

TY-PDN Tool User's Manual

Prototype

This manual is a prototype (trial) version.

Please handle with care.

1. Table of Contents

1.	Table of Contents	1
2.	Revision History.....	2
3.	Introduction.....	3
4.	Preparation	3
4.1.	Recommended Operating Environment	3
4.2.	Tools/Files Used for PDN Analysis	3
4.3.	Obtain S-parameter Files.....	4
4.4.	Enable Macros for Excel2013.....	6
5.	Summary of Respective Worksheets	8
5.1.	Main Sheet.....	8
5.2.	Data Sheet	8
5.3.	Capacitor Sheet	9
6.	Start/Exit the Tool	10
6.1.	Start the Tool	10
6.2.	Exit the Tool	11
7.	PDN Analysis	13
7.1.	Setting Up Target Impedance	13
7.2.	Input Target Frequency.....	14
7.3.	Enable/Disable Real-time Updates.....	15
7.3.1.	Disable Real-time Updates	15
7.3.2.	Enable Real-time Updates.....	15
7.4.	Select/Delete Capacitors.....	16
7.4.1.	Select Capacitors	16
7.4.2.	Delete Capacitors	19
7.5.	Input Quantities.....	20
7.6.	Input Mount Inductance.....	21
7.7.	Checking Result of Analysis.....	22
7.7.1.	Respective Patterns Comparison	22
7.7.2.	Checking Graph of Impedance/Freq.	23
7.8.	Updating Capacitor List.....	30

2. Revision History

Version number	Date	Revision summary
Pre-Prototype	March 31, 2017	Prototype edition issued.
Prototype	September 15, 2017	Separating of language version (English and Japanese).

3. Introduction

Along with the improvement of semiconductor technology and performance, LSI low voltage and large current has been rapidly progressing from around the early 2000s. In order to prevent malfunction due to voltage drop of the power supply circuit, it is required that design which suppresses the impedance of **Power Distribution Network** (=PDN). Related research has started since the middle of 1990, and the PDN design tends to be severe year by year.

For the PDN design, it is possible to use an advanced simulator which is maybe expensive, a circuit simulator which is free or pay, a tool which released by semiconductor manufacturer, and etc. However, there was no tool for comparing capacitor combination characteristics at low cost and simply. For this reason, we made **TY-PDN_Tool** that we can operate easily.

This manual describes how to use **TY-PDN_Tool** (hereafter **the Tool**).

4. Preparation

4.1. Recommended Operating Environment

Item	Recommended environment
OS	Windows7 or later
Excel	Excel 2007 or later

4.2. Tools/Files Used for PDN Analysis

You should copy **the Tool**① and S-parameter files② under same(arbitrary) folder in your PC environment.

① **The Tool** (TY-PDN_Tool_****.xlsm)

Note: **** is indicate the version information (like number, etc.).

② S-parameter files. (TY-PDN_Tool_S-Para/****)

Note: *** is indicate sub-folder(s) and/or file(s) (like xxx.s2p).

Note: For steps on obtaining S-parameter files, see **【4.3. Obtain S-parameter Files】**.

Note: For steps on adding or updating S-parameter files, see **【7.8. Updating Capacitor List】**.

Note: To change the folder position/name, or to add other folder, see **【7.8. Updating Capacitor List】** and specify the S-parameter folder.

4.3. Obtain S-parameter Files

This section describe the steps to download the S-parameter file(s) of the capacitor(s) made by Taiyo Yuden.

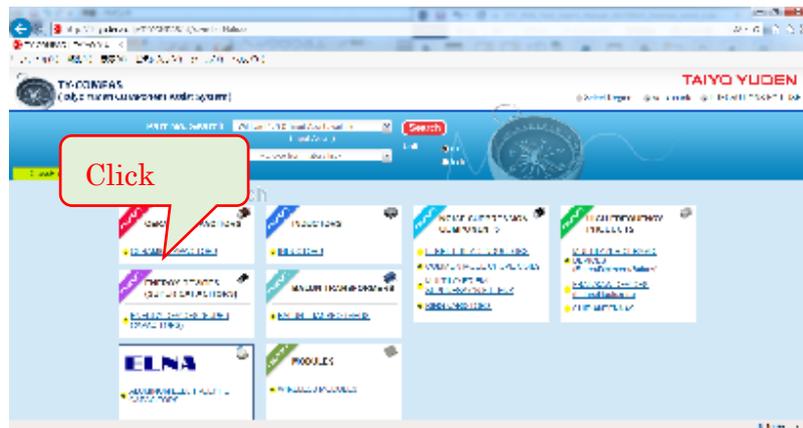
Note: To obtain the S-parameter file(s) of a capacitor(s) made by another company, refer to each company web site.

If desired S-parameter files can not be found, you should inquire each maker.

Step 1 — Open **TY-COMPAS** (URL below) managed by Taiyo Yuden.

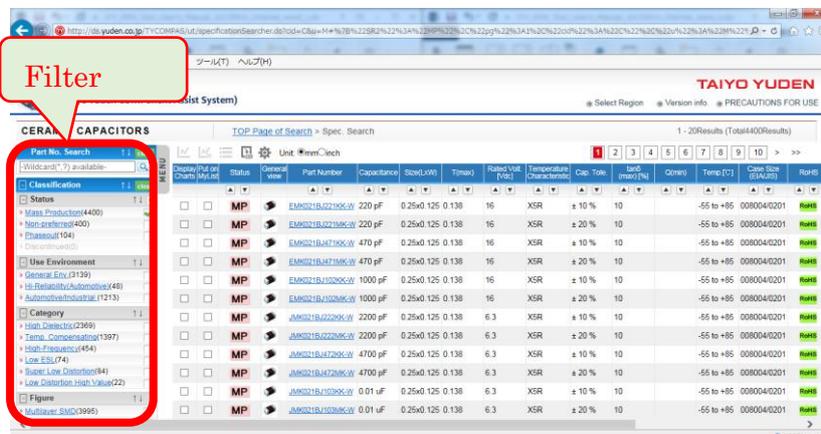
URL : <http://ds.yuden.co.jp/TYCOMPAS/ut/searcherMain.do>

Step 2 — Click **CERAMIC CAPACITORS**.

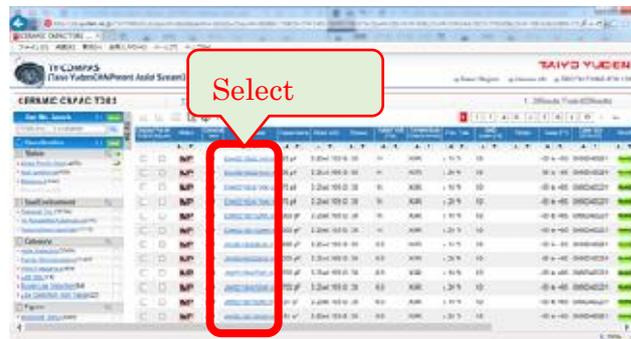


Step 3 — You can filter with part No./characteristics/etc to narrow down parts.

Note: This step can be omitted.



Step 4 — Select desired parts from right list.



Step 5 — Scroll down the wind, select the S-parameter file(s), and save it in an arbitrary folder.

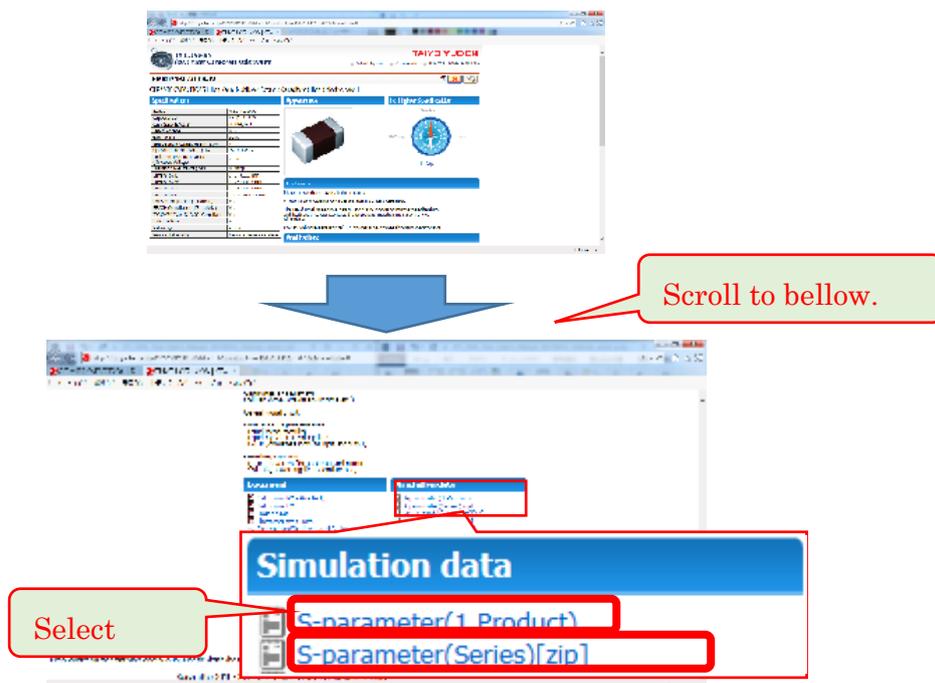
Note:

S-parameter(1 Product) is selected part's S-parameter file.

S-parameter(Series)[zip] is zip file which contains S-parameters that series of selected part and same series.

The recommended storage destination is an arbitrary folder under **TY-PDN_Tool_S-Para** in the same folder as **the Tool**.

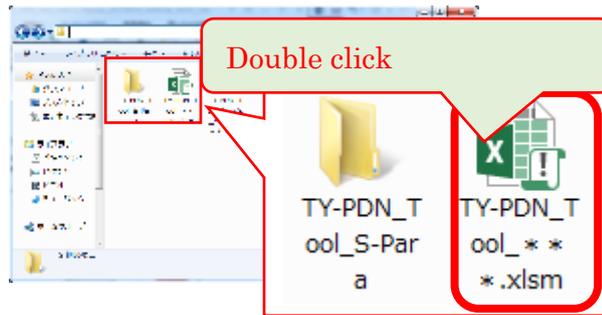
Since it can not be read from **the Tool** with the zip file, you should do step 【7.8. Updating Capacitor List】 after extract it.



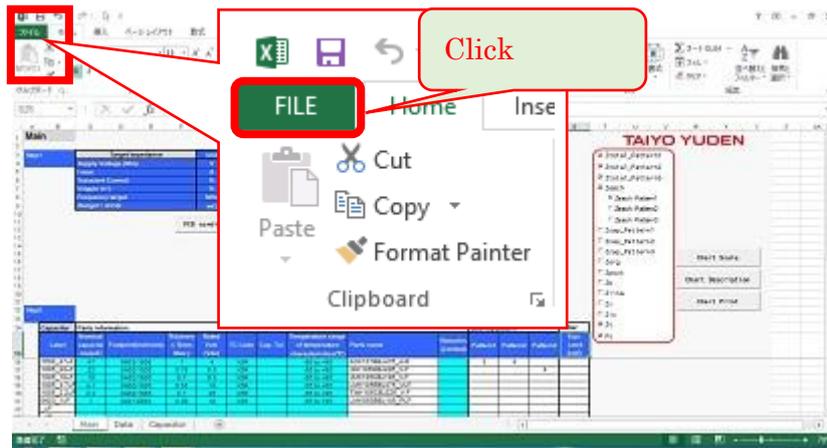
4.4. Enable Macros for Excel2013

Since **the Tool** calculates with macros, you should change the security setting by the following steps, and make the macro valid.

Step 1 — Double click **the Tool** (TY-PDN_Tool_***.xlsm) icon to open and start **the Tool**.



Step 2 — Click the **File** tab.



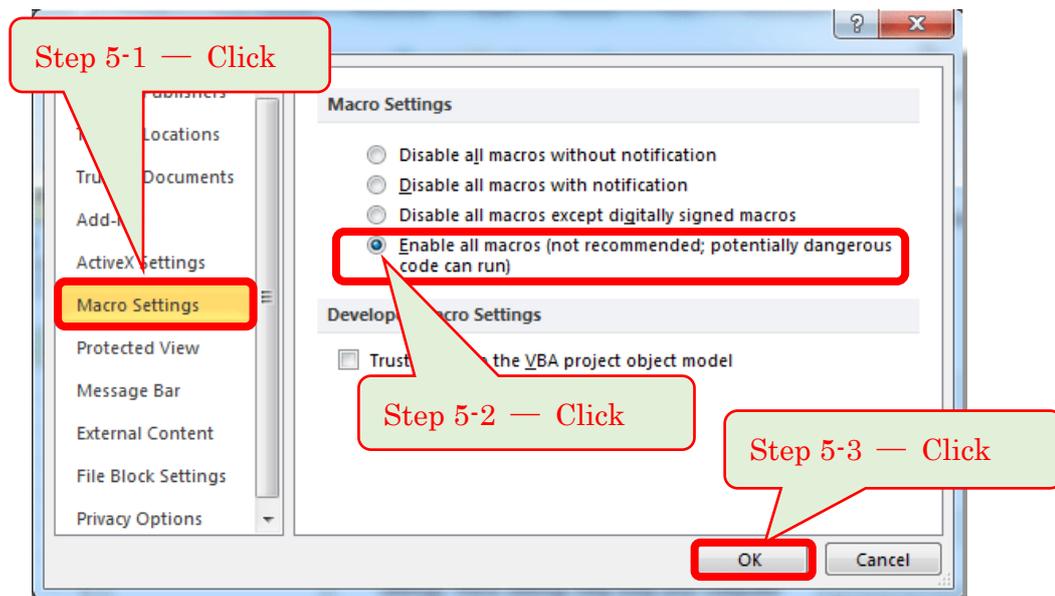
Step 3 — Click **Option**.



Step 4 — Click **Trust center**, and then click **Trust Center Settings**.



Step 5 — In the **Trust Center**, click **Macro Settings**, and then select **Enable all macros (not recommended; potentially dangerous code can run)**, and then click **OK**.



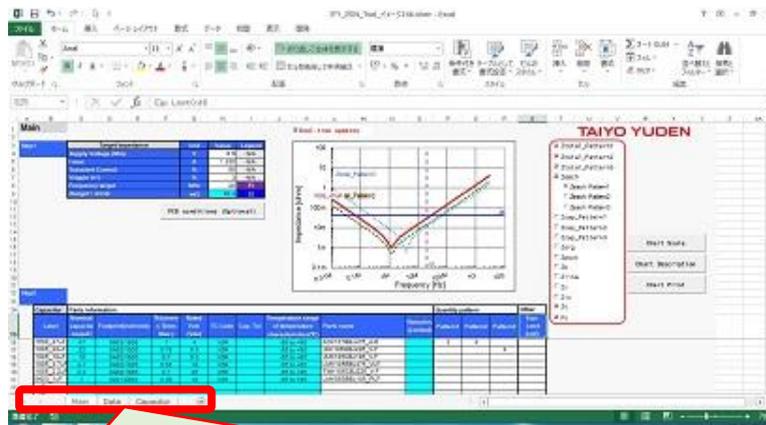
Step 6 — Click **OK** or **×** to close the other Excel windows.

Step 7 — Close and restart **the Tool**, and then macros will be enabled.

5. Summary of Respective Worksheets

5.1. Main Sheet

Usually, you should operate this sheet. You can select capacitor (parts name) and input quantities/etc, for PDN analysis. You can display a graph of (total) impedance-frequency characteristic curve.

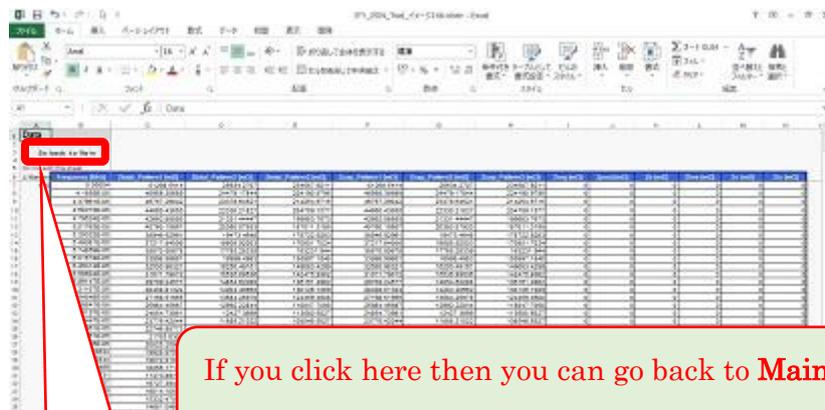


You can select sheet tab to display other sheet.

5.2. Data Sheet

This sheet contains data for the graph of the Main sheet. Various impedance and frequency data calculated by macro are inputted.

You should not usually operate this sheet because it affects graph display.



Go back to Main

If you click here then you can go back to Main sheet.

5.3. Capacitor Sheet

This sheet is used to regist S-parameter files for simulation or MLCC three element(C, ESL, ESR) model's each value.

You can input the parts name, nominal capacitance, footprint (chip size), file path of S-parameter, etc.

The capacitors registered with this sheet can be selected on the Main sheet and used for PDN analysis.

Go back to Main

If you click here then you can go back to **Main** sheet.

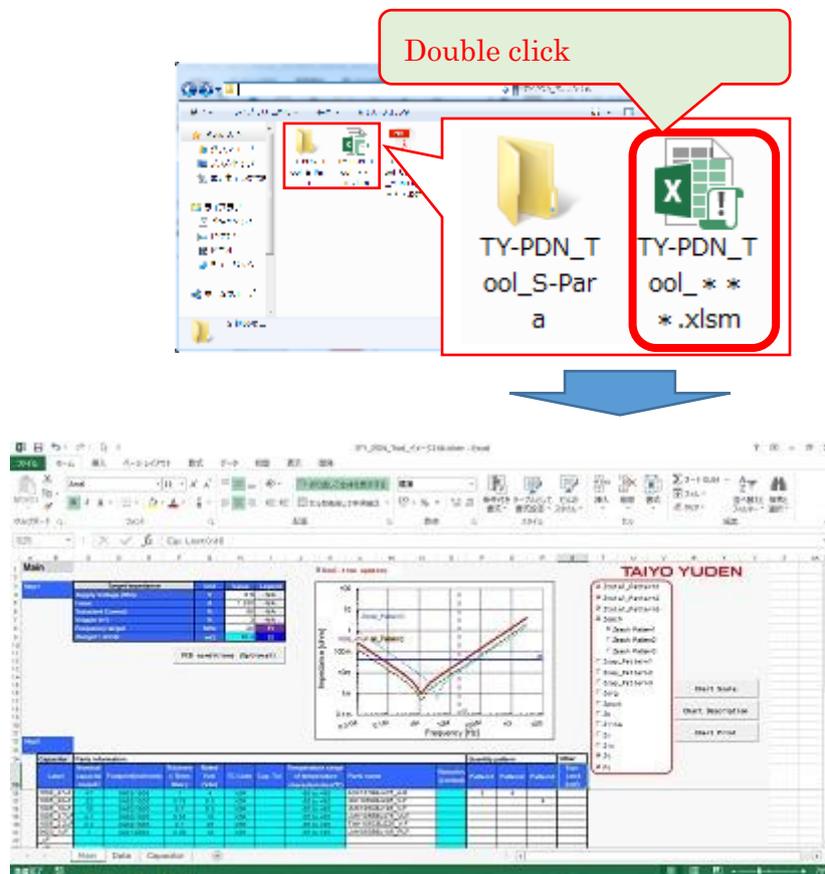
6. Start/Exit the Tool

6.1. Start the Tool

In advance, you should prepare **the Tool** and files (【4.2. Tools/Files Used for PDN Analysis】), and make the macro valid (【4.4. Enable Macros for Excel2013】).

Note: To suppress unexpected malfunction and processing load, it is recommended to close the unnecessary files other than **the Tool**, in advance.

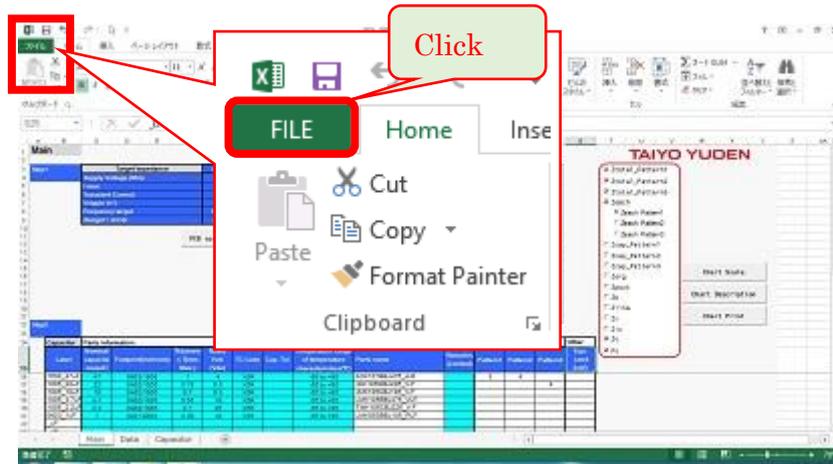
Step 1 — Double click **the Tool** (TY-PDN_Tool_***.xslm) icon to open and start **the Tool**.



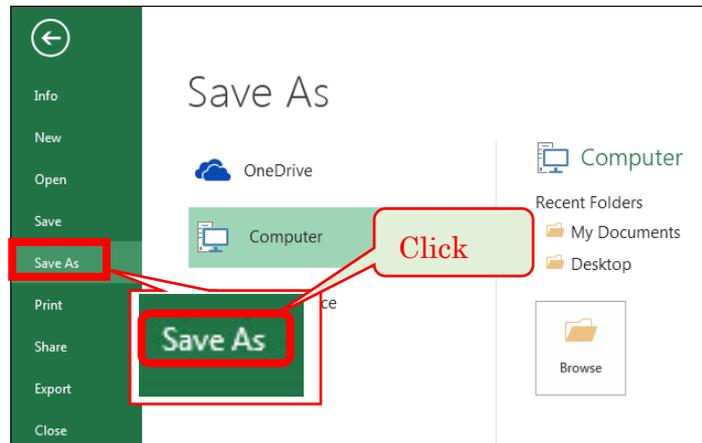
6.2. Exit the Tool

If you close **the Tool** without saving after operating **the Tool**, change contents will be lost, so if you want to keep the change contents, you should save **the Tool** after change.

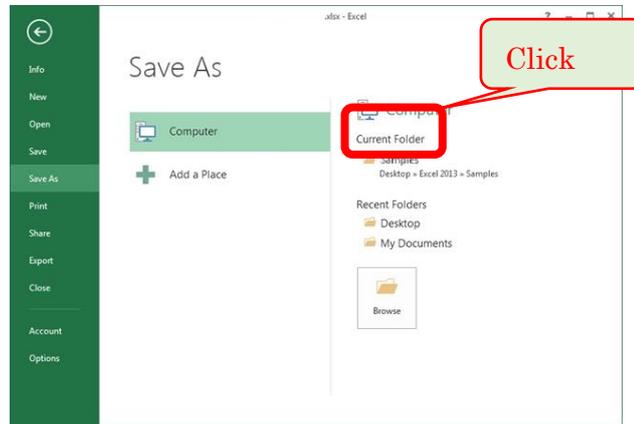
Step 1 — Click the **File** tab.



Step 2 — Click the **Save As**.

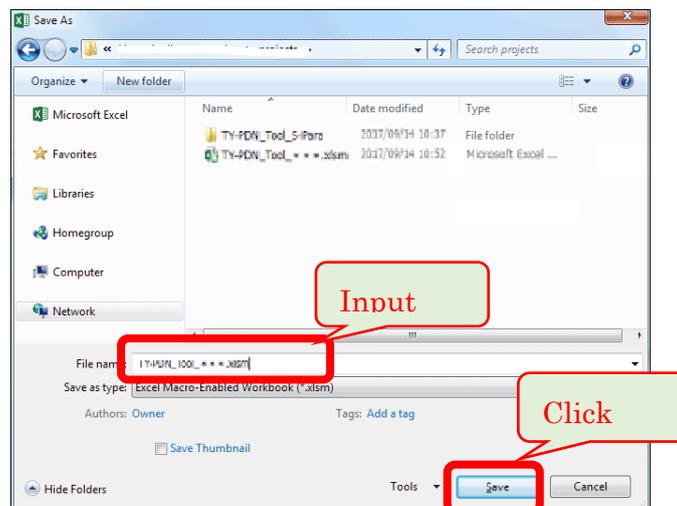


Step 3 — Click the folder which located below **Current Folder**.



Note: If you change the saving folder of **the Tool**, you should copy the S-parameter folder/file(s) to same folder, or you should specify the S-parameter folder. See **【7.8. Updating Capacitor List】** .

Step 4 — Input an arbitrary name in the **File name**, then click **Save**.



Step 5 — Click the Close button on the title bar to close **the Tool**.



7. PDN Analysis

7.1. Setting Up Target Impedance

On the **Main** sheet of the **Tool**, you can set up the Target Impedance (**Zt**). If you set up the **Zt**, then you can display the position of the **Zt** in the graph of **Main** sheet. The **Zt** indicate a border line of impedance that you should suppress. **Zt** or less means that the PDN quality is in allowable level. In other words, the **Zt** should be set so as to that.

Note: This step can be omitted. It can set up even later. It does not affect the calculation of the impedance characteristic curve.

Step 1 — Input values to **Target Impedance** fields in the upper left of the **Main** sheet (with attention to units), with reference to the calculation formula below.

$$Z_{\text{target}} = \frac{\Delta V}{\Delta I} = \frac{V \times V_{\text{ripple}} / 100}{I \times I_{\text{transient}} / 100} \times 1000 \quad [\text{m}\Omega]$$

Note: ΔV represents allowable voltage ripple (amplitude of noise), and ΔI represents maximum transient current (estimated with use rate of total current I).

Target Impedance			
	Unit	Value	Legend
Supply Voltage (Min)	V	0.9	N/A
I max	A	1.33	N/A
Transient Current	%	50	N/A
Vripple (+/-)	%	3	N/A
Frequency target	MHz	20	Ft
Ztarget = $\Delta V / \Delta I$	m Ω	40	Zt

Unit of value in the right side

Auto calculation

Manual input

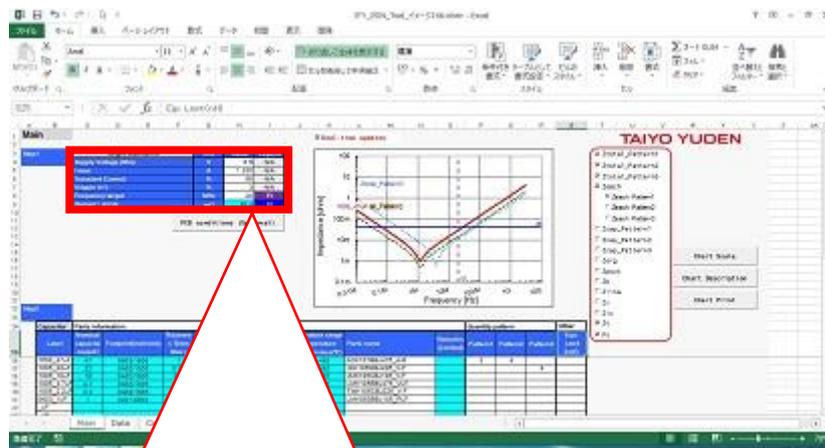
7.2. Input Target Frequency

On the **Main** sheet of the **Tool**, you can input the target frequency (**Ft**). If you input the **Ft**, then you can display the position of the **Ft** in the graph of **Main** sheet. The **Ft** indicate a border line of frequency that you should care the PDN quality is in allowable level (the **Zt** or less).

Note: This step can be omitted. It can set up even later. It does not affect the calculation of the impedance characteristic curve.

Step 1 — Input a value (MHz) to **Frequency target** field in the upper left of the Main sheet (with attention to unit).

Note: Since the Target Frequency (Ft) depends on the specification of the connected IC and how it is used, contact IC makers or equipment designers as necessary to obtain information. If you have no information about it, it is recommend to input value like 100 MHz or less.



Target Impedance		Unit	Value	Legend
Supply Voltage (Min)		V	0.9	N/A
I max	Unit is MHz	A	1.335	N/A
Transient Current		%	50	N/A
Vripple (+/-)		%	3	N/A
Frequency target		MHz	20	Ft
Ztarget = $\Delta V/\Delta I$	Manual input	m Ω	40.4	Zt

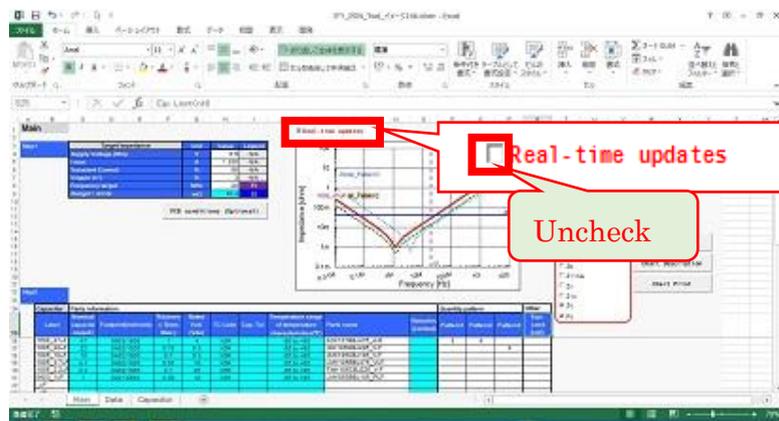
7.3. Enable/Disable Real-time Updates

You can temporarily enable/disable Real-time Updates in order to speed up processing (processing load reduction).

Note: This step can be omitted. It can set up even later. It does not affect the calculation of the impedance characteristic curve.

7.3.1. Disable Real-time Updates

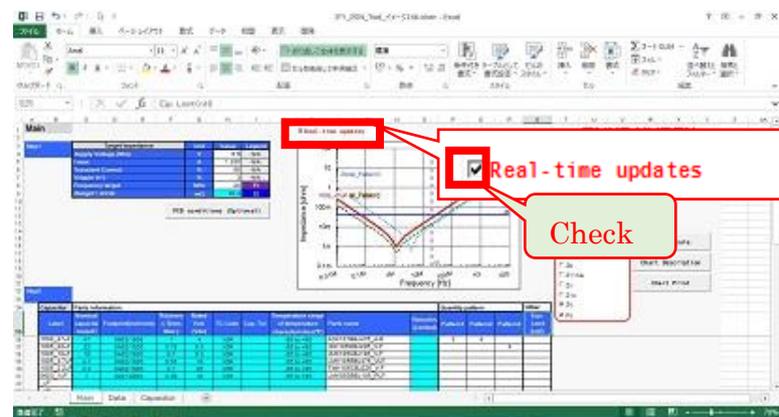
Step 1 — Uncheck the **Real-time updates** check box.



Note: Be sure to turn it enable again to update the graph of **Main** sheet.
See 【7.3.2. Enable Real-time Updates】 .

7.3.2. Enable Real-time Updates

Step 1 — Check the **Real-time updates** check box.



7.4. Select/Delete Capacitors

It is recommended to stay Real-time Update disable while the time you process below steps in order to speed up processing (processing load reduction). See 【 7.3. Enable/Disable Real-time Updates】 .

7.4.1. Select Capacitors

Step 1 — Double click at **Parts information** field to open **Capacitor selection** window.

Note: You should not input the cells which background color is aqua (bright light blue) by manual, because they are automatically set by the macro.

The screenshot shows a software window with a table of capacitor parts. The table has columns for Label, capacitance, Footprint, Thickness, Volt, TC Code, Cap. Tol., of temperature, Parts name, Remarks, and Quantity. A red box highlights a row with an aqua background. A callout box points to this row with the text "Double click the row to add or change." Another red box highlights the same row with the text "You should not input the cells which background color is aqua (bright light blue) by manual." To the right of the table is a graph showing Impedance [ohm] vs Frequency [Hz] on a log-log scale. The graph has a red line and a blue line. A red box highlights the graph area. To the right of the graph is a sidebar with a tree view of components and buttons for Chart Scale, Chart Description, and Chart Print.

Step 2 — You can filter by capacitance, footprint, thickness, rated voltage, temperature code, tolerance of capacitance, temperature range and parts name.

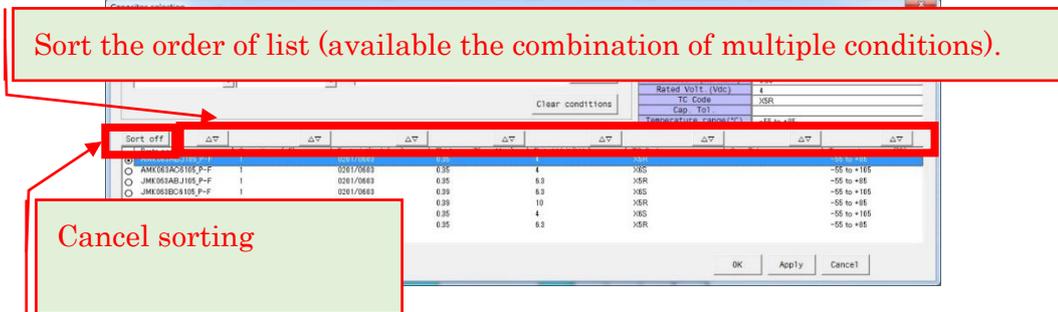
You can click **Clear conditions** button to clear the filter condition.

Note: This step can be omitted.

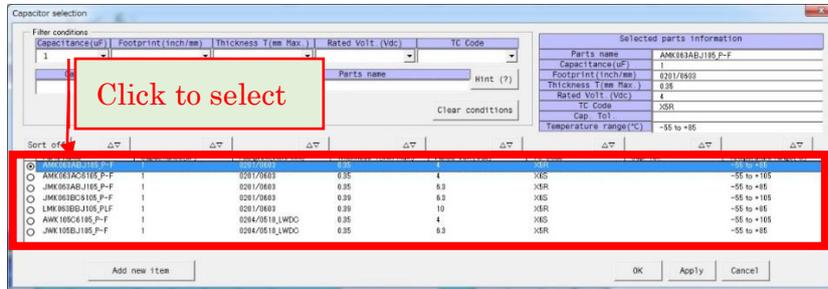
The screenshot shows the "Capacitor selection" dialog box. It has a "Filter conditions" section with several input fields: Capacitance (uF), Footprint (inch/mm), Thickness T (mm Max.), Rated Volt. (Vdc), TC Code, Cap. Tol., Temperature range (°C), and Parts name. A red box highlights the "Filter" button and the "Clear conditions" button. A callout box points to the "Filter" button with the text "Filter". Another callout box points to the "Clear conditions" button with the text "Clear conditions". A third callout box points to the "Parts name" field with the text "Show the hint of operation to filter Parts name." Below the filter fields is a table of capacitor parts with columns for Cap. (uF), Footprint (inch/mm), Thickness T (mm Max.), Rated Volt (Vdc), TC Code, Cap. Tol., and Temperature range (°C). The table has several rows of data. At the bottom of the dialog box are buttons for "Add new item", "OK", "Apply", and "Cancel".

Step 3 — You can sort the order of list with $\Delta \nabla$ button. You can click **Sort off** button to cancel sorting.

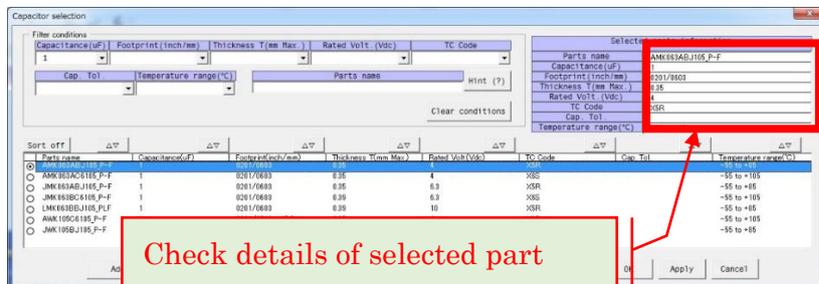
Note: This step can be omitted.



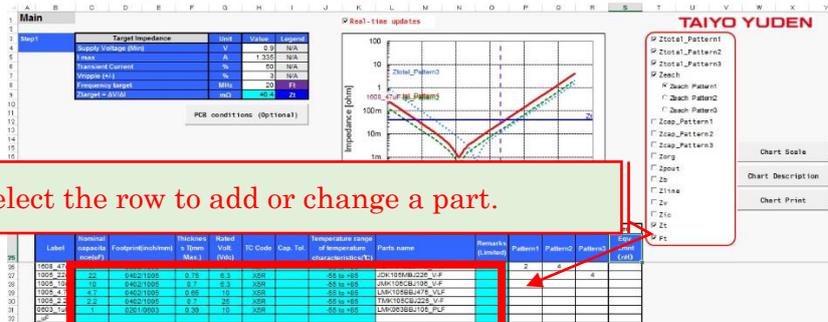
Step 4 — Click parts list to select part.



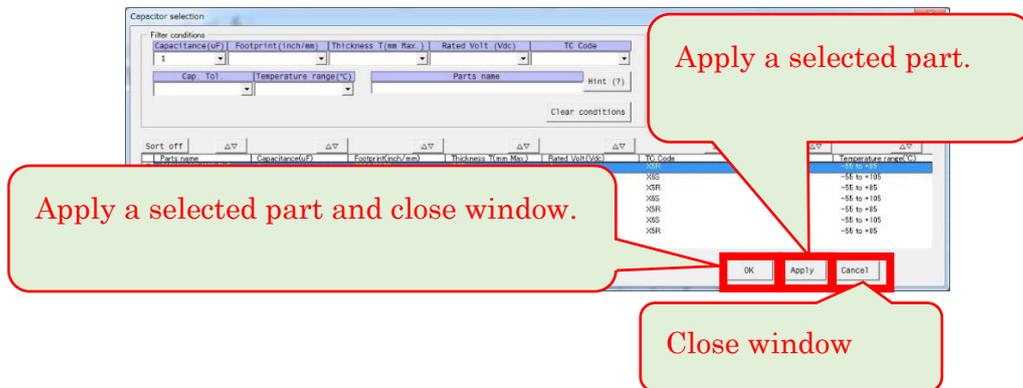
Step 5 — Check details of selected part with **Selected part information** fields.



Step 6 — Check the row of selected cell is that desired to add or change a part. If it is not that, select the desired cell.



Step 7 — Click **OK** or **Apply** button to apply a selected part.



Note:

OK : apply a selected part to the selected cells in **Main** sheet and close **Capacitor selection** window.

Apply : apply a selected part to the selected cells in **Main** sheet. You can continue to select parts.

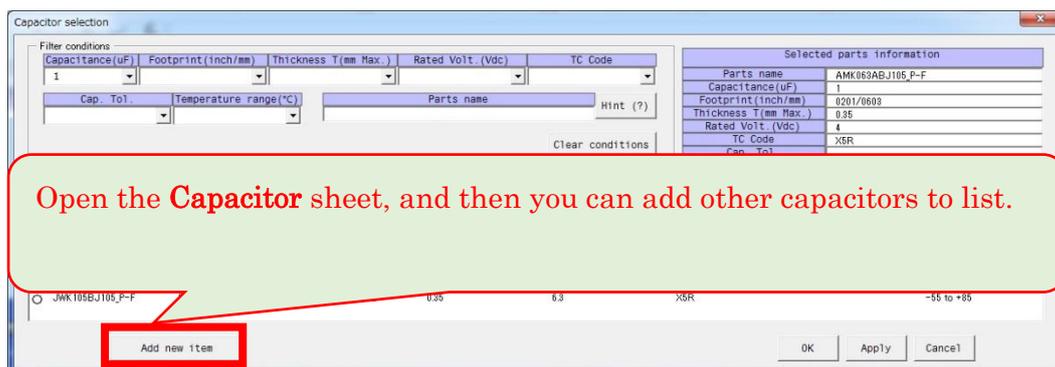
Cancel: close **Capacitor selection** window.

Step 8 — Confirm that it was correctly applied on the **Main** sheet.

Note: To continue the selection, click **Clear conditions** button to clear the filter condition, click **Sort off** button to cancel sorting, and start from Step 2 again.

To cancel the selection, click **Cancel** or **X (Exit)** button to close the window.

If you can't find the desired part from the list, click **Add new item** button to add the part to the list (see **[7.8. Updating Capacitor List]**) and start over from Step 1 .



7.4.2. Delete Capacitors

Step 1 — Click to select line(s) to delete.

The screenshot shows the 'Capacitor' table in the software. The following table represents the data visible in the image:

Label	Nominal Capacitance (nF)	Footprint (inch/mm)	Thickness (mm)	Rated Volt. (Vdc)	TC Code	Cap. Tol.	Temperature range of temperature characteristics (°C)	Parts name	Remarks (Limit)	Quantity patterns	Other
1408_47uF	47	0903/1003	1	8	XDR		-55 to +85	TK105CBJ225_V1F		2	4
1005_22uF	22	0402/1005	0.75	6.3	XDR		-55 to +85	TK105CBJ225_V1F			
1005_10uF	10	0402/1005	0.7	6.3	XDR		-55 to +85	TK105CBJ105_V1F			
1005_4.7uF	4.7	0402/1005	0.65	10	XDR		-55 to +85	TK105CBJ475_V1F			
1005_2.2uF	2.2	0402/1005	0.7	25	XDR		-55 to +85	TK105CBJ225_V1F			
0805_1uF	1	0201/0803	0.39	10	XDR		-55 to +85	TK105CBJ105_V1F			

Red callout boxes contain the following text:

- Click to select line(s).
- You can clear value(s) of **Parts name** field.

Step 2 — Hovering mouse pointer on selected line(s), and then right click.

Step 3 — Click **Delete** in the context menu to delete the selected line(s).

The screenshot shows a context menu with the following options:

- Cut
- Copy
- Paste
- Paste Special...
- Insert
- Delete** (highlighted)
- Clear Contents
- Format Cells...
- Row Height...
- Hide
- Unhide

A red box and arrow point to the 'Delete' option with the text: Click

7.5. Input Quantities

It is recommended to stay Real-time Update disable while the time you process below steps in order to speed up processing (processing load reduction). See 【 7.3. Enable/Disable Real-time Updates】 .

Step 1 — Input the quantity of each capacitor in the **Quantity pattern** field.

Note: You can input 3 patterns (**Pattern1 to Pattern3**) of quantity per a part.

The screenshot displays a software interface for capacitor analysis. It includes a 'Target Impedance' table, a graph of Impedance (ohm) vs Frequency (Hz), and a 'Capacitor' table. A red callout box points to the 'Pattern3' column in the table with the text 'Input the quantity of each part.'

Step1	Target Impedance	Unit	Value	Legend
Supply Voltage (Vrms)	V	0.5	N/A	
I _{max}	A	1.335	N/A	
Transient Current	%	50	N/A	
Wobble (Hz)	%	3	N/A	
Frequency target	MHz	20	Ft	
Target = ΔV/ΔI	mΩ	40.4	Zi	

Capacitor	Parts Information	Thickness	Rated Volt.	TC Code	Cap. Tol.	Temperature range of temperature characteristics(°C)	Parts name	Remarks (Limit)	Pattern	Other		
Label	Nominal capacitance(μF)	Footprint(inch/mm)	5.7mm Max.)	(Vdc)					Pattern1	Pattern2	Pattern3	Eqv Limit (unit)
1005_47uF	47	0803/1003	1	5	X5R	-55 to +85	ADK1078BJ475_A-R					
1005_22uF	22	0402/1005	0.75	6.3	X5R	-55 to +85	JKK105MBJ225_V-F				4	
1005_10uF	10	0402/1005	0.7	6.3	X5R	-55 to +85	JMK105CBJ105_V-F					
1005_4.7uF	4.7	0402/1005	0.65	10	X5R	-55 to +85	LMK1058BJ475_V-F					
1005_2.2uF	2.2	0402/1005	0.7	25	X5R	-55 to +85	TMK105CBJ225_V-F					
0805_1uF	1	0201/0803	0.39	10	X5R	-55 to +85	LMK083BBJ105_PLF					

7.6. Input Mount Inductance

You can input the mount inductance for each part, which is added due to mounting on PCB (Printed Circuit Board). The mount inductance is parasitic L component like that solder, via, wiring, etc.

Note: This step can be omitted.

It is recommended to stay Real-time Update disable while the time you process below steps in order to speed up processing (processing load reduction). See 【 7.3. Enable/Disable Real-time Updates】 .

Step 1 — Input the mount inductance of each capacitor in the **Eqv. Lmmt(nH)** field.

The screenshot shows the TAIYO YUDEN software interface. At the top, there's a 'Main' window with various settings. Below it is a graph showing Impedance [Ω] vs Frequency [Hz]. The bottom part of the interface features a table with columns for 'Capacitor', 'Part Information', 'Production', 'Date', 'TC Code', 'Cap. Val.', 'Temperature range', 'Parts name', 'Resistance', and 'Quantity pattern'. A red box highlights the 'Eqv. Lmmt (nH)' column. A callout bubble with a red border and a light green background contains the text 'Input the mount inductance.' pointing to this column.

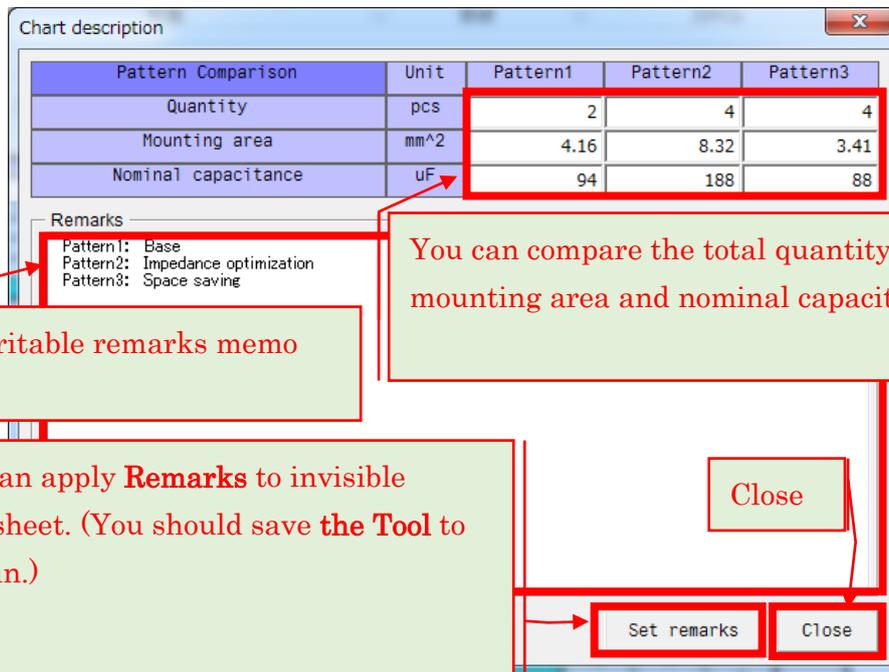
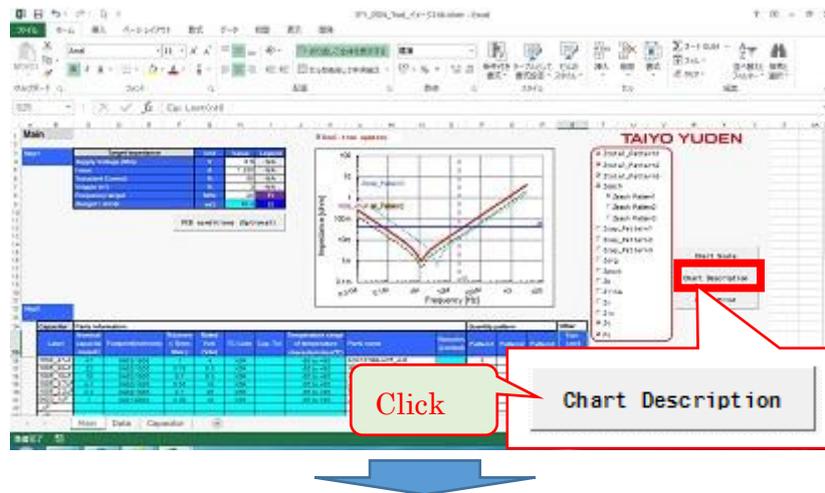
Note: **Eqv. Lmmt(nH)** means Equivalent L (Inductance) by Mounting, unit is nH. Since the **Eqv. Lmmt(nH)** depends on the PCB, mounting method, etc., contact equipment designers as necessary to obtain information. If you have no information about it, you can blank that means ignore.

7.7. Checking Result of Analysis

7.7.1. Respective Patterns Comparison

各パターンの総量、総実装面積、総容量を比較できる。備考メモの確認・更新も可能。

Step 1 — Click **Chart Description** to open **Chart description** window.



Rewritable remarks memo

You can compare the total quantity, mounting area and nominal capacity.

You can apply **Remarks** to invisible worksheet. (You should save the **Tool** to remain.)

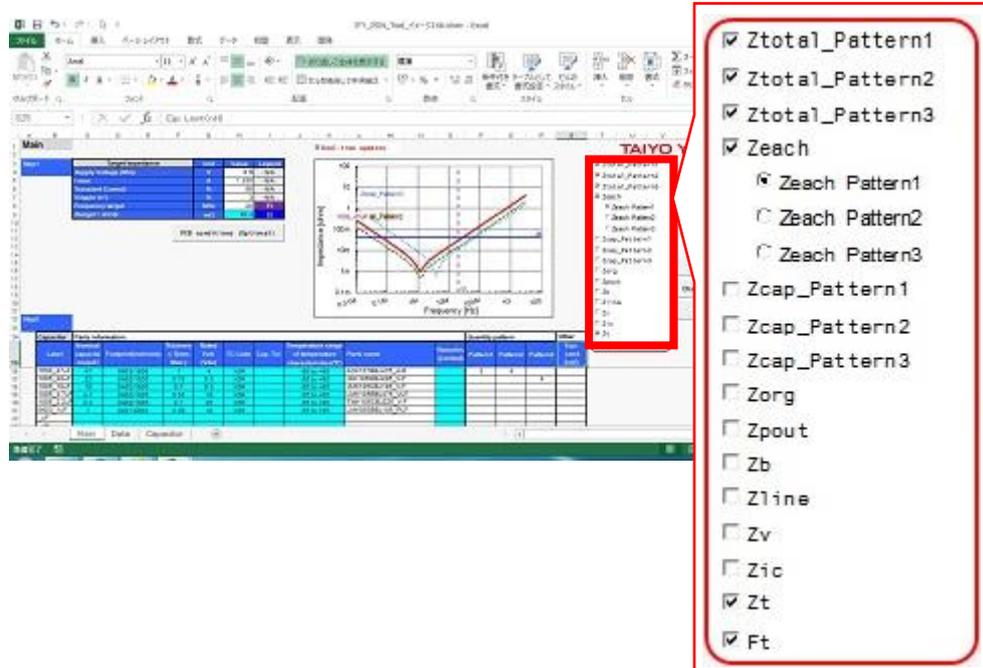
Close

Set remarks

Close

7.7.2. Checking Graph of Impedance/Freq.

Step 1 — Check the check box of graph which you want to show.



Note: In usually, it is recommend to check the **Ztotal_Pattern***(from 1 to 3), **Zt** and **Ft** check box.

To show impedance of respective capacitor, you should check the **Zeach** check box, and then check one of the pattern (from **Zeach_Pattern1** to **Zeach_Pattern3** check box) which you want to show.

In usually, it is recommend to stay uncheck the other check boxes, and check only when you need to show other graphs.

■ Description of each check box (It will be displayed by hovering mouse pointer over each check box.)

- Ztotal_Pattern1
Show (or hide) chart of 'Ztotal' (the total impedance) which the quantity pattern is 'Pattern1'.
- Ztotal_Pattern2
Show (or hide) chart of 'Ztotal' (the total impedance) which the quantity pattern is 'Pattern2'.
- Ztotal_Pattern3
Show (or hide) chart of 'Ztotal' (the total impedance) which the quantity pattern is 'Pattern3'.
- Zeach
Show (or hide) chart of total impedance each capacitor.
You should select the quantity pattern from 'Pattern1'~'Pattern3' with below option button.
- Zeach_Pattern1
Show (or hide) chart of total impedance of each capacitor which the quantity pattern is 'Pattern1'.
- Zeach_Pattern2
Show (or hide) chart of total impedance of each capacitor which the quantity pattern is 'Pattern2'.
- Zeach_Pattern3
Show (or hide) chart of total impedance of each capacitor which the quantity pattern is 'Pattern3'.

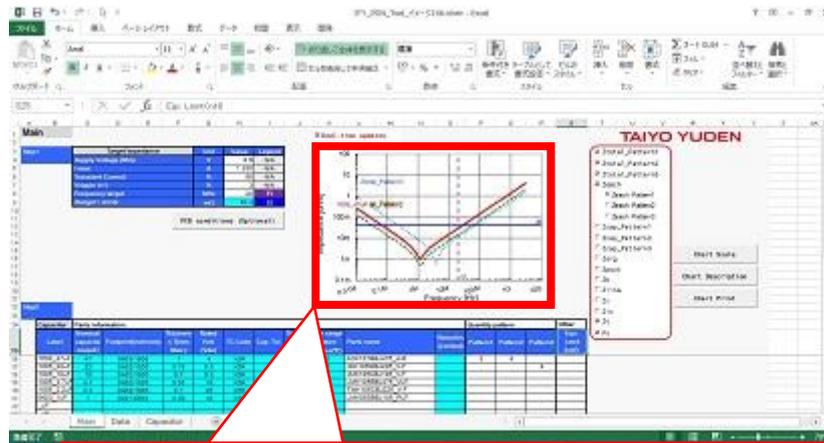
- **Zpout**
Show (or hide) chart of the VRM(voltage regulator module) impedance.
For details, click [PCB conditions (Optional)] button and see PDN circuit topology (VRM).
- **Zb**
Show (or hide) chart of the board(parallel plate) impedance.
For details, click [PCB conditions (Optional)] button and see PDN circuit topology (PCB).
- **Zline**
Show (or hide) chart of the line (board wiring) impedance.
For details, click [PCB conditions (Optional)] button and see PDN circuit topology (Line).
- **Zv**
Show (or hide) chart of the via impedance.
For details, click [PCB conditions (Optional)] button and see PDN circuit topology (Via).
- **Zic**
Show (or hide) chart of the IC impedance.
For details, click [PCB conditions (Optional)] button and see PDN circuit topology (IC).
- **Zt**
Show (or hide) chart of the 'Ztarget' (target impedance).
- **Ft**
Show (or hide) chart of the 'Frequency target' (target frequency).

Step 2 — Check the graph.

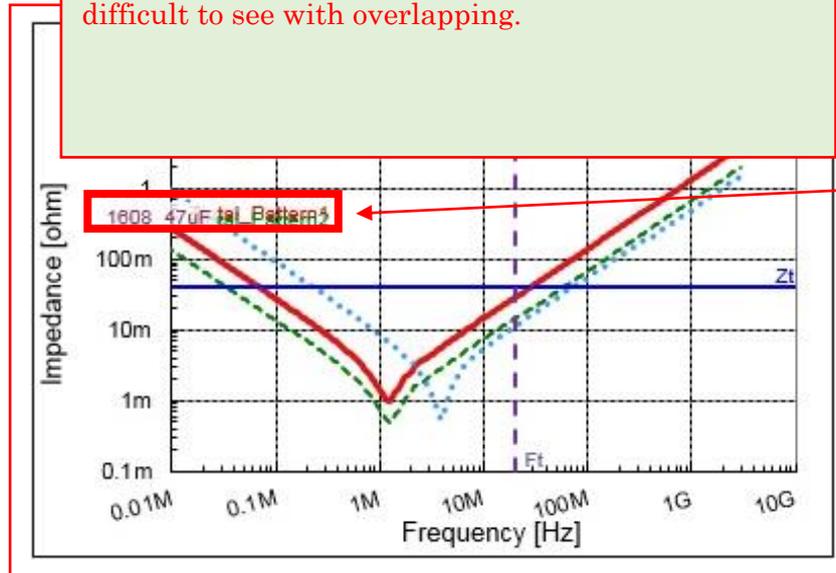
Note:

Horizontal axis: is Frequency[Hz]. **M** means MHz, **G** means GHz.

Vertical axis: is Impedance[Ohm]. **m** means mohm.

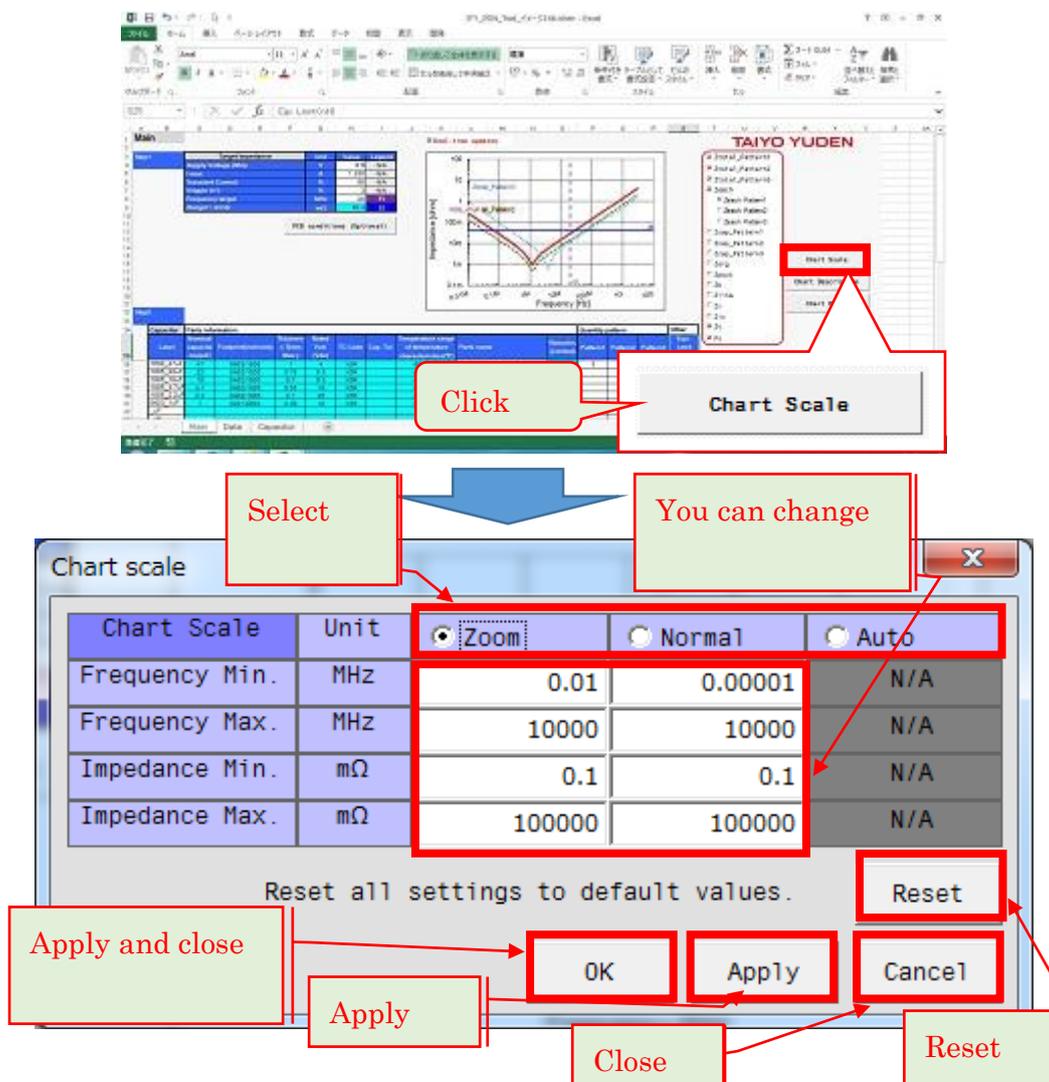


You can move the label by mouse dragging, if it is difficult to see with overlapping.



Step 3 — Click the **Chart scale** to open **Chart scale** window. You can change the scale of the graph for easy to see.

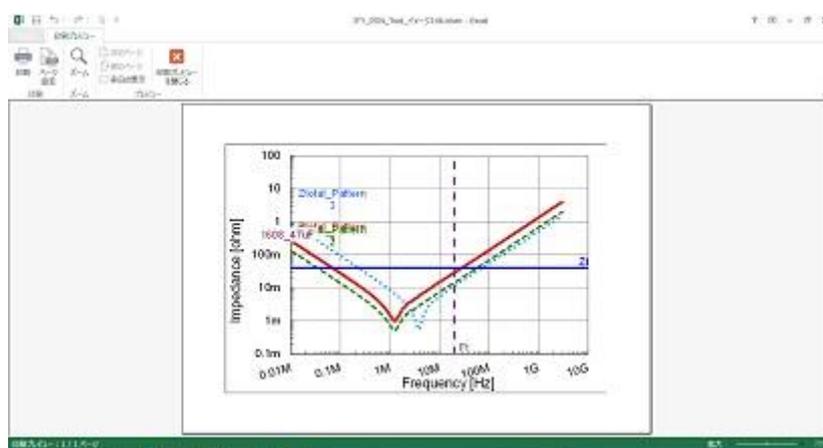
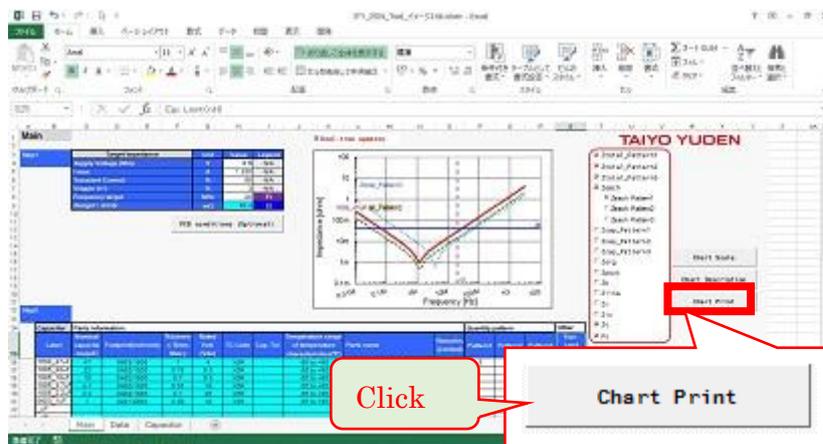
Note: This step can be omitted.



Note: **Zoom** and **Normal** can be changed value by manual. **Auto** is auto scale with Excel function.

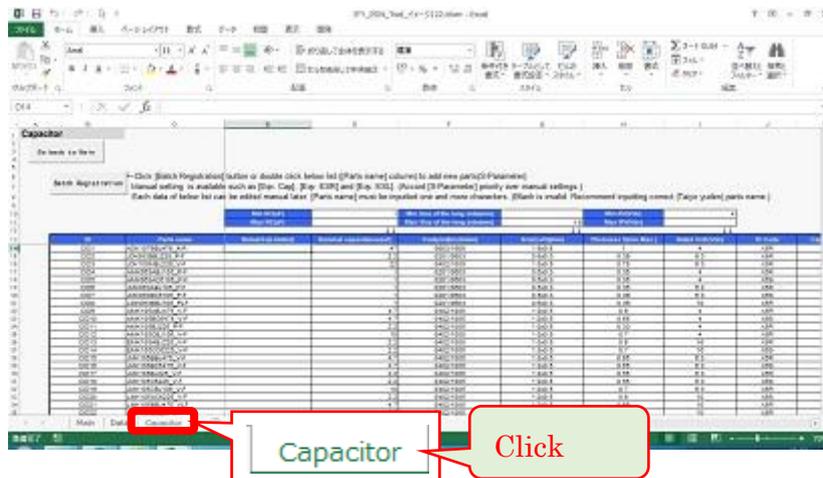
Step 4 — Click the **Chart Print** to display the print preview of the graph.

Note: This step can be omitted.



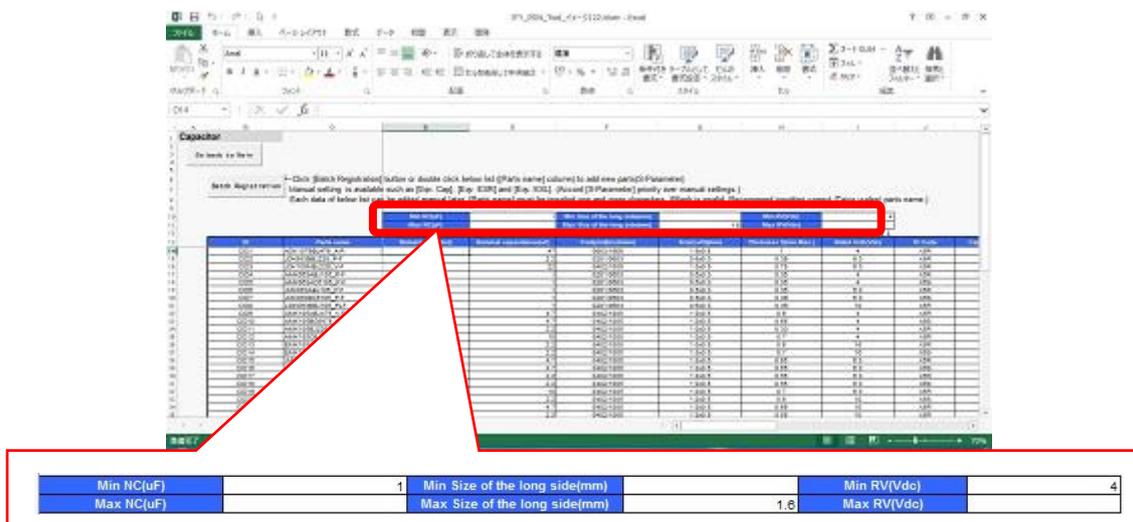
7.8. Updating Capacitor List

Step 1 — Select **Capacitor** sheet tab.



Step 2 — If you want to narrow down the data to register, set the following. (It is recommended to set for reduce processing load.)

Note: This step can be omitted. You can blank that means ignore.



Note:

Min NC(uF): is lower limit of Nominal capacitance (unit is uF) to register.

Max NC(uF): is upper limit of Nominal capacitance (unit is uF) to register.

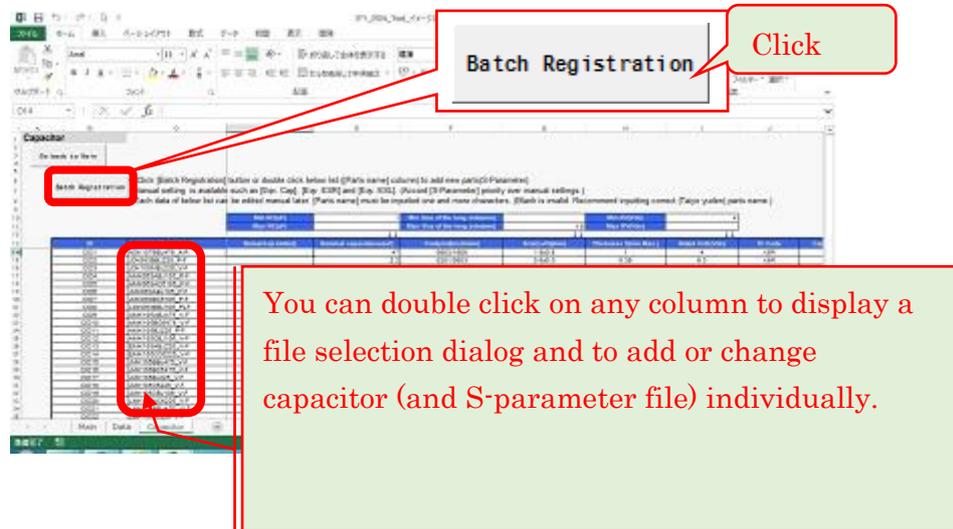
Min Size of the long side(mm): is lower limit of long side(unit is mm) to register.

Max Size of the long side(mm): is upper limit of long side(unit is mm) to register.

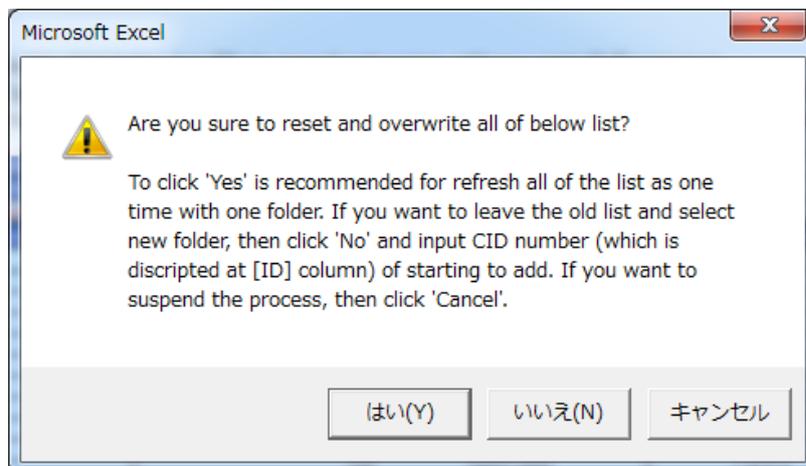
Min RV(Vdc): is lower limit of Rated Volt.(unit is Vdc) to register.

Max RV(Vdc): is upper limit of Rated Volt.(unit is Vdc) to register.

Step 3 — Click **Batch Registration** button and then follow the instructions of screen to select the folder containing the S-parameter.

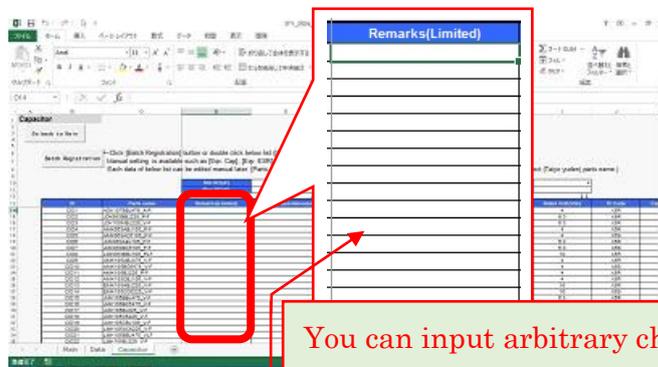


Note: Since the following popup is displayed before selecting the folder, it is recommended to click **Yes** when you update all of S-parameter in one time. If you want to remain the current setting, you should click **No** and input the CID number (see ID column) which you want to start updating. You can click **Cancel** to interrupt processing.

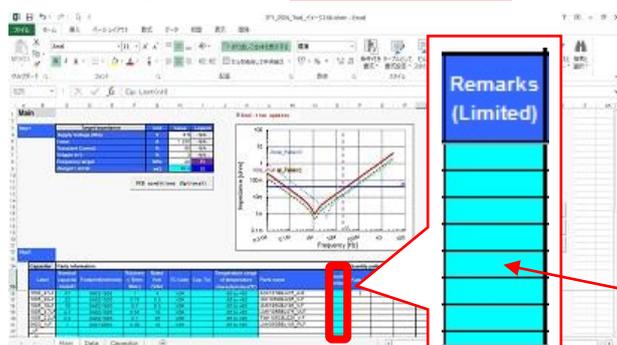


Step 4 — You can input a remarks (anything of limited, special description, etc.) to the **Remarks(Limited)** column.

Note: This step can be omitted.



You can input arbitrary characters.



You can check the remarks in the **Remarks (Limited)** field.

Note: When the folder name includes a string such as "for **", the string of "for **" is automatically extracted from the folder name and added to the **Remarks (Limited)** column of **Capacitor** sheet. You can fix it manually later. To reflect changing, you should update the **Main** sheet, for example, re-check **Real-time updates** check box, or re-select the capacitor.