph view; "Voltage and current vs. time", "Capacity vs. cycle number(Capacity)", "dQ/dV vs. voltage (Differential capacity)", "dV/dQ vs. discharging capacity(Differential voltage)

- Plot Type: Line, Scatter(dot), Line+Scatter
- Zoom: Drag to select the area for zooming

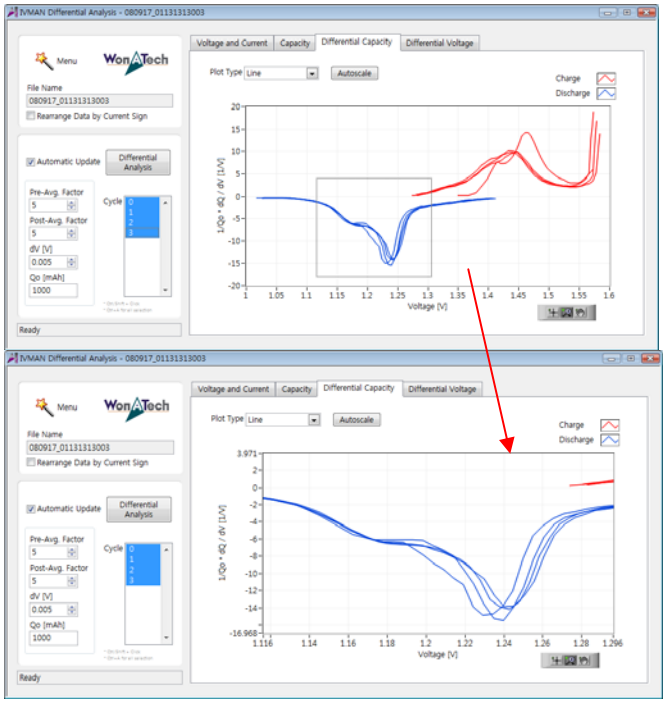
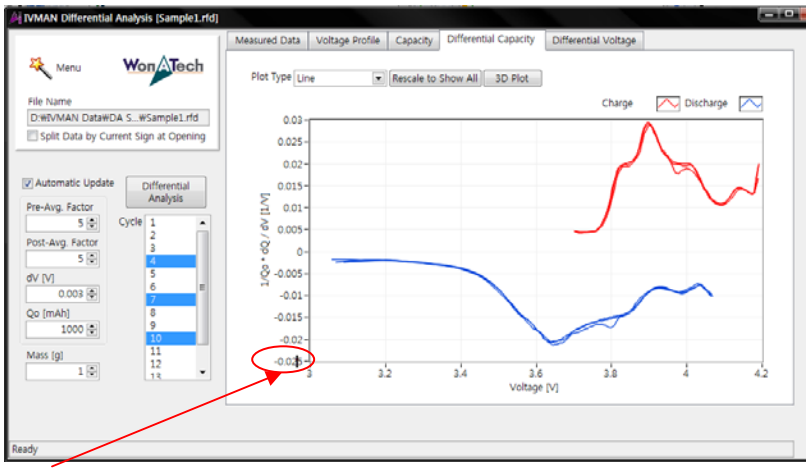


Figure 120. Zoom up

- Rescale to show all: initialize the zoomed plot

2. Manual axis range setting



By clicking the maximum number or Minimum number of each axis, you can input the number to select Max or Min value of graph view

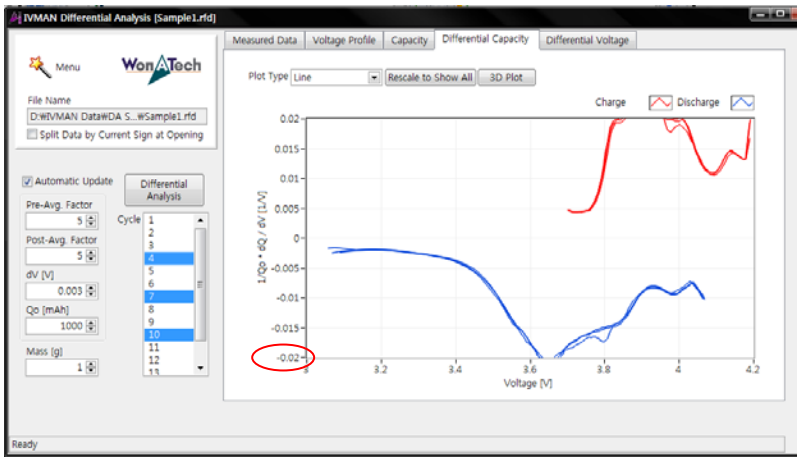


Figure 121. Axis value change for manual zooming

3. Graph option

Click legend then submenu will appear. The menu language will display following our OS language.

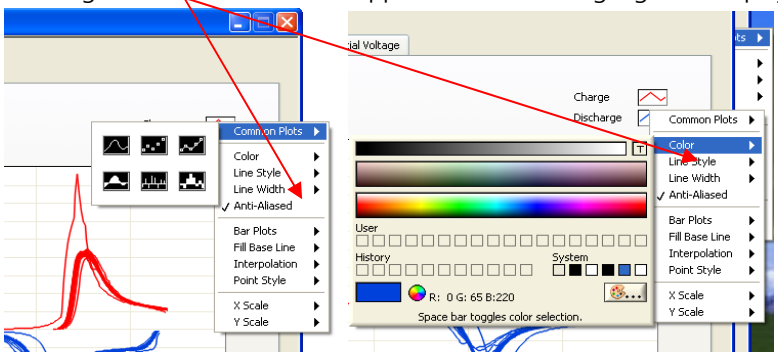


Figure 122. Graph option

Move cursor to graph region and click **right button** of mouse. The submenu will appear.

1) Common plot

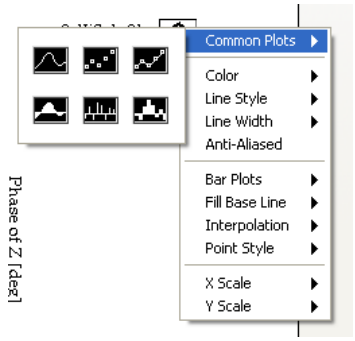


Figure 123. Legend menu

2) Line color

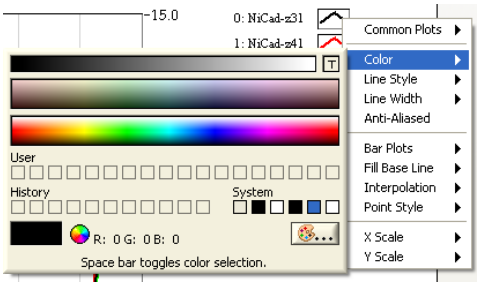


Figure 124. Line color setting

3) Line style

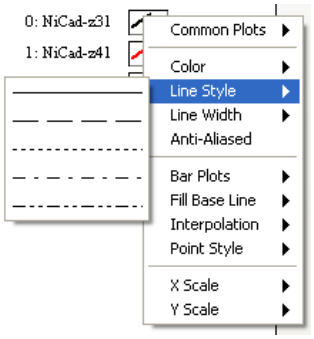


Figure 125. Line style setting

4) Line width

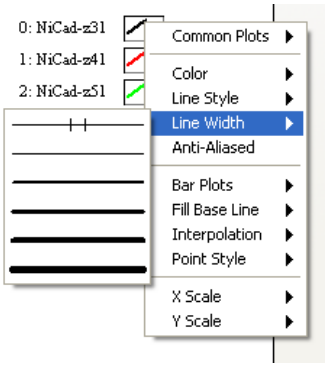


Figure 126. Line width setting

5) Bar plot

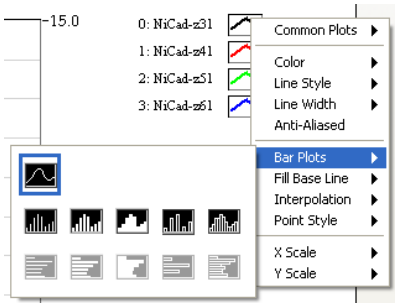


Figure 127. Bar plot setting

6) Interpolation

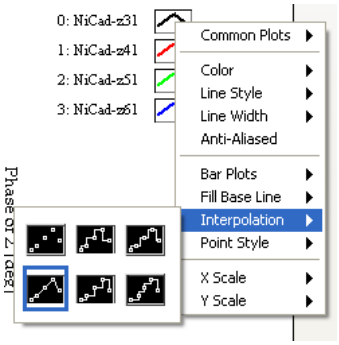


Figure 128. Interpolartion setting

7) Point Style

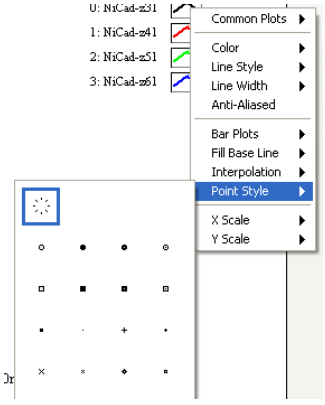


Figure 129. Point style selection

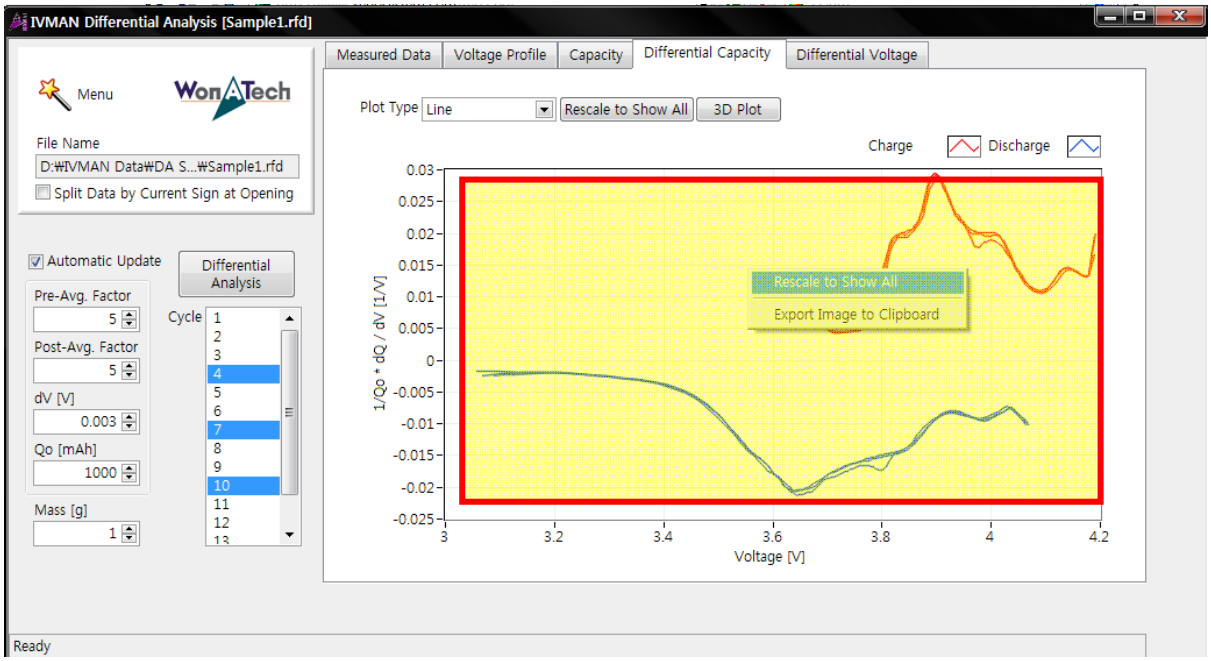


Figure 130. Popup menu on graph region

You can copy the graph into clipboard by selecting "Export Image to Clipboard"

You can paste this graph by "ctrl"+v on your application software such as Excel, Word etc.

C. Measured Data

This tab displays charging/discharging raw data as V, I vs time plot

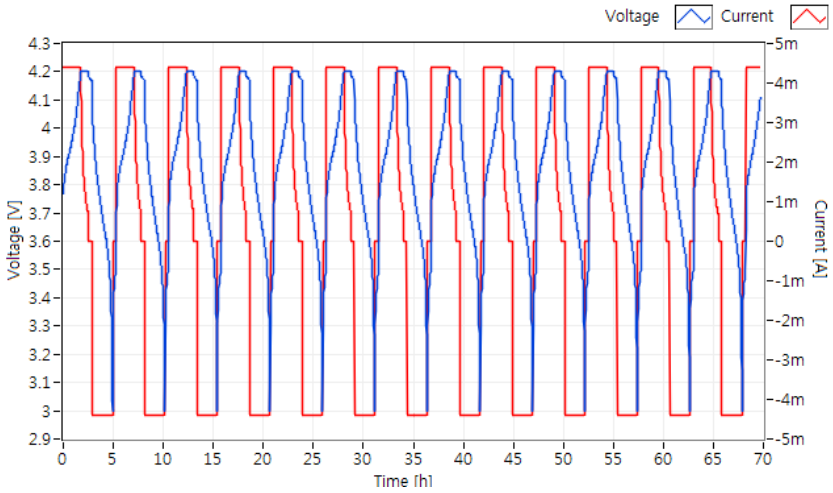


Figure 131. V, I vs time plot

This graph is not affected by parameter setting.

D. Voltage Profile

This tab displays specific capacity vs. voltage.

Cycle number setting and Mass value in parameter setting at left side bar will be applied to the graph.

Specific capacity (mAhr/g)=Capacity(mAhr) / Mass (g)

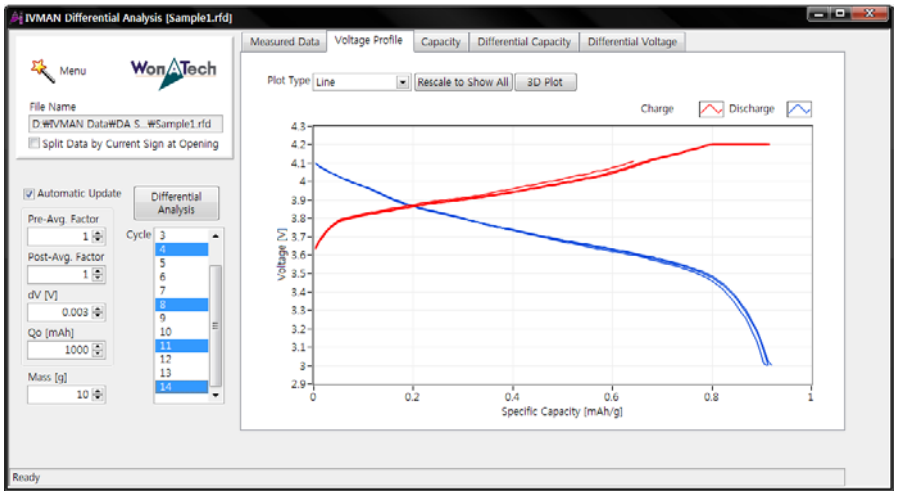


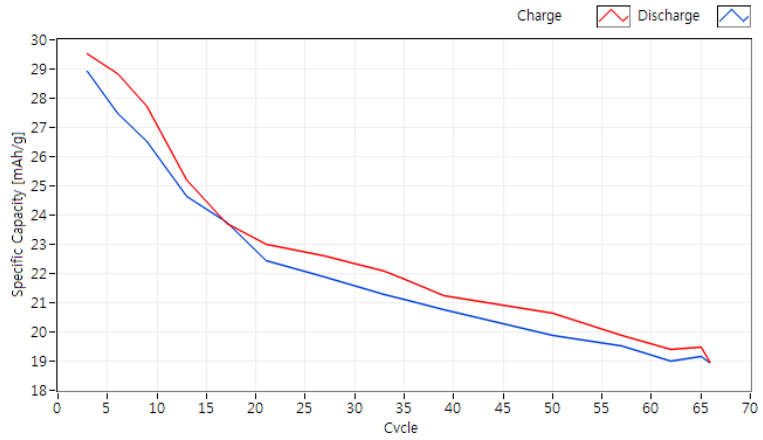
Figure 132. Specific Capacity vs. voltage

E. Capacity plot

This tab displays specific capacity vs. cycle no.

Cycle number setting and Mass value in parameter setting at left side bar will be applied to the graph.

Specific capacity (mAhr/g)=Capacity(mAhr) / Mass (g)



F. Differential Analysis

This analysis mode is to converting data to Differential capacity(dQ/dV vs. voltage) calling EVS (Electrochemical voltage Spectroscopy) or Differential voltage(dV/dQ vs. specific capacity) graph using battery charging/discharging data file.

1. Differential Capacity (EVS)

Differential capacity is the relative change in capacity as a function of the voltage, normalized by the average BOL C1/25 capacity, Q_{BOL}. The C1/25 discharge and charge data are first smoothed, then the differential capacity is calculated using Equation (1) with a two-point numerical differentiation.

$$\text{Differential Capacity} = 1/Q_{BOL} * d(Ah)/dV$$

To view differential capacity data, click " differential capacity" tab"

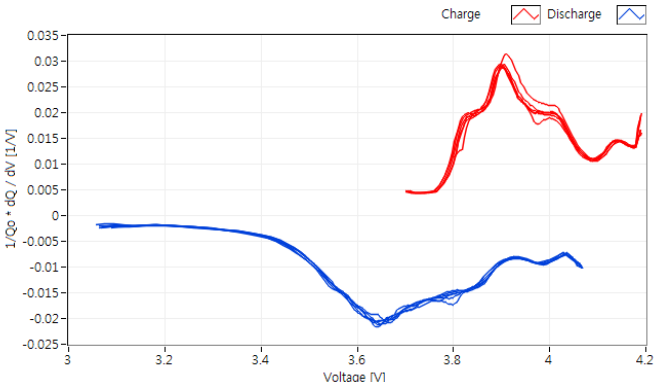


Figure 133. Differential Capacity graph

2. Differential Voltage

An alternative way of viewing the data is differential voltage, as described in Equation (2).

Differential Voltage = $Q_{BOL} * dV / d(A\,h)$

To view differential capacity data, click " differential voltage" tab"

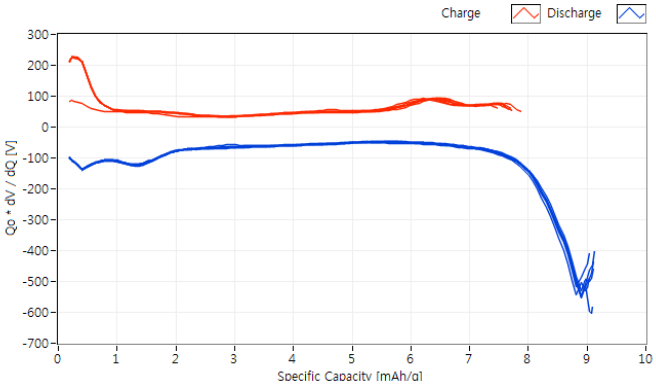


Figure 134. Differential Voltage Graph

3. Parameters for differential analysis

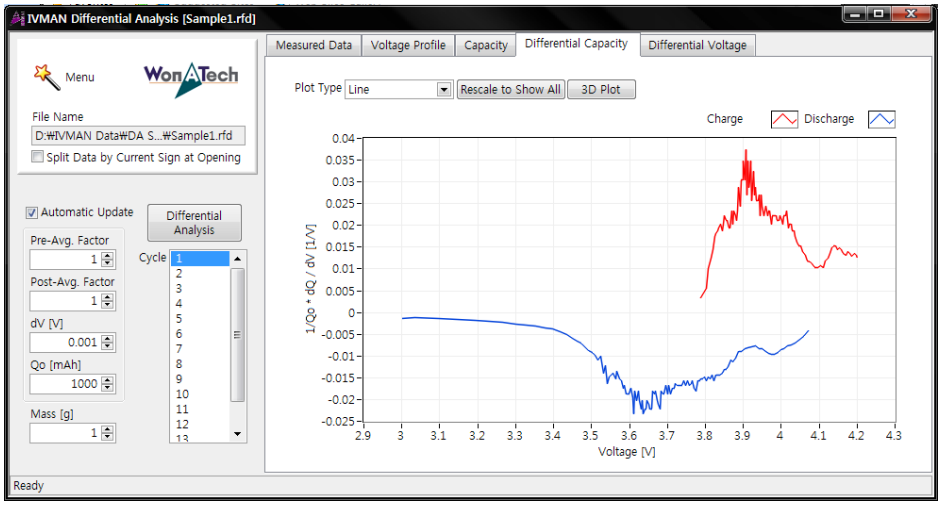


Figure 135. Parameter setting

You may select averaging function by selecting Pre-Avg.factor and Post-Avg.Factor.(select data point number for averaging)

- Pre-Avg.factor: Averaging points in raw data
- Post-Avg.Factor: Averaging points in calculated data
- You can determine dV value.
- Q0 value can be input for calculation of 1/Q0
- Mass value can be defined for specific capacity calculation

(The graph will be changed by selecting averaging and/or dV automatically if you select "Automatic Update")

If you did not check on "Automatic Update", you must click "Differential Analysis" button whenever you change the variables

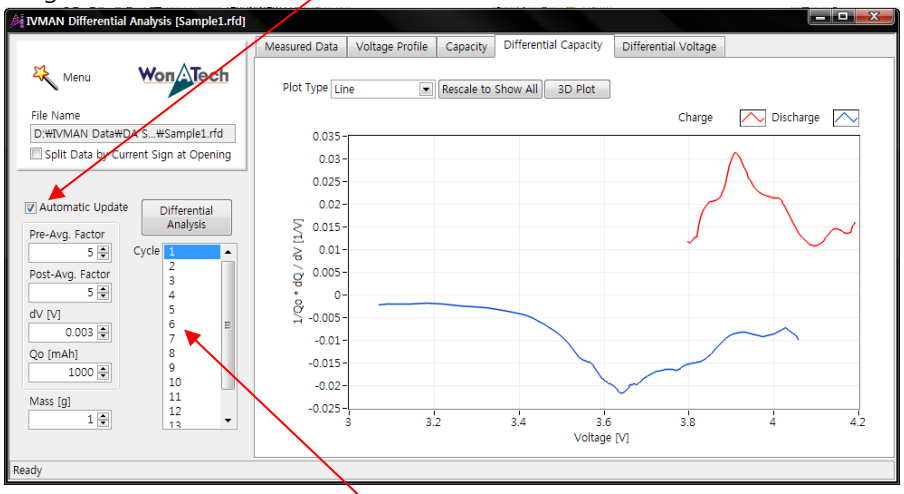


Figure 136. Automatic update and cycle selection

You can select cycle number to display graph.

If you want overlay multiple cycles data, click the cycle number with pressing "ctrl" key or "shift" key for ranged selection

4. 3D graph

You can see 3D graph for differential data display or Voltage profile plot by clicking 3D graph.

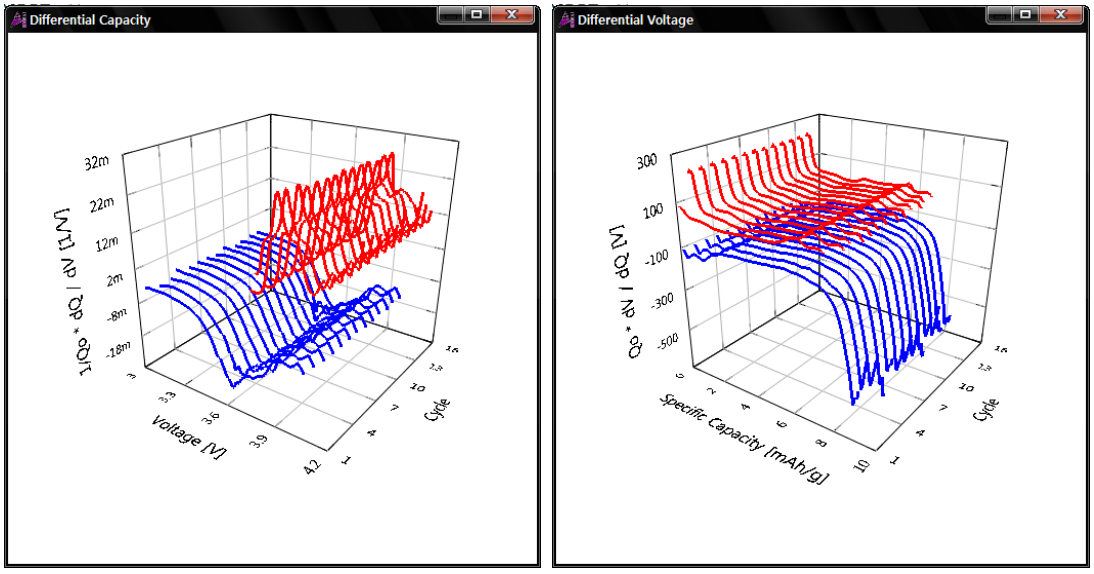


Figure 137. 3D graph

1) Plane Projection

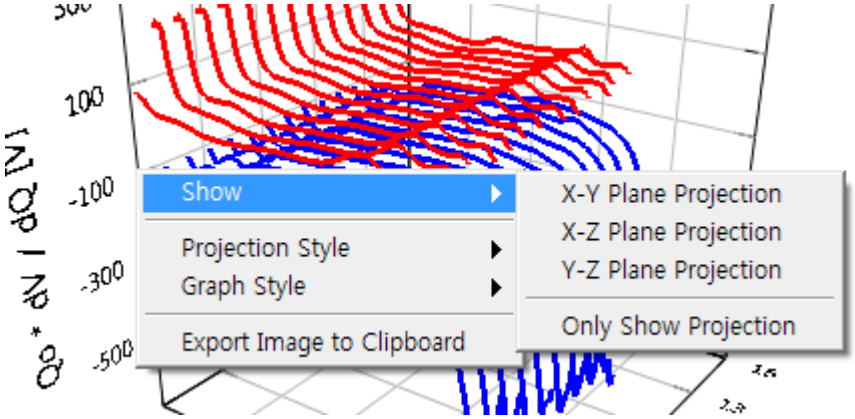


Figure 138. 3D graph show menu

You can select plane projection in Show option.

5. Projection Style

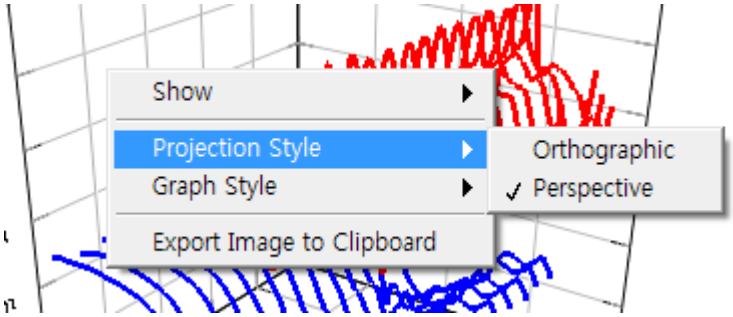


Figure 139. Projection style

There is two type depending on projection style (orthographic or perspective)

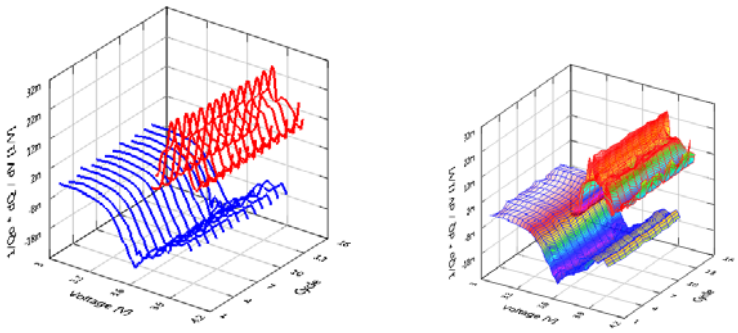


Figure 140. 3D plot (orthographic style)

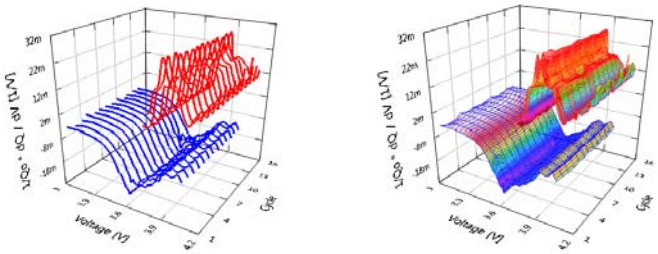


Figure 141. 3D plot(perspective style)

Version 2.2 does not provide surface plot which have provided in previous versions.

You can change the view angle by dragging on the graph

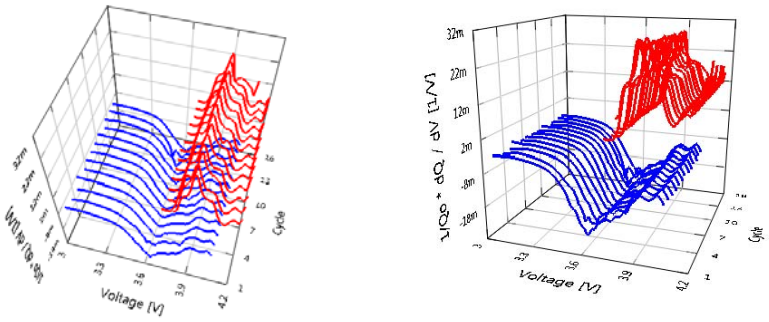


Figure 142. View angle change(Left: orthographic, Right perspective)

6. Graph Style

Curve plot

This graph style displays plot as indivisual plot. Line and dot for each data set is available.

Surface plot

You can show 3D plot with surface.

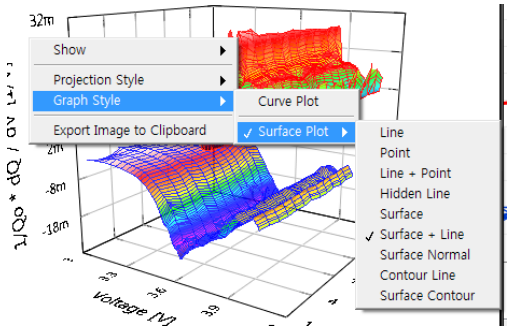


Figure 143. Surface plot option

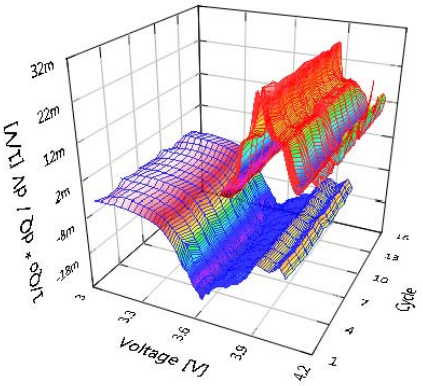


Figure 144. Surface plot with "surface+line"

G. Export Data as CVS

You can convert the file as ascii format. To do this function, select "export data as cvs" in Menu.

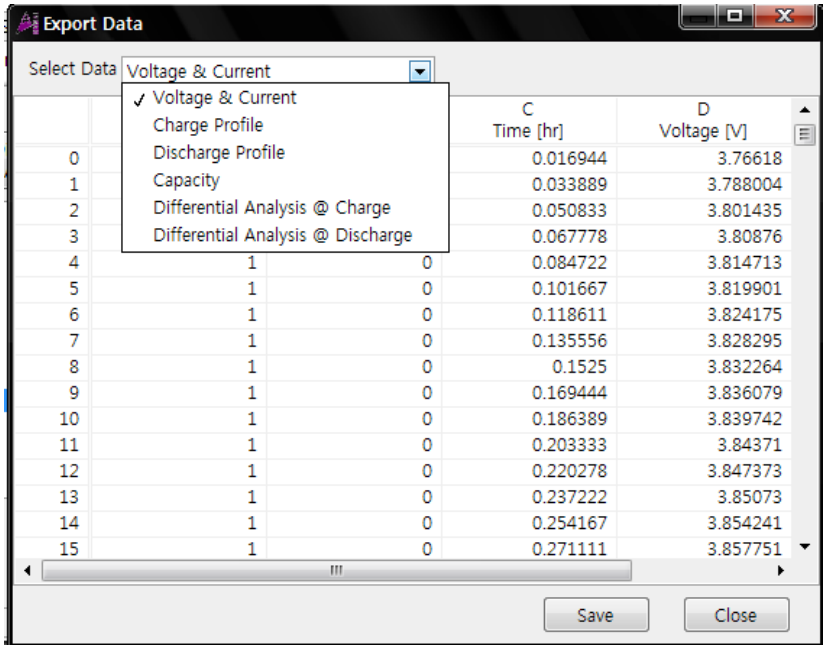


Figure 145. Export data as cvs

You can select data in the followings

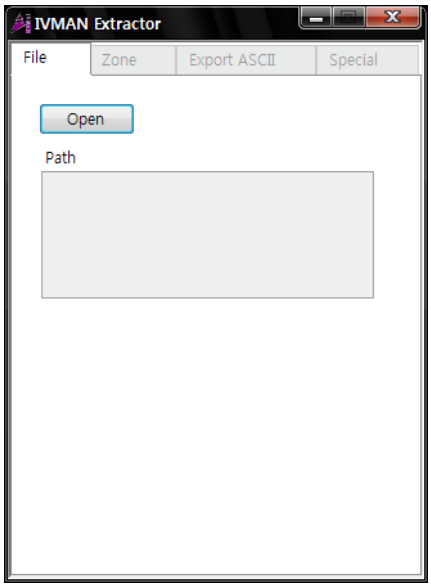
- Voltage & current
- Charge profile
- Discharge profile
- Capacity
- Differential analysis-Charge
- Differential analysis-discharge

This file conversion is depending on your selection of cycle numbers.

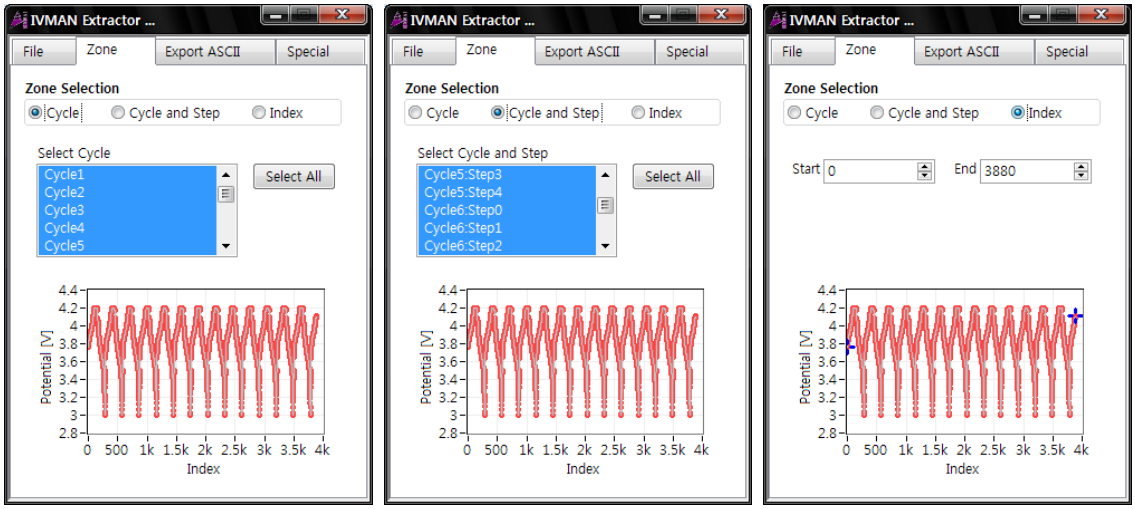
IVMAN Extractor

This software function makes cycle data as splitted by cycle or step.

To run IV differential analysis, select IV extractors on IV untilities or Run "C:₩Program Files₩WonATech₩IVMAN extractor₩IVMAN extractor.exe"

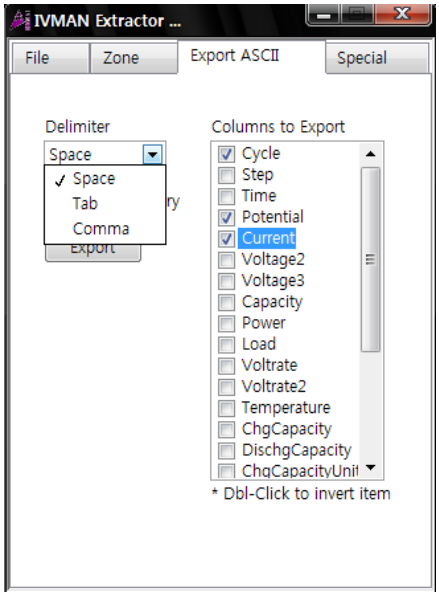


To open the source file, click Open button and select the file.



Break down criteria can be selected among cycle,, cycle & step or index.

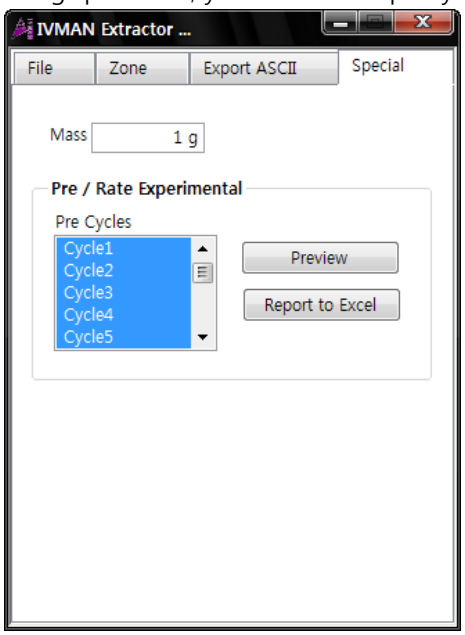
To save splitted files, select Export ASCII tab.



You can select delimiter by space or tab or comma.

When you click "export" button, each ascii file will be saved on destination folder.

Using special tab, you can make capacity vs. voltage data.



To generate specific capacity, you can input Mass value.

Pre cycle selection is for discharging data analysis. Except of selected cycles as pre cycle, unselected cycles will display discharging capacity data only. Selected pre cycles, charging data & discharging data will be displayed. If you want to see charging and discharging for all cycles, you can select all cycles as pre cycle by ctrl+A

If you click Preview button, you can see the following window

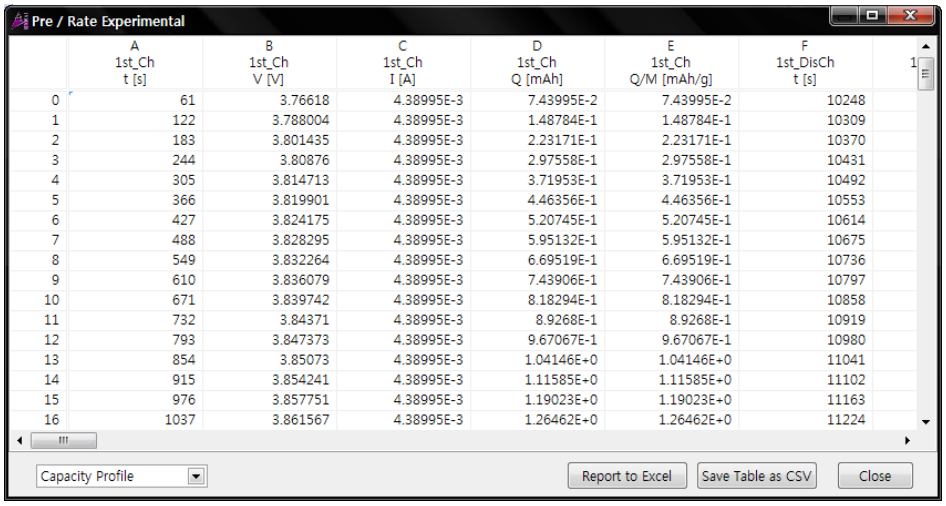


Figure 146. Capacity profile preview

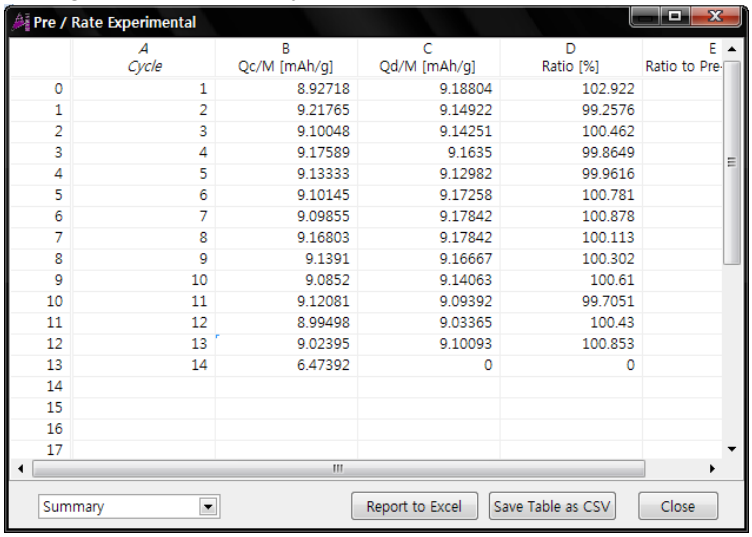


Figure 147. Summary preview

You can save this contents as ascii file or transfer it to Excel.

If you have your own excel template, Automatic reporting is available.

IVMAN peak find module

This IVMAN utility is to find peaks on voltammogram simply.

To run IV differential analysis, select IV differential analysis on IV untilities or Run "C:₩Program Files₩WonATech₩IVMANpfm₩IVMAN peak find module.exe"

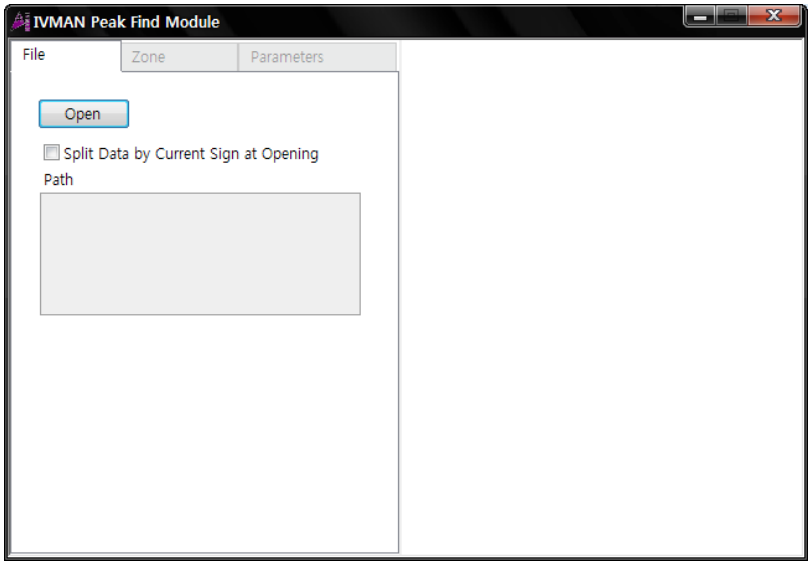


Figure 148. IVMAN peak find module

By clicking "open" button, you can select data file.

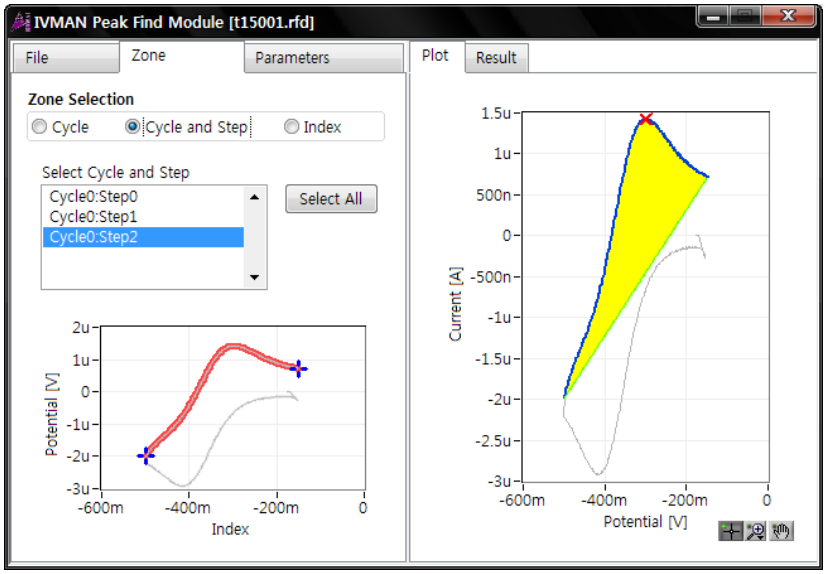


Figure 149. Zone selection to detect peak etc.

To change searching parameter, select parameters tab.

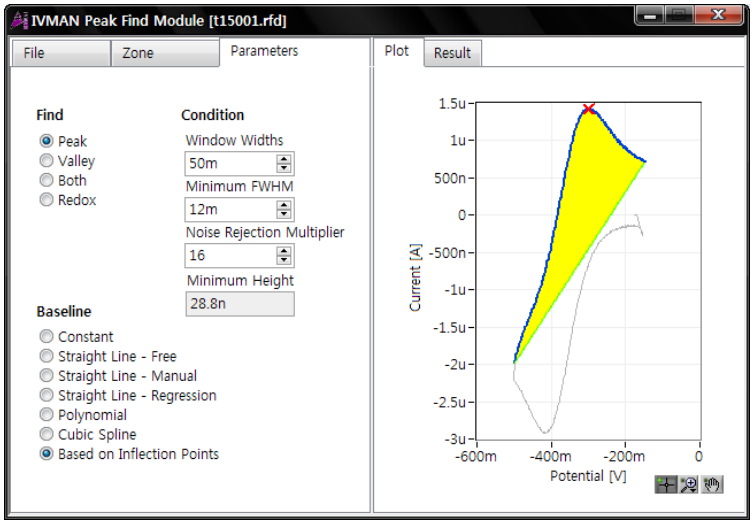


Figure 150. Parameters setting

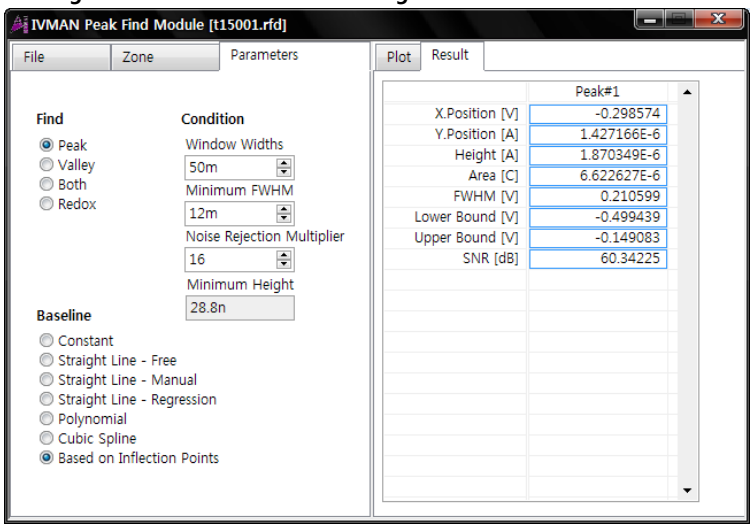


Figure 151. Peak finding result