SPICE Netlist Library

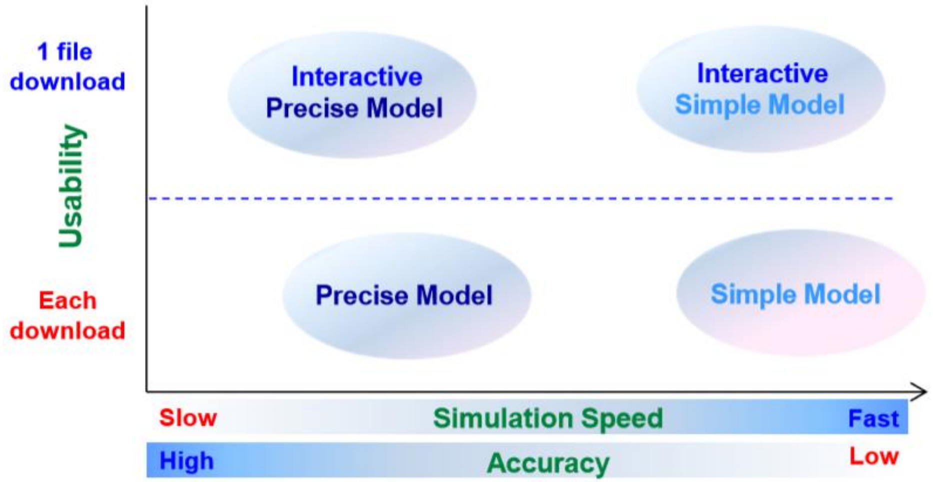
(for Multi-Layer Ceramic Capacitors)

Component Solution Division
Samsung Electro-Mechanics

Contents

1-1. Type of Models

We have 4 types of SPICE models for multi-layer ceramic capacitors.



Type	Elements / Description	DC bias condition	Temperature condition
Interactive Precise Model	*40~60 elements : Insulation Resistor, Capacitance Equivalent series resistance, inductance + Piezo peak for **each frequency** (Closer to the measurement data)	1 file	
Precise Model		Each download on Web	Each download on Web
Interactive Simple Model	*4 elements (Average value) : Insulation Resistor, Avg Capacitance Equivalent series resistance, Avg Inductance for **whole frequency**	1 file	
Simple Model		Each download on Web	Each download on Web

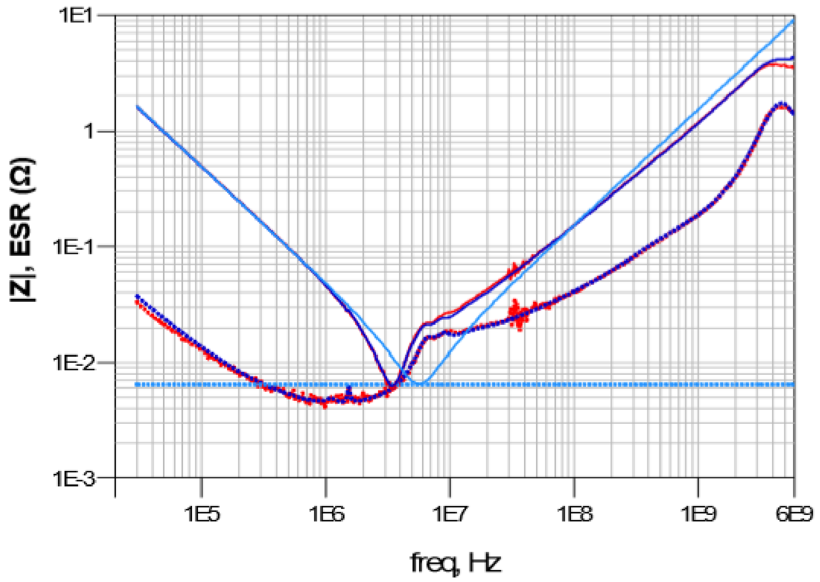
1-2. Simple Models vs Precise Model

Example : CL21A475KBQNNN

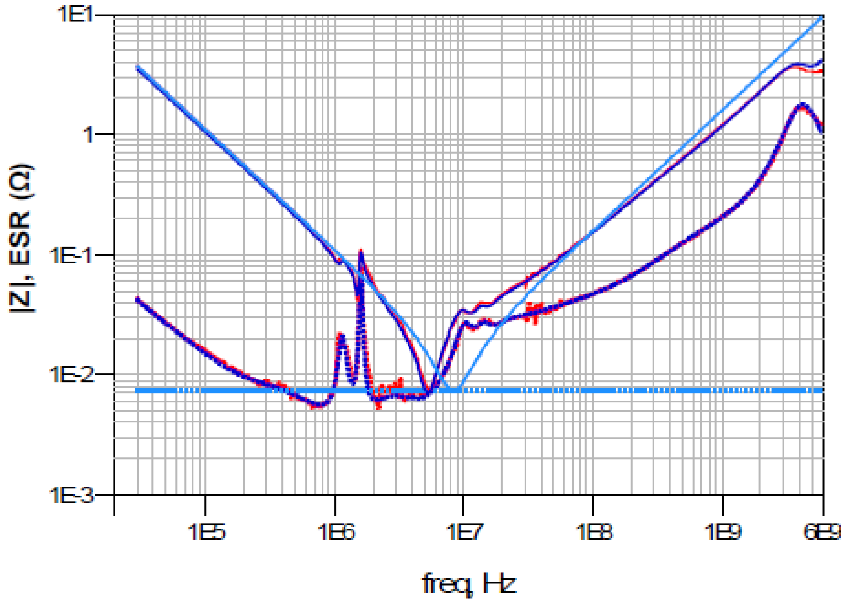
* Impedance graph comparison for frequency

Simple model / Simple interactive model
Precise model / Precise Interactive model
Network Analyzer Measurement data

1) Temperature : 25℃, DC bias 0V condition



2) Temperature : 55℃, DC bias 10V condition



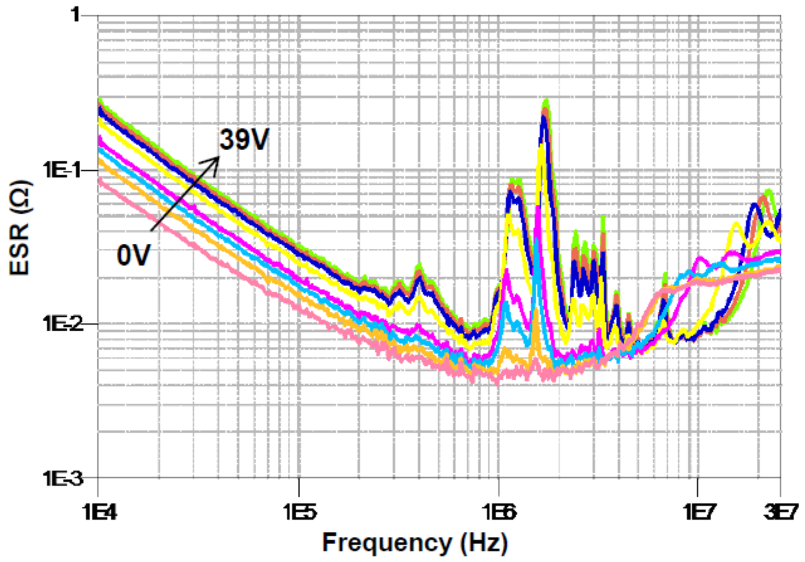
- Precise model almost same with the measurement data for each frequency.
- Simple model has two reactance(XC, XL) as average value of measurement data and a constant resistance as impedance value at the self resonant frequency.
- In case of simulation related loss analysis, Precise model might be proper than Simple model.
- Simple model can help obtain simulation result more quickly.

1-3. Precise Model reflected Piezo effect (1/2)

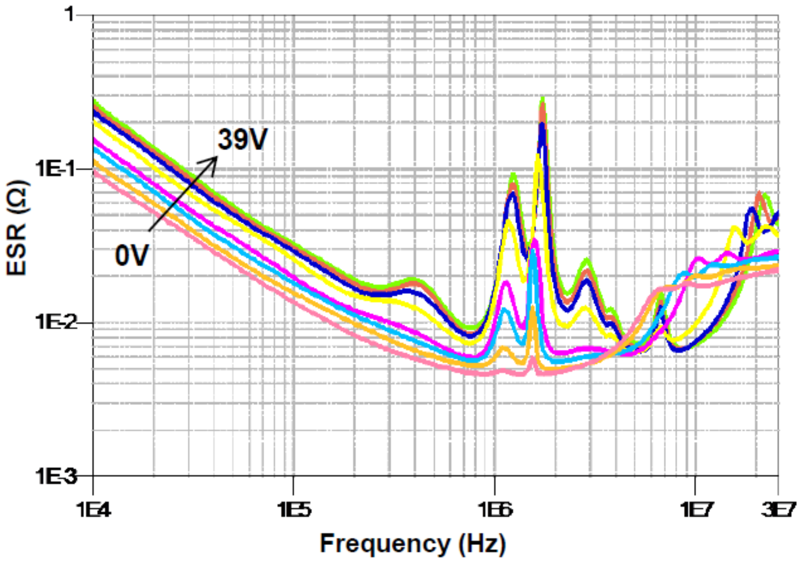
Example : CL21A475KBQNNN

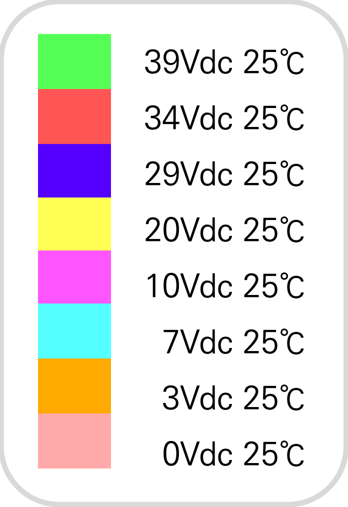
* **ESR graph comparison for frequency** (Temperature : 25℃, DC bias 0~39V condition)

1) Measurement data



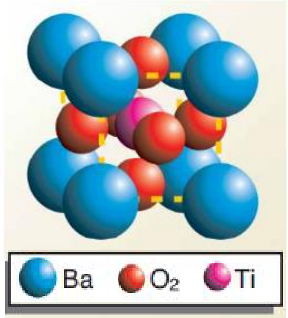
2) Precise model data (S2P/PSPICE Lib)

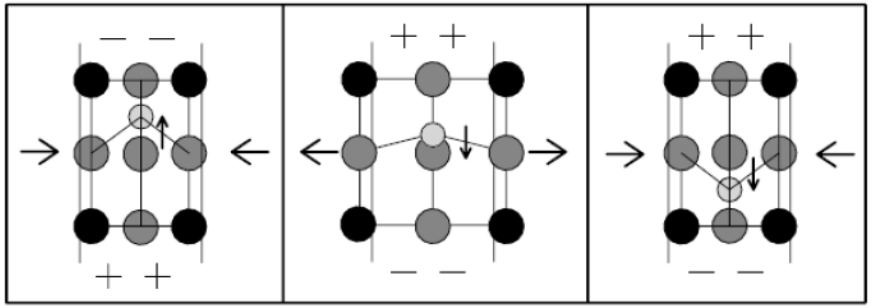




- ESR data measured by Network Analyzer shows Piezo effect related to DC bias.
- Samsung Precise model has ESR data reflecting Piezo effect. It is similar to measurement data.

※ The **Piezoelectric Effect** occurs in crystals that have no center of symmetry. This lends itself to a net polarization of the crystal. Barium titanate MLCCs exhibit a mechanical distortion with applied electric field.

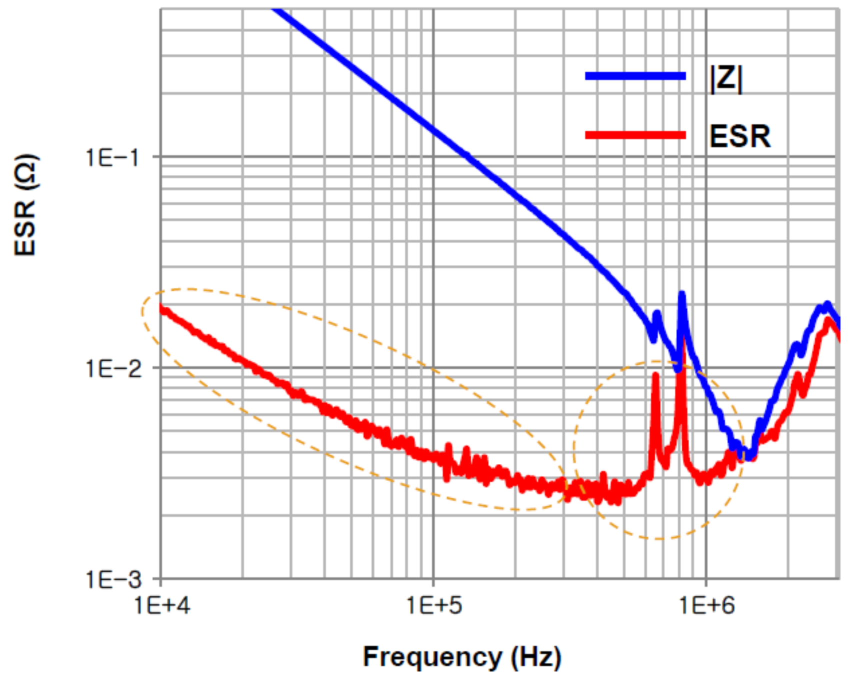




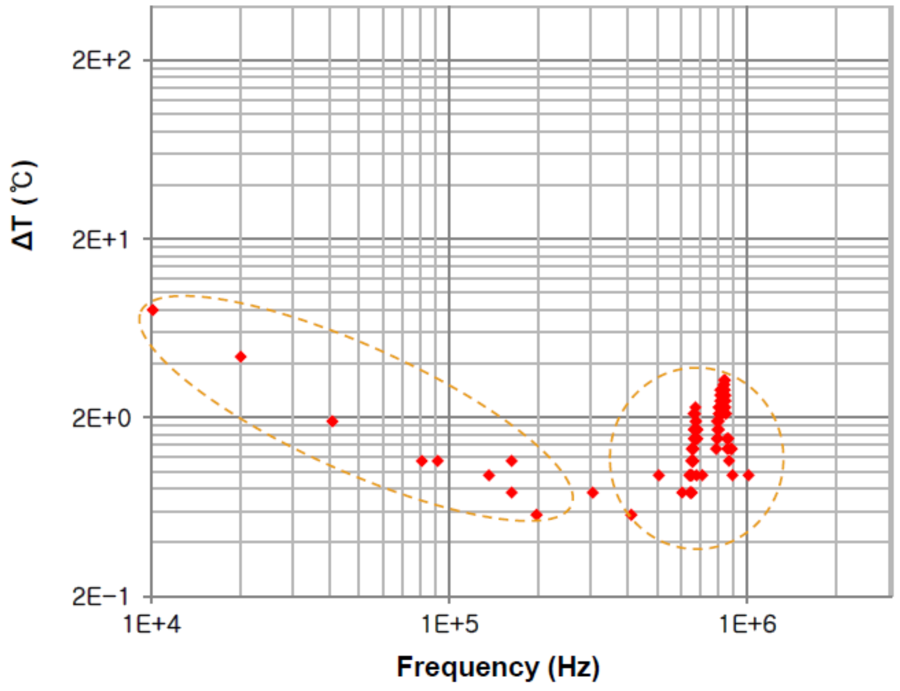
Example : CL32B476KPJNNW

* **ESR graph comparison for frequency** (Temperature : 25℃, DC bias 10V condition)

1) ESR Measurement data



2) Loss Measurement data (AC 1A ripple current heating)

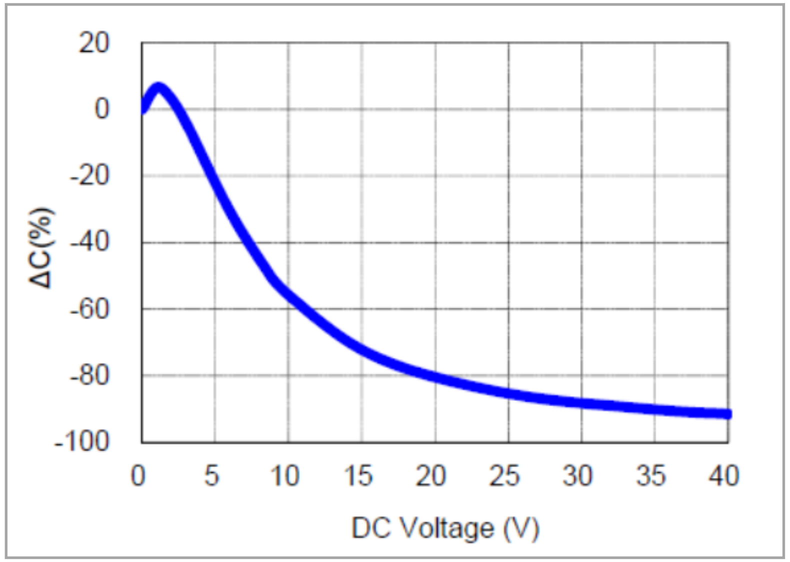


- ESR data of Precise Model shows 'dielectric loss' and 'Piezo effect' related to DC bias.
- **Precise model** is better than Simple Model in Loss Analysis.

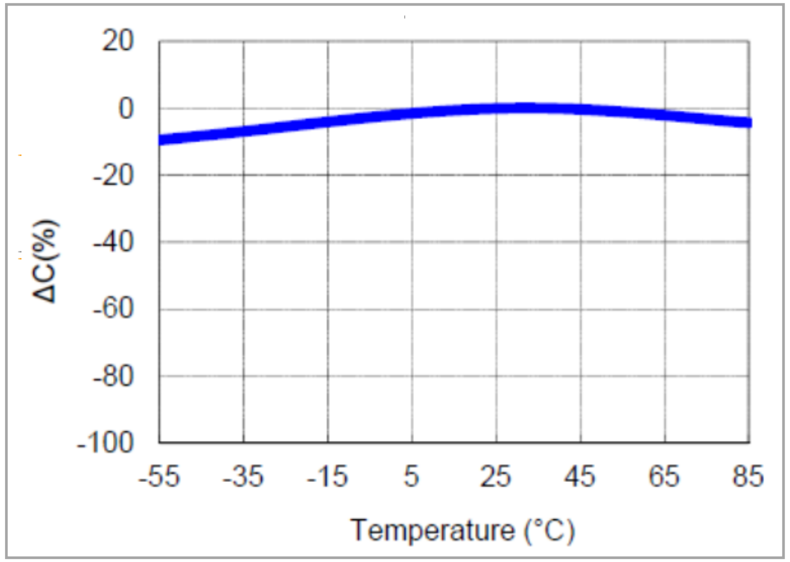
1-4. Interactive model?

As below graph, MLCC of high dielectric constant has DC bias and Temperature dependent characteristics. Our web library is providing each CKT file and S-parameters for specific condition (DC bias / temperature). Especially, Interactive model was included DC bias and temperature dependent characteristics in only one file.

[DC bias characteristics]



[Temperature characteristics]



- Simple model, Precise model

  : User should download each files for DC bias/Temperature condition.
  All inner element was normal passive components.

- Interactive Simple model, Interactive Precise model

  : One file was reflected DC bias/Temperature dependent characteristics.
  Inner elements was included some nonlinear components.

1–5. Using Interactive model (Example)

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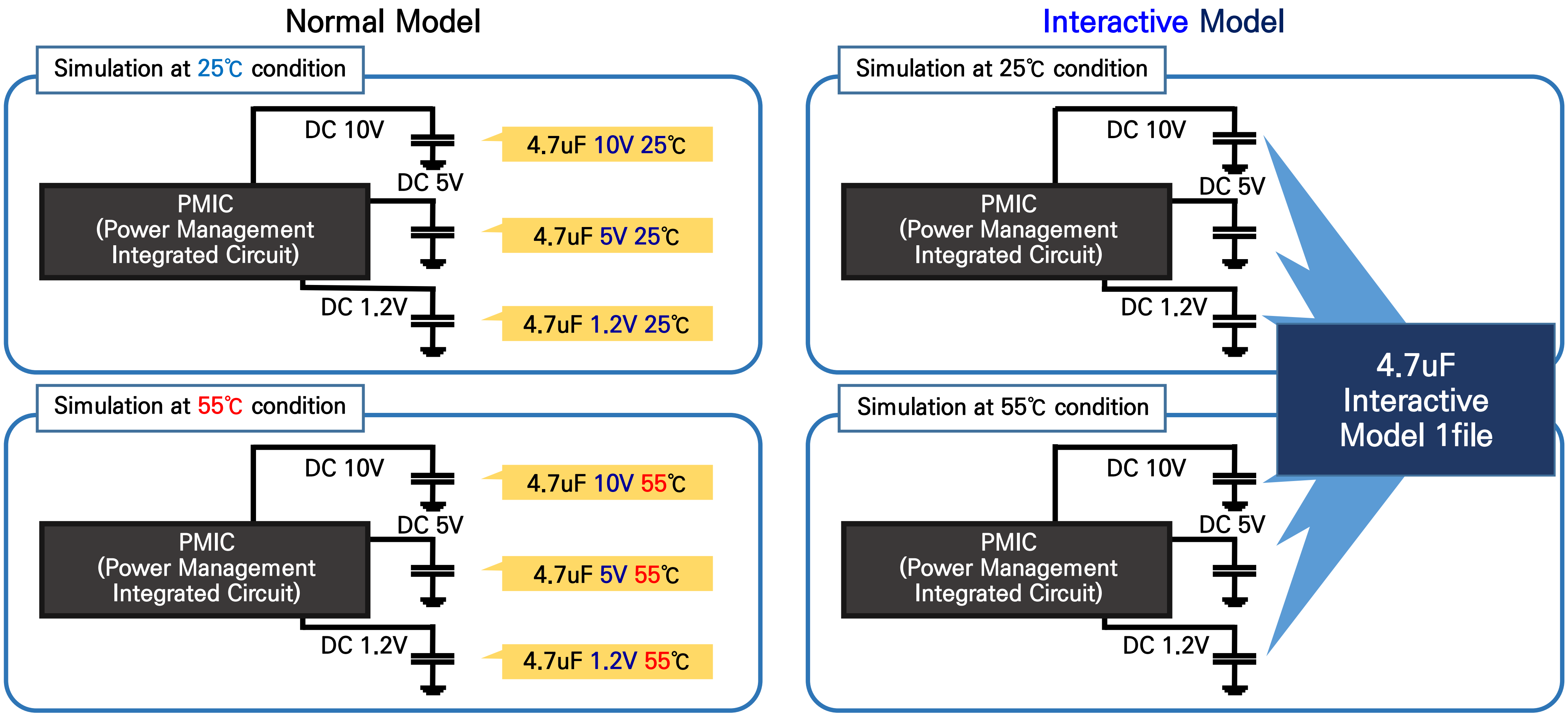

– Interactive Simple model, Interactive Precise model

: One file was reflected DC bias/temperature dependent characteristics.

DC bias characteristics are calculated automatically as voltage condition in circuit.

Temperature characteristics are calculated automatically by setting simulation condition.

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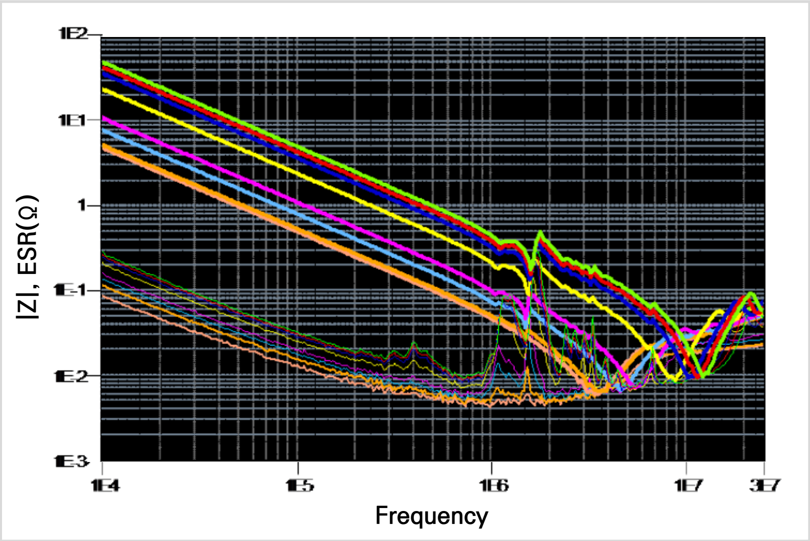
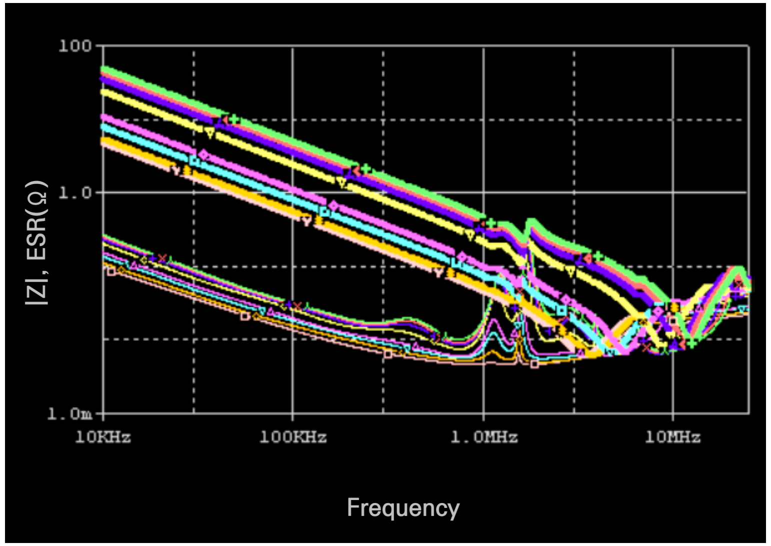
Example : CL21A475KBQNNN
[DC bias sweep (0~40V, 25℃)]

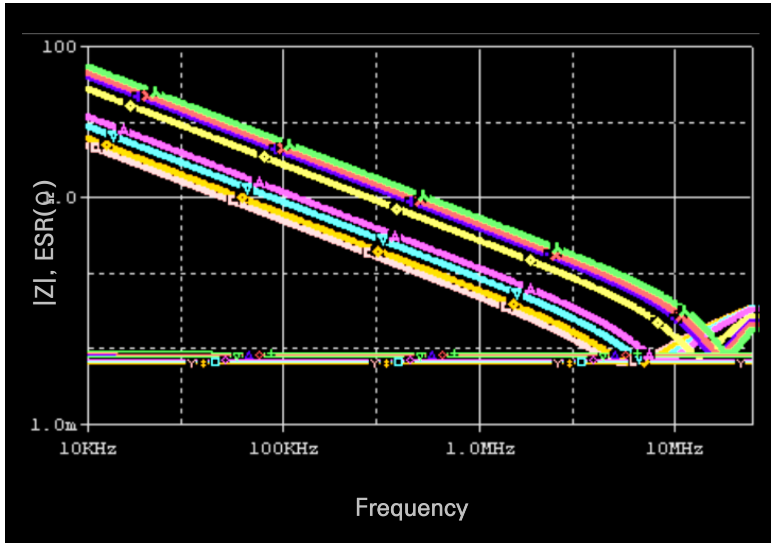
▶ Measurement data



▶ Interactive Precise Model



▶ Interactive Simple Model



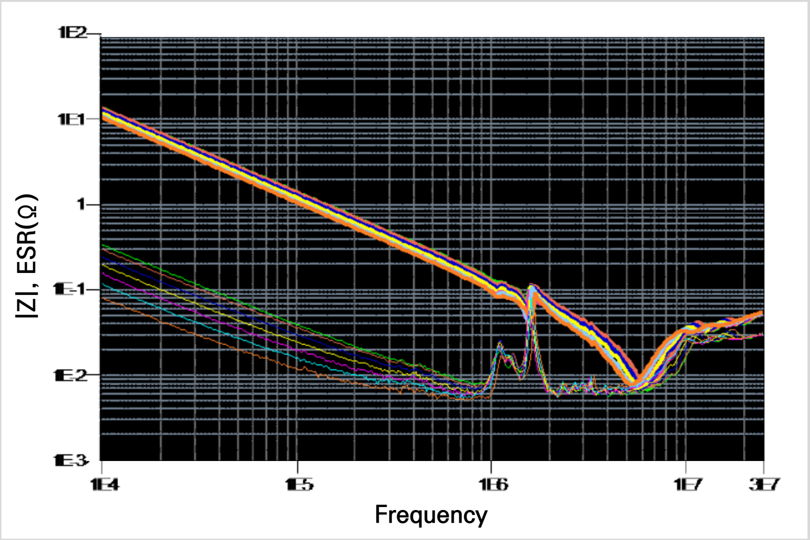
39Vdc 25℃	34Vdc 25℃	29Vdc 25℃	20Vdc 25℃
10Vdc 25℃	7Vdc 25℃	3Vdc 25℃	0Vdc 25℃

- One Interactive file was reflected DC bias dependent characteristics for each frequency.

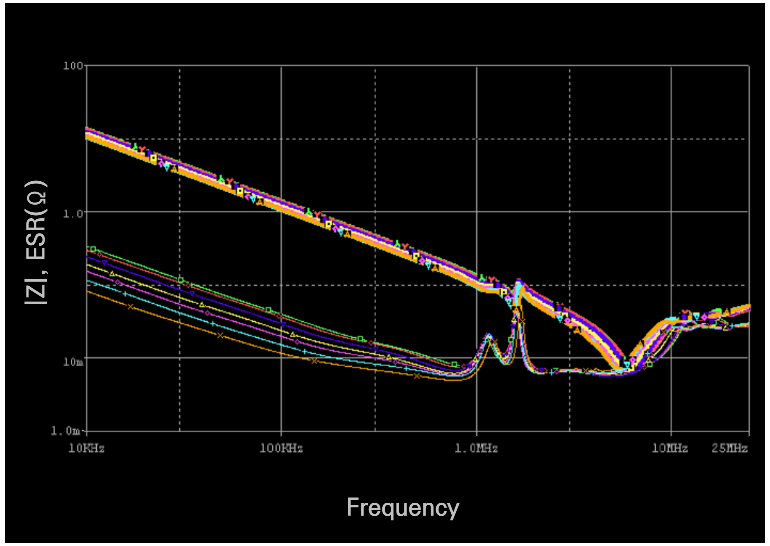
Example : CL21A475KBQNNN

[Temperature bias sweep (-55℃~ +85℃, 10V DC-bias]

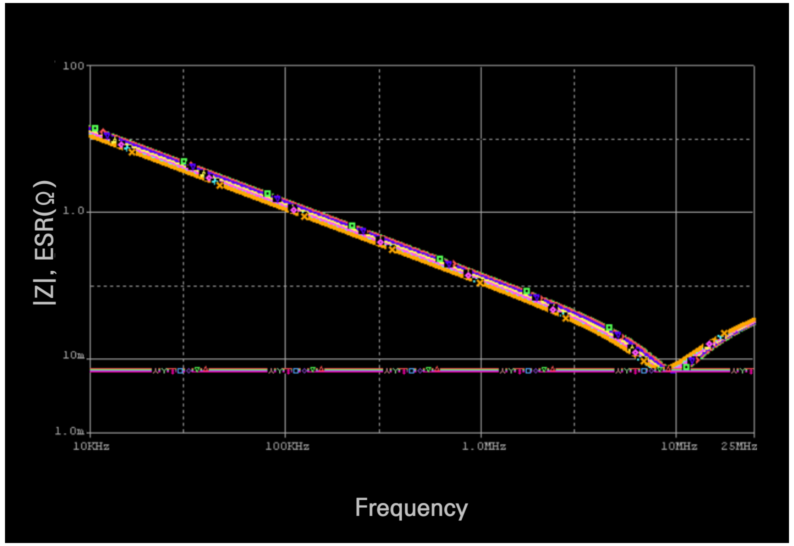
▶ Measurement data



▶ Interactive Precise Model



▶ Interactive Simple Model



10Vdc -55℃
10Vdc -35℃
10Vdc -15℃
10Vdc 5℃
10Vdc 25℃
10Vdc 55℃
10Vdc 85℃

- Also, One Interactive file was reflected Temperature dependent characteristics for each frequency.

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The PSPICE Interactive/static model can be downloaded from SAMSUNG Web site. (http://www.samsungsem.com)

1. Download netlist file. It is recommended to save as. [*.lib]

Simple model Example

```
* Products : Multilayer Ceramic Capacitor
*-----------------------------------------------
* Characteristics :
*
*     Nominal Capacitance = 4.7uF
*     Capacitance Tolerance = ±10%
*     TCC = X5R(-55 ~ +85 Cels.)
*     Rated Voltage = 50Vdc
*     Size = 0805(unit:inch), 2012(unit:mm)
*     Length = 2.00 +/-0.15 mm
*     Width = 1.25 +/-0.15 mm
*     Thickness = 1.25 +/-0.15 mm
*     Measurement Temperature : 25Cels.
*     DC bias Value = 0V
*-----------------------------------------------
* External Node Assignments :
*
*  1  o---||---o  2
*
*-----------------------------------------------
.SUBCKT CL21A475KBQNNN 1 2
C1 1 3 3.24e-6
R1 1 3 1.00e-8
R2 3 4 6.41e-3
L1 4 2 2.37e-10
.ENDS CL21A475KBQNNN
```

Precise model Example

```
* Products : Multilayer Ceramic Capacitor
*-----------------------------------------------
* Characteristics :
*
*     Nominal Capacitance = 4.7uF
*     Capacitance Tolerance = ±10%
*     TCC = X5R(-55 ~ +85 Cels.)
*     Rated Voltage = 50Vdc
*     Size = 0805(unit:inch), 2012(unit:mm)
*     Length = 2.00 +/-0.15 mm
*     Width = 1.25 +/-0.15 mm
*     Thickness = 1.25 +/-0.15 mm
*     Measurement Temperature : 55Cels.
*     DC bias Value = 10V
*-----------------------------------------------
* External Node Assignments :
*
*  1  o---||---o  2
*
*-----------------------------------------------
.SUBCKT CL21A475KBQNNN 1 2
C1 1 3 1.61661e-6
C2 3 4 1.59844e-4
C3 4 5 8.23247e-5
C4 5 6 2.40151e-4
C5 6 7 1.34948e-4
C6 7 8 1.32562e-4
C7 8 9 9.33097e-5
C8 9 10 2.63326e-4
R1 1 3 1.00000e+8
R2 3 4 3.75187e+1
R3 4 5 5.51509
R4 5 6 1.68167
C5 6 7 1.34948e-4
C6 7 8 1.32562e-4
C7 8 9 9.33097e-5
C8 9 10 2.63326e-4
R1 1 3 1.00000e+8
R2 3 4 3.75187e+1
R3 4 5 5.51509
R4 5 6 1.68167
R5 6 7 4.92800e-1
R6 7 8 8.23247e-2
R7 8 9 1.41573e-2
R8 9 10 1.05347e-2
R9 10 11 5.68272e-5
L10 11 12 1.23378e-10
L11 12 13 1.94373e-11
L12 13 14 2.13857e-11
L13 14 15 1.84101e-10
L14 15 16 4.08916e-11
L15 16 17 5.31596e-13
L16 17 18 3.17535e-10
L17 18 19 3.60562e-10
L18 19 20 2.73866e-10
L19 20 21 8.61761e-12
.ENDS CL21A475KBQNNN
```

Interactive Simple model Example

```
* Products : Multilayer Ceramic Capacitor
*-----------------------------------------------
* Characteristics :
*
*     Nominal Capacitance = 4.7uF
*     Capacitance Tolerance = ±10%
*     TCC = X5R(-55 ~ +85 Cels.)
*     Rated Voltage = 50Vdc
*     Size = 0805(unit:inch), 2012(unit:mm)
*     Length = 2.00 +/-0.15 mm
*     Width = 1.25 +/-0.15 mm
*     Thickness = 1.25 +/-0.15 mm
* Applicable condition :
*     Frequency : 300Hz ~ 6GHz
*     Measurement Temperature : -55 ~ 85Cels.
*     DC bias Value = 0V ~ 40V
*     Small Signal as Network Analyzer
*-----------------------------------------------
* External Node Assignments :
*
*  1  o---||---o  2
*
*-----------------------------------------------
**$ENCRYPTED_LIB
**$PARTIAL
.SUBCKT CL21A475KBQNNNsimple_DCtemp Port1 Por
$CDNENCSTART_ADV2
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006667ae5346eafe8085c040208b4cec0cae42976dedd
0de58834cad1b099[illegible]7064fe1520c3c5e5a
995a756d201943[illegible]4dca373ba3df67ecab9d
6f97a60e025f5b6f448131fa90be07e48e1756be92670
$CDNENCFINISH_ADV2
.ENDS CL21A475KBQNNNsimple_DCtemp
```

Encrypt

Interactive Precise model Example

```
* Products : Multilayer Ceramic Capacitor
*-----------------------------------------------
* Characteristics :
*
*     Nominal Capacitance = 4.7uF
*     Capacitance Tolerance = ±10%
*     TCC = X5R(-55 ~ +85 Cels.)
*     Rated Voltage = 50Vdc
*     Size = 0805(unit:inch), 2012(unit:mm)
*     Length = 2.00 +/-0.15 mm
*     Width = 1.25 +/-0.15 mm
*     Thickness = 1.25 +/-0.15 mm
* Applicable condition :
*     Frequency : 300Hz ~ 6GHz
*     Measurement Temperature : -55 ~ 85Cels.
*     DC bias Value = 0V ~ 40V
*     Small Signal as Network Analyzer
*-----------------------------------------------
* External Node Assignments :
*
*  1  o---||---o  2
*
*-----------------------------------------------
**$ENCRYPTED_LIB
**$PARTIAL
.SUBCKT CL21A475KBQNNN_DCtemp Port1 Port2
$CDNENCSTART_ADV2
17f62b1fb318c25603aeb85644ae98a5720609594b55
f42281a1e01984ca61ee9568245776d80530244a17a1
fad8241a74ce51610528c66b7425d2d7cb5155dba8c7
233ac6ee8b6792f60737ba26e24ed803314e927defdb
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a772424e1573d2be0728fca1fc7d78c7d43c8d969216
25b1541e69e1a4eb456fa82982b00532b7f75fb5f657
86bd874f58d635360bc9fde8100391f3abc12a91777c
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8666467fa8fbfff9fe0ad87e7bd3ef43d8b3921635be
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e2a8cea2588b844d25e353b386b2ae37a2c5f0d065b2
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9436275f000b5b8c9bbc9a7e356f32d1243978b95cb9
cff278d59748dff56dd44ba34321d8cddf19da036203
01e3786b871ba9e3269e3624fbbecd545d6702fee75a
4666aa858079ab80e559cad1c03724964bd1f323ec32
$CDNENCFINISH_ADV2
.ENDS CL21A475KBQNNN_DCtemp
```

Encrypt

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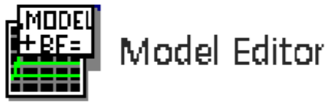
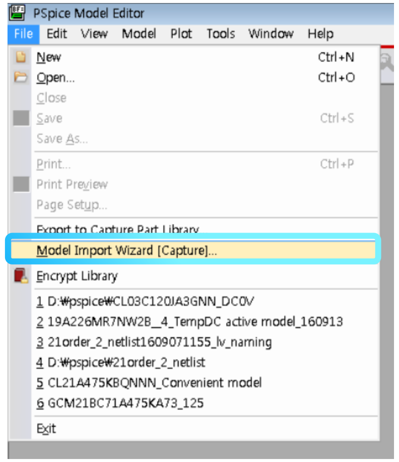
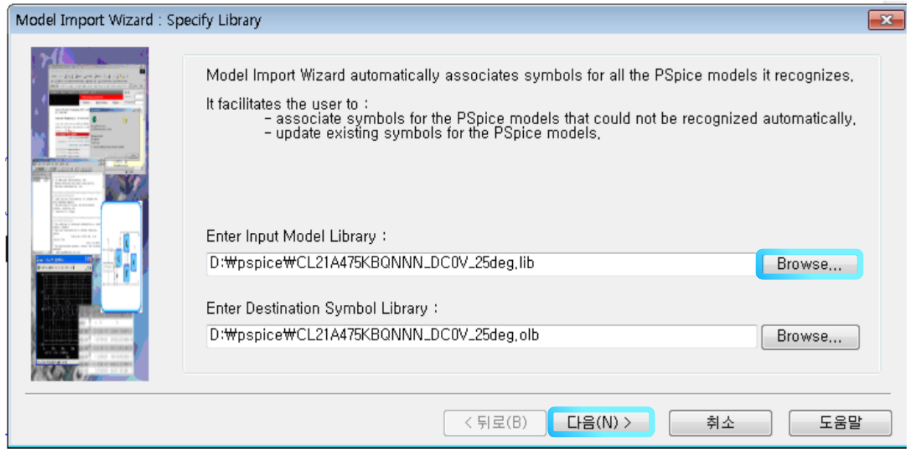
2. Execute 'PSpice Model Editor'.



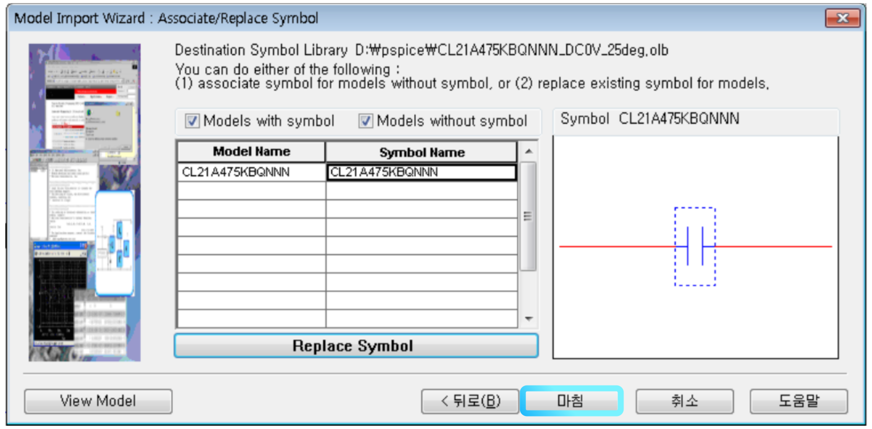
3. File → Model Import Wizard.

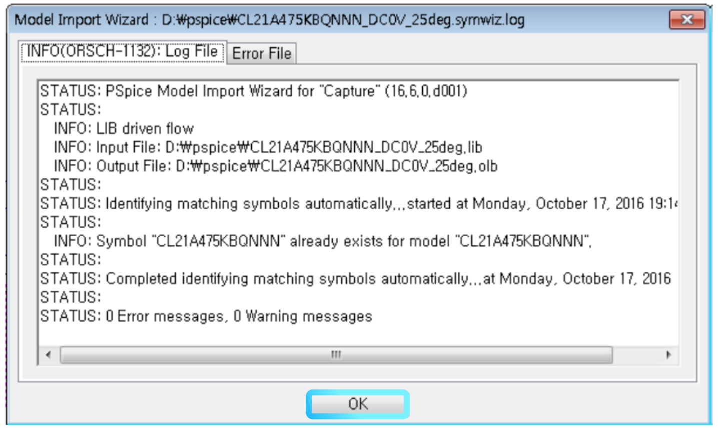


4. File → Click 'Browse' button and select downloaded file(*.lib) then press 'Next' button.



5. Configure proper Symbol of Library file and press 'Finish' Buotton. then check message box. *.OLB file is generated



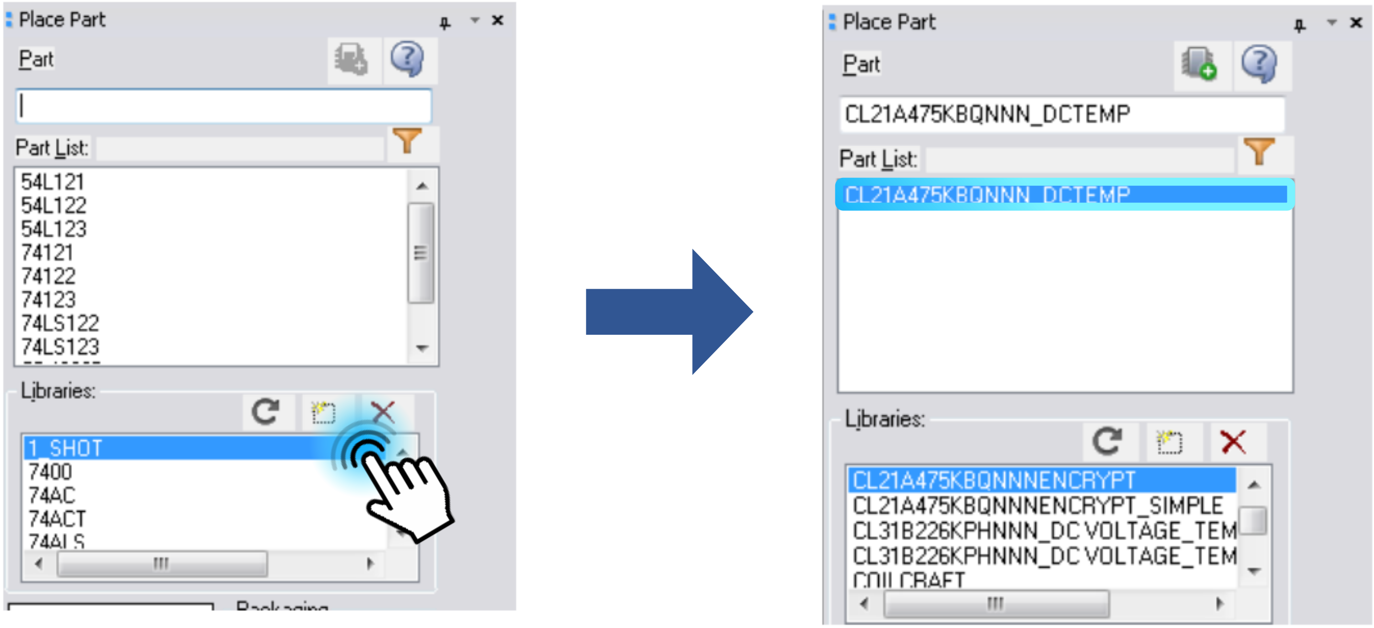


6. Execute OrCAD Capture program.

OrCAD Capture CIS

7. Place Part(Press “P” key) → ‘Add Library’ Select generated.   *.OLB file

- Then double click the model name in Part list box and drop-down Model on your schematic sheet.



2. How to use PSPICE netlist Library [4/4]

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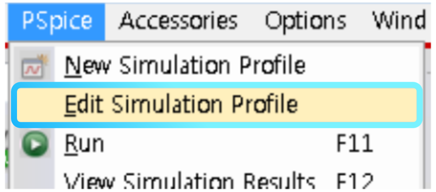
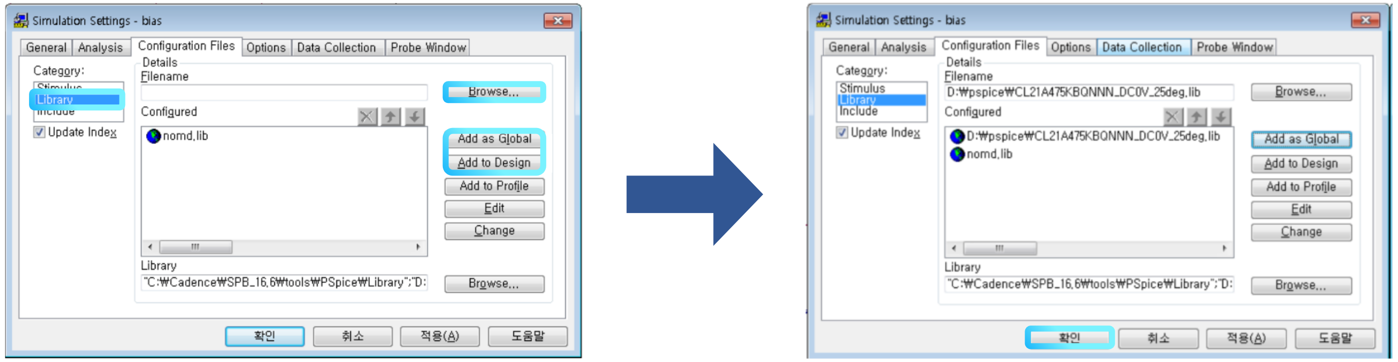
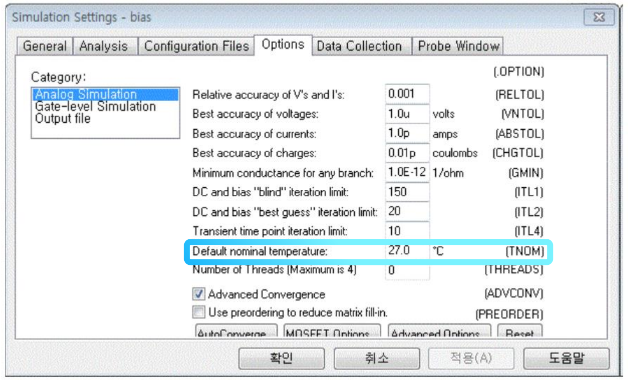
8. Before simulation Run, OrCAD Capture menu [P Spice] → Edit Simulation Profile.



9. ‘Configuration Files’ Tab → Select ‘Library’ in Category → Click ‘Browse...’ Button → Select the downloaded file(*.lib) and Press ‘Add as Global’ or ‘Add to Design’ Button. then click ‘OK’ button.



10.(Interactive model case) You can adjust simulation temperature value on ‘Options’ Tab.
* Default nominal temperature.



3. How to use LTSPICE netlist Library [1/3]

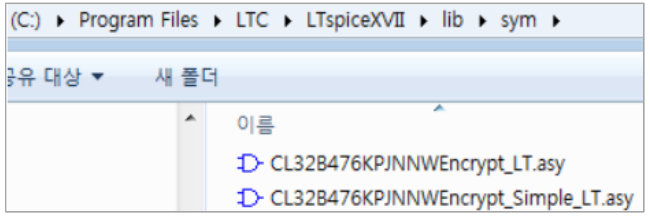
The LTSPICE Interactive/static model can be downloaded from SAMSUNG Web site. (http://www.samsungsem.com)

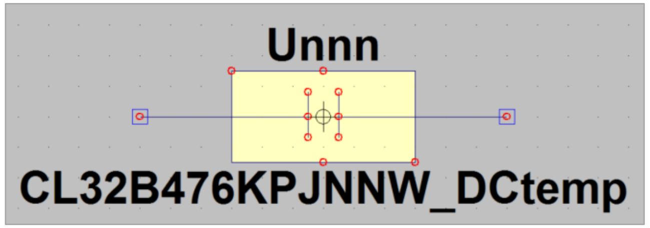
1. Download two files in LTSpice Library folder. (Symbol File : .asy / Netlist File : .mod)

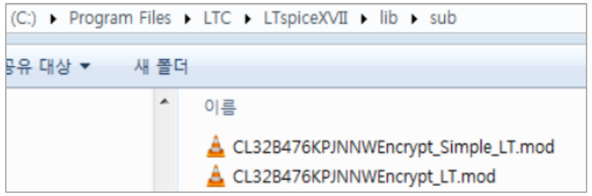
   – Save symbol file at C:/Program Files/LTC/LTspiceIVII/lib/sym
   or C:\Users\Administrator\Documents\LTspiceXVII\lib\sym
   – Save encrypted netlist file at C:/Program Files/LTC/LTspiceIVII/lib/sub
   or C:\Users\Administrator\Documents\LTspiceXVII\lib\sub

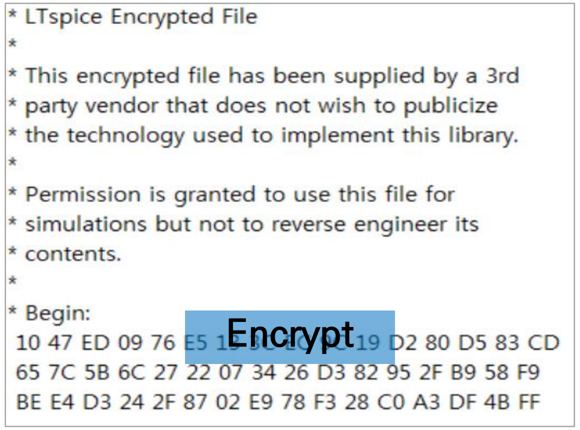
※ LTspice version : LTspiceXVII.

※ Save both .asy and .mod files at the directory where intended simulation circuit is saved In this case, The model can be used only in the simulation circuits saved at the same directory.







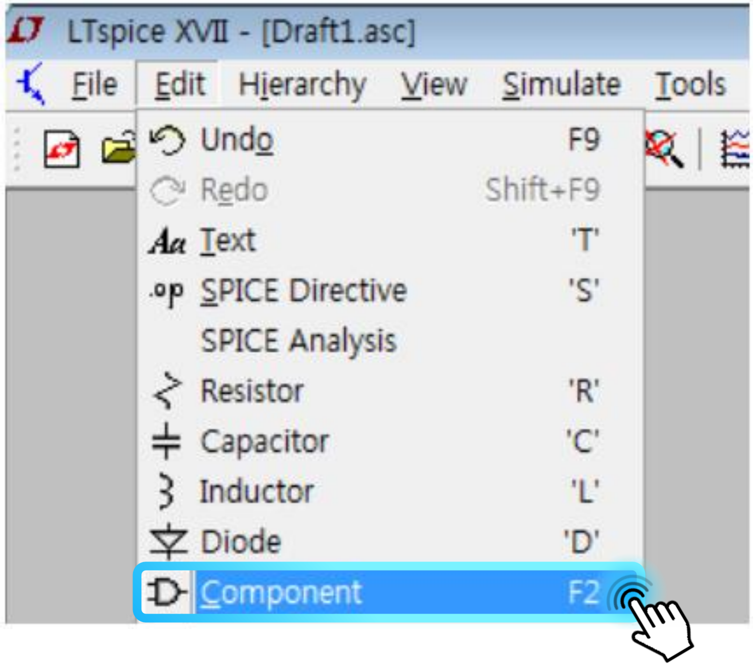


3. How to use LTSPICE netlist Library [2/3]

2. Execute LTSPICE program.

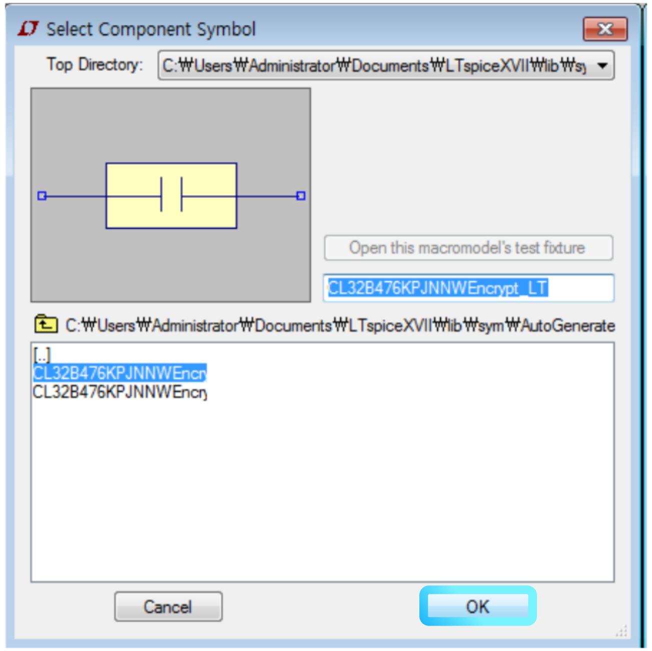
3. Select component symbol at your schematic.

Edit → Component or F2.



Select the component file and click 'OK' button.

※ Saved files in the directory as '1' Step.



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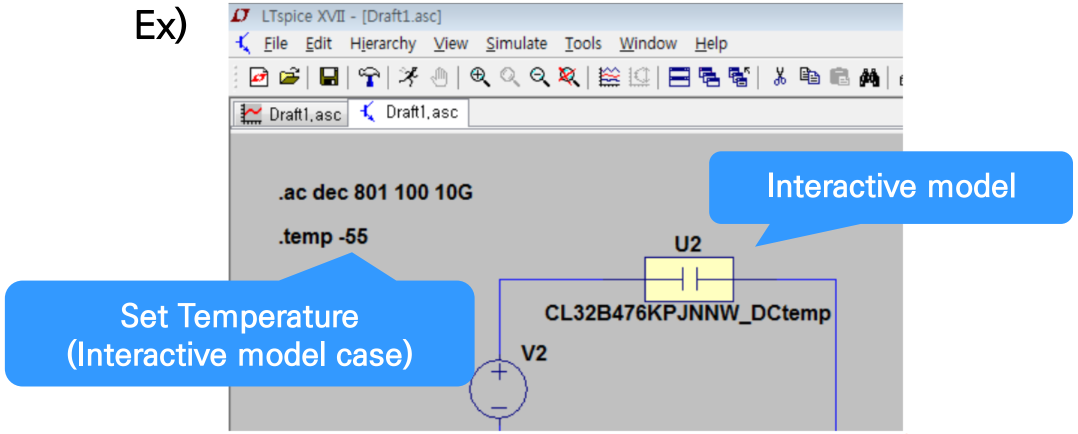
4. Run Simulation as your circuit condition.

Ex)



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- The HSPICE Interactive model can be downloaded from SAMSUNG Web site. (http://www.samsungsem.com)

1. Download ' *_H.lib ' files in HSpice Library folder.
2. Open the file as text document, Check the file path and the variable decared as subcircuit.

- Interactive precise model Example
  - file path name : /proj/hspice/CL32Y106KBJVPJ_Simple_Interactive_H.lib
  - subcircuit variable : CL32B475KCVZNW_DCtemp

```
* CL32B475KCVZNW Multilayer Ceramic Capacitor Interactive Precise Model for HSPICE
*-------------------------------------------------------------------------------------
* Model Generated by Samsung Electro-Mechanics
* Samsung Spice Model Version 4.0
* Products : Multilayer Ceramic Capacitor(High Reliability)
*-------------------------------------------------------------------------------------
* Characteristics :
*
*     Nominal Capacitance = 4.7uF
*     Capacitance Tolerance = +/-10%
*     TCC = X7R(-55 ~ +125 Cels.)
*     Rated Voltage = 100Vdc
*     Size = 1210(unit:inch), 3225(unit:mm)
*     Length = 3.20 +/-0.30 mm
*     Width = 2.50 +/-0.30 mm
*     Thickness = 2.50 +/-0.30 mm
* Applicable condition :
*     Frequency : 300Hz ~ 6GHz
*     Measurement Temperature : X7R(-55 ~ +125 Cels.)
*     DC bias Value = 0V ~ 40V
*     Small Signal as Network Analyzer
*-------------------------------------------------------------------------------------
* External Node Assignments :
*
*  1  o---||---o  2
*
*-------------------------------------------------------------------------------------
.SUBCKT CL32B475KCVZNW_DCtemp Port1 Port2
```

.PROT dd[illegible]9[t#GWC [illegible]:9HjuC:xJ5ejH>(%J)[illegible]ep$v,C'/25B]+):fJ5H#uC(1y)e-u>9%J;X5i#'%
UPSVE45*M;v%9<K:5F(Dz)b5+3:]K-.X5L'B[illegible]c21h)CF'2d6=5!-3)#-= 8%,q=/j9x3IB;Z[illegible]$$]8[illegible]DQ
jHU/(=h#pH//(=j#6eEuhT35W3E1ET3VW*[B[illegible]:$Bh;0.j:!J-s<<6)6[illegible]:25!;,9!J2=>+pw*#hP7.pHU
$$3;XC$257J#6Me/vt33u:!%-OX<63[x)z>U)*[12=i+PC*#Hp[[illegible]2S;K Gal# >IFE*x# >IFE;h#/RYa1L[illegible]T#vlv>H.

Subcircuit Variable

Encrypt

3. Open or Create Simulation Setting file (*.sp) and set the variables as shown below.

```
.OPTION LIST NODE POST
.inc /proj/hspice/CL32Y106KBJVPJ_Simple_Interactive_H.lib
.ac dec 101 3e4 6e9
.Temp 48
X1 n003 0 CL32Y106KBJVPJ_Dctemp
```

Downloaded file path

Set Temperature (Interactive model case)

Set node

Subcircuit Variable

※ DC Voltage value is automatically detected in circuit

4. Run Simulation.

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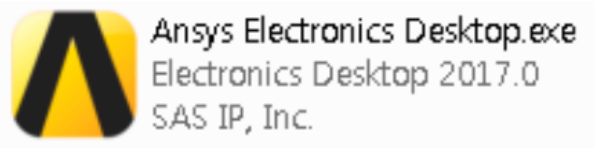
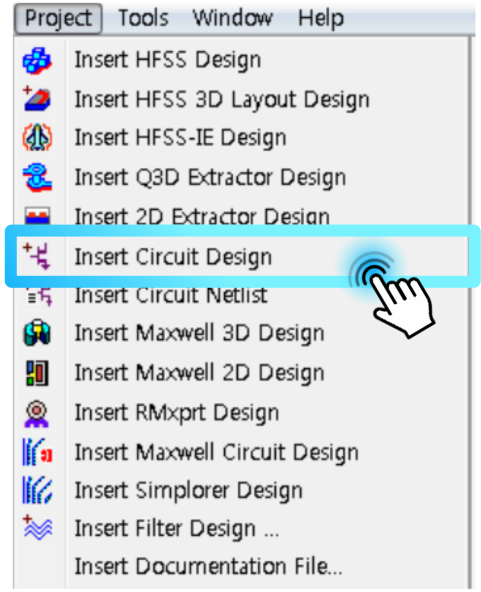
The netlist file can be downloaded from SAMSUNG Electro-Mechanics Web site. (http://www.samsungsem.com)

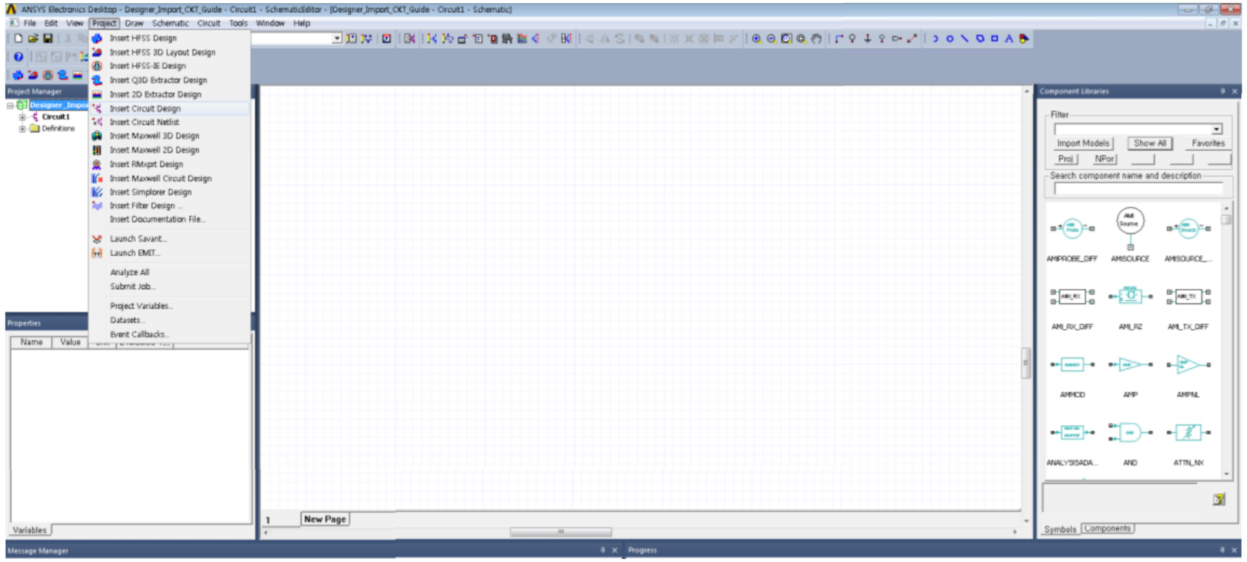
1. Download CKT file. It is recommended to save as [*.lib] or [*.cir].
   ※ Ansys Designer support format: [* .cir], [* spc], [* .sp], [* .lib], [* .scs]

2. Execute 'Ansys Electronics Desktop'.

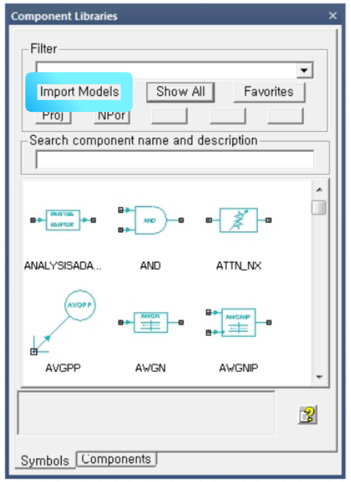


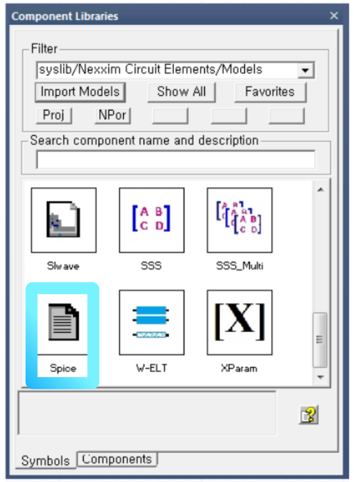
3. After creating a new project, click Insert Circuit Design on the Project menu to execute the circuit.



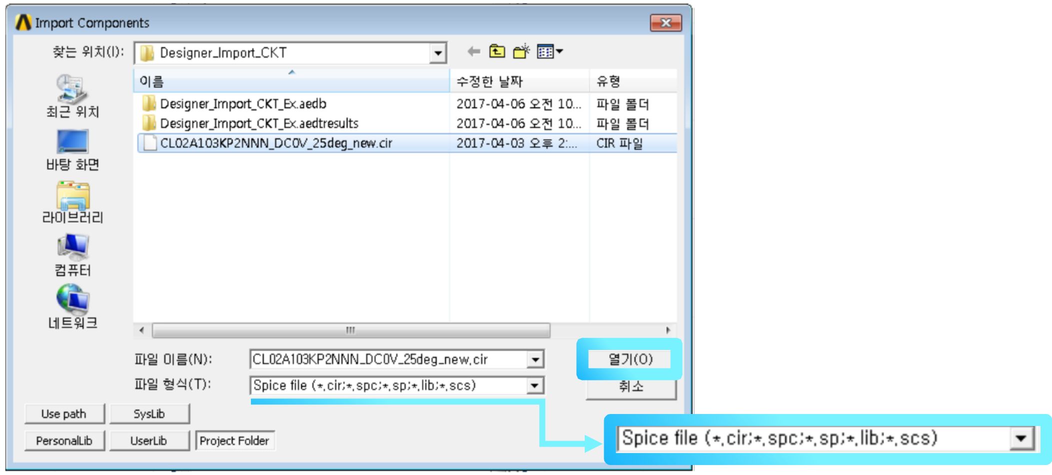


4. In the Component Libraries window, click the Import Model button on the Symbol tab.
   Move the scroll bar to select 'Spice'.

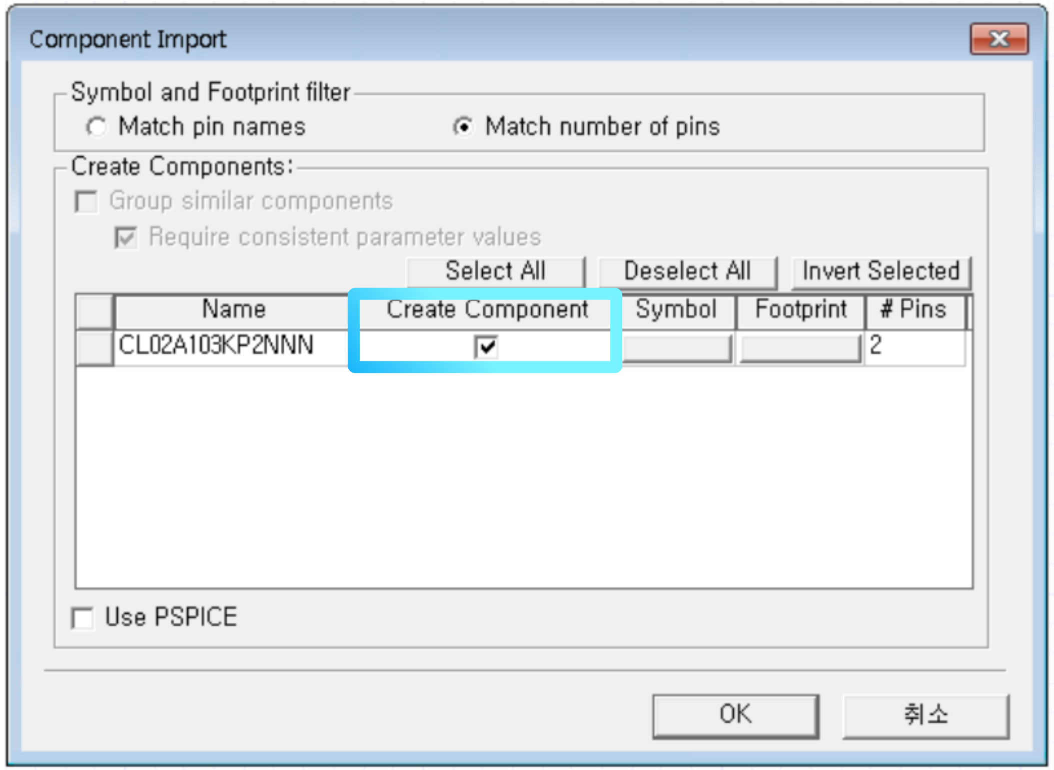




5. When the Import Components window appears, select the relevant netlist file and click on the 'Open' button.

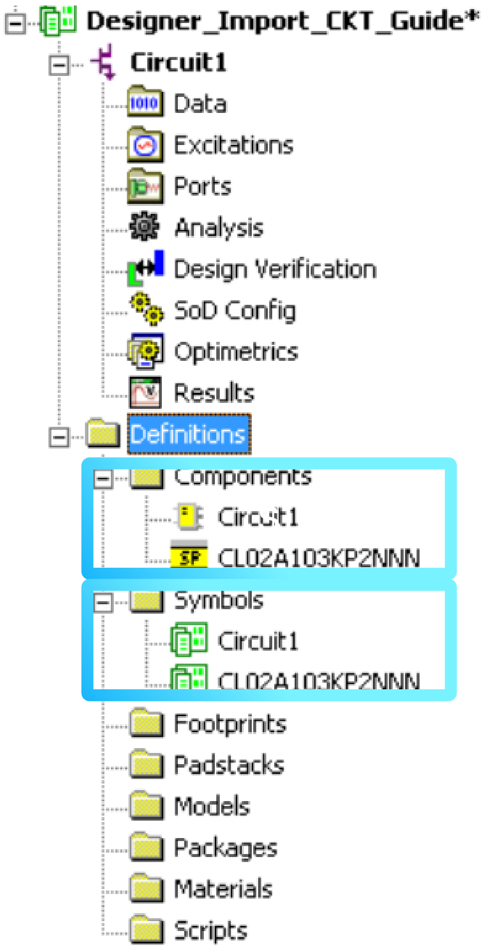


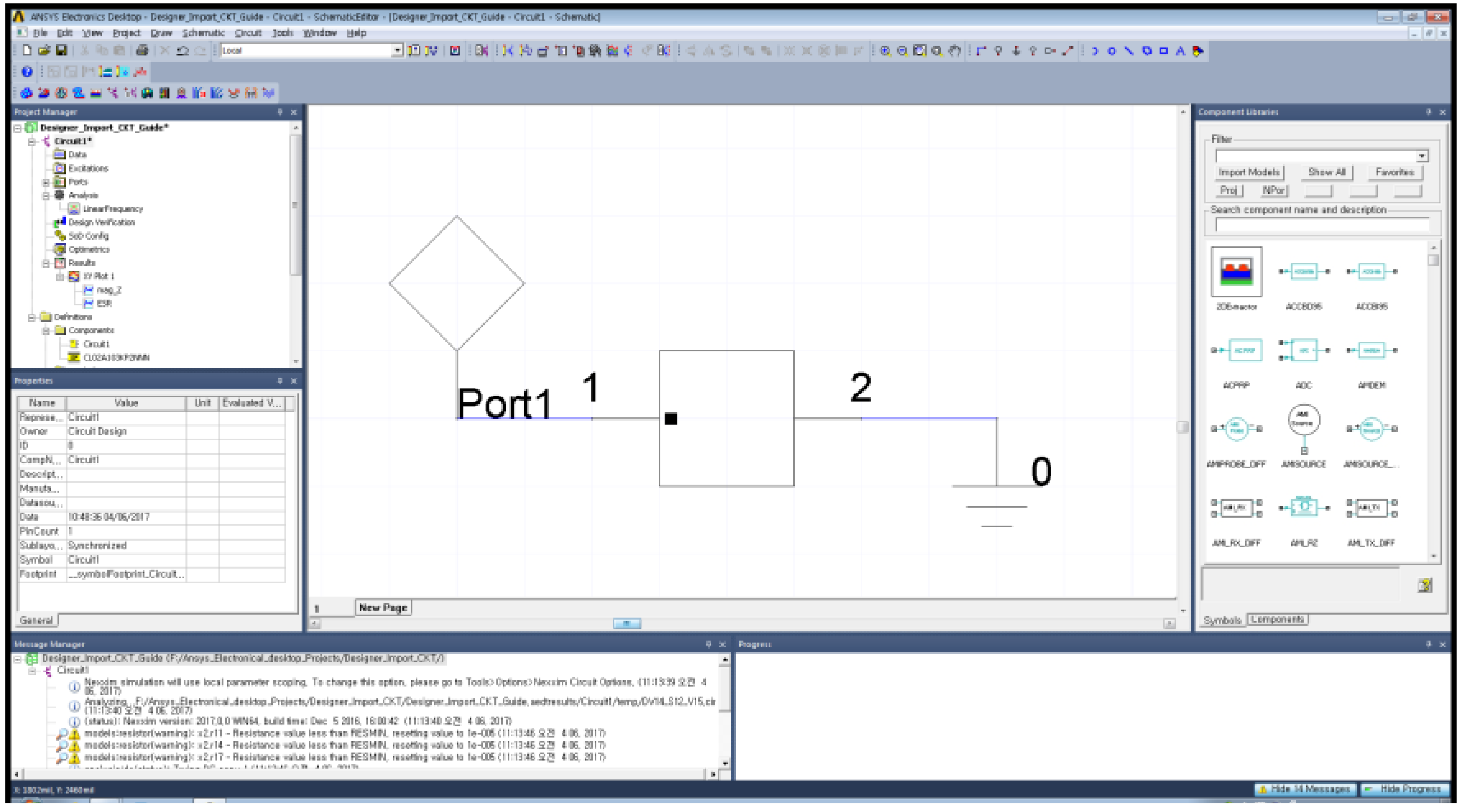
6. When Component Import window appears, Check Create Component and click 'OK'.
The corresponding symbol appears at the end of the mouse. Press ESC to release the layout.



5. How to import netlist file in ANSYS [4/4]

7. In the Components and Symbols folders, Make sure that the parts are as shown.
Drag components created from the Components Tree and click to place components.

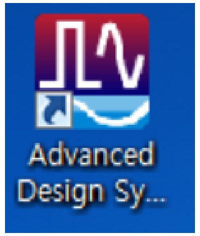




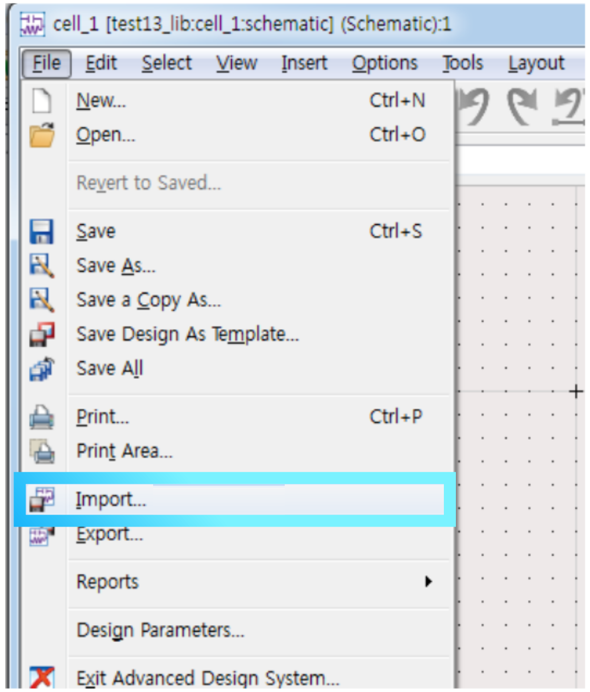
The netlist file can be downloaded from SAMSUNG Electro-Mechanics Web site. (http://www.samsungsem.com)

1. Download CKT file.

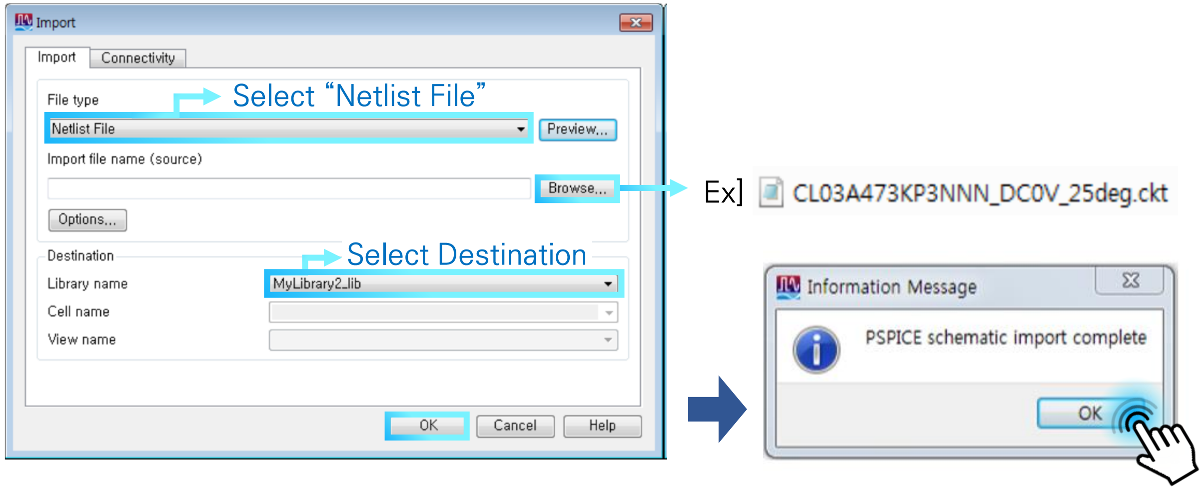
2. Execute 'Advanced Design System'.



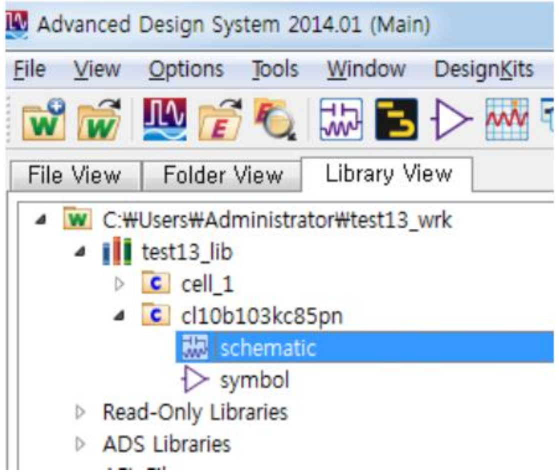
3. Open your own Schematic sheet, Then File 〉 Import.



4. Click 'Browse' button and select downloaded file [*.ckt] then press 'OK' button.



5. 'Main library View' shows the imported file in destination library.



6. How to import netlist file in ADS [3/3]

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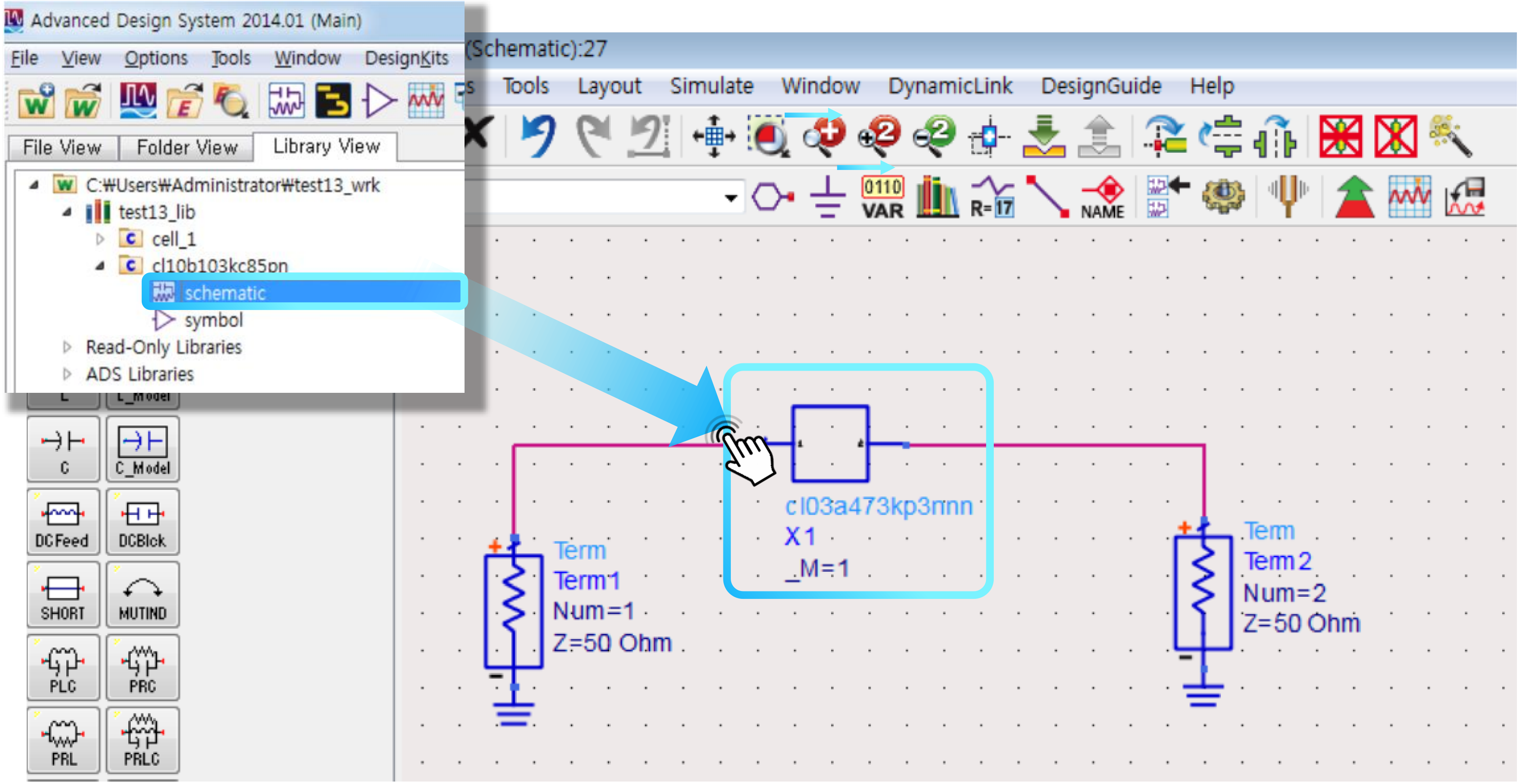
6. Drag & drop the imported library to your schematic sheet.



7. How to import netlist file in SIMetrix/SIMPLIS [1/6]

The SIMetrix/SIMPLS Interactive/static model can be downloaded from SAMSUNG Web site. (http://www.samsungsem.com)
*Interactive models can only be used with SIMetrix.

1. Download '_SIM.lib' files in SIMetrix/SIMPLS Library folder.

2. Save the library file at the directory where intended simulation circuit is saved in this case or folder of yours.

Static model

```
*------------------------------------------------------------------------------------------------
* External Node Assignments :
*
* 1 o---||---o 2
*
*------------------------------------------------------------------------------------------------
.SUBCKT CL31Y106KLKVPN_Precise_DC0V_25degC 1 2

*#ASSOC symbol=cap_simple_subckt category=Samsung_MLCC_Automotive simulator=simetrix|simplis
C1 1 3 9.39680E-6
C2 3 4 2.53666E-4
C3 4 5 4.72977E-4
C4 5 6 4.95428E-4
C5 6 7 4.74108E-4
```

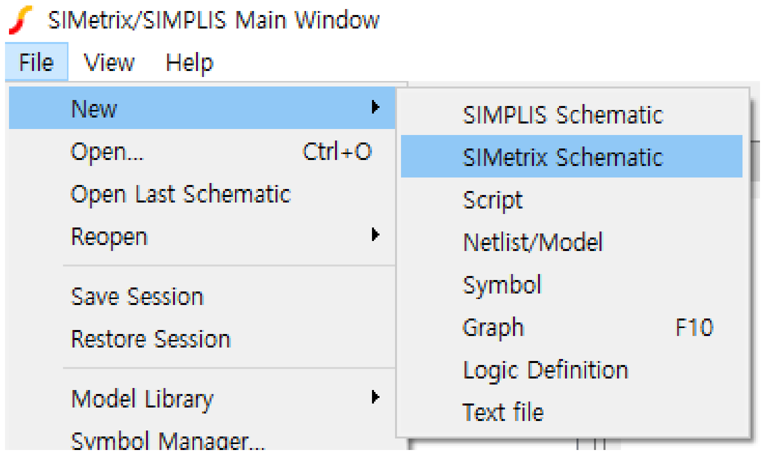
Interactive model

```
.SIMULATOR SIMPLIS
* source 21ORDER_2
.SUBCKT CL31Y106KLKVPN_Precise_Interactive Port1 Port2
*#ASSOC symbol=cap_simple_subckt category=Samsung_MLCC simulator=simetrix|simplis
*
?@@--START ENCRYPTION: "SMX_AES "
?@@Ad+8C/uueujyLqolRgYWHfXPafU1YWpZsr1i836x9BsRX7UmCr9SHd/3lZP1MK+s?##
?@@jmN/PLT5mc4TMsPNHBOa6ehdAXnpS2zCr9hzS15o4R7qVJr3a3pUPF7pd4Z6lul5?##
?@@kTlC4s1Yjei1nttjZPEsoTL02f8bZ4t4kqFTCpF8ql2NZWXWAUp1lk5Yj1+f0RxF?##
?@@8phK6QAklyZv7ol/y2K7A5V8HVI Encrypt A4NKClzRmEvydTYidL0wEqpL?##
?@@fL960vRG2ESdALuyr9CzU4KzSBY /6bvBbDjxMZ1RD6Glwe0ehOB?##
?@@cDoPMtD5sm5W/6mdTQKhbtxZ9aafmu5evQq/PffhciTm39gD4TUkyWWGgdQ7TNWr?##
?@@0S65Ofh5xv0U69HiJsKDb+qjNFW9+qDLLYN1WlPwFHSgSEqlrvkQZez/OjztY9LE?##
?@@Viycw2j+S+ezDRl4L9Hl+vdayd0uPs+B3s+wpn8SqiobgYohjvnDtgGE4rxlZ1fV?##
```

7. How to import netlist file in SIMetrix/SIMPLIS [2/6]

3. Execute SIMetrix-SIMPLIS program.

4. After creating a new SIMetrix Schematic.



7. How to import netlist file in SIMetrix/SIMPLIS [3/6]

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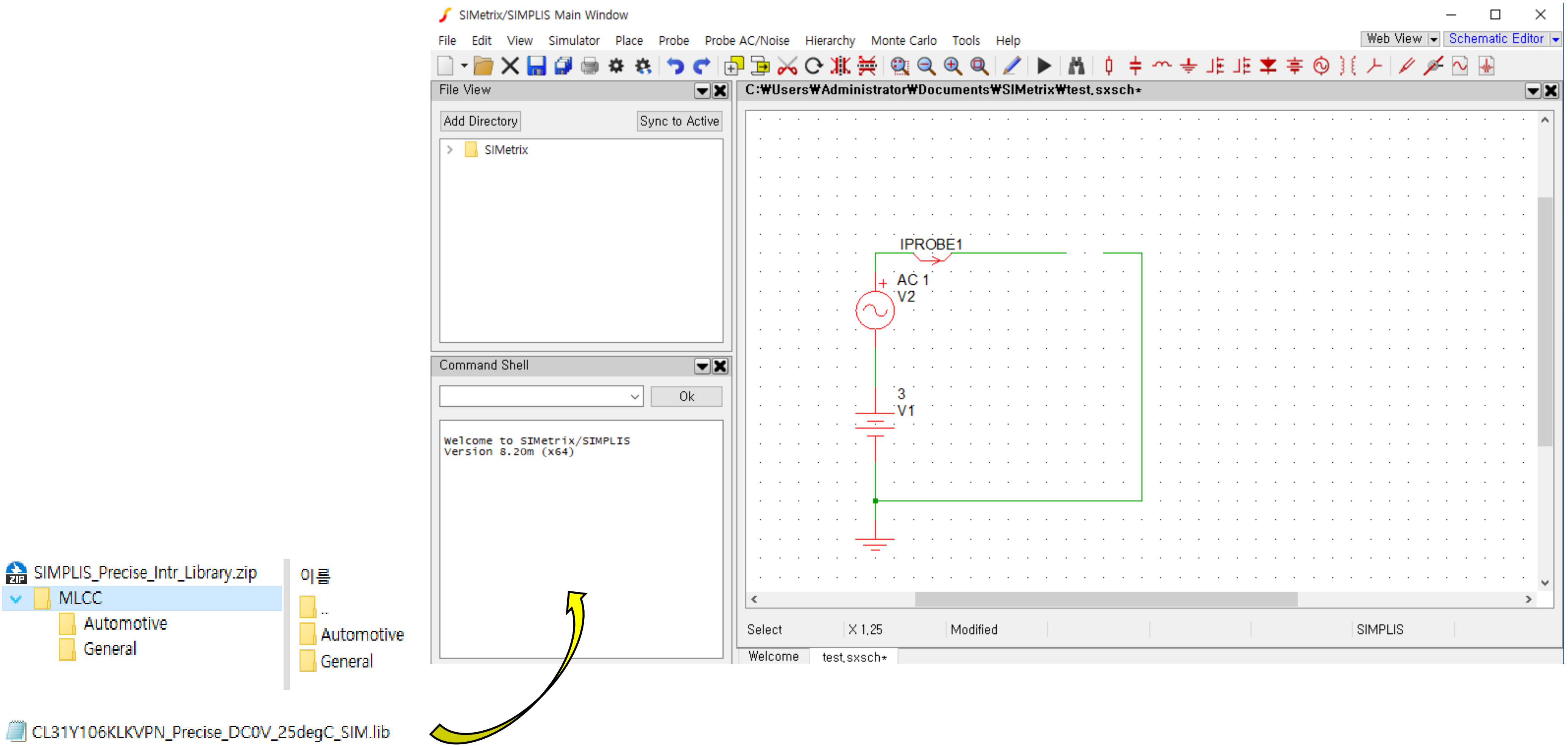
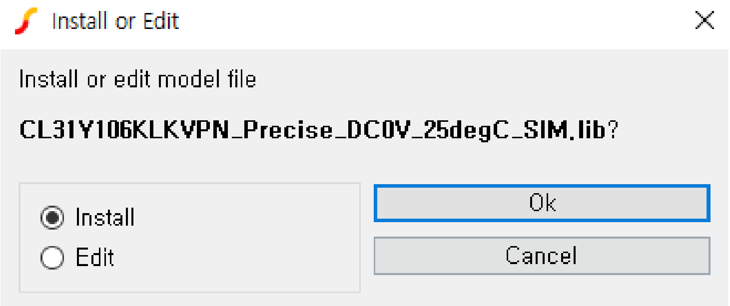
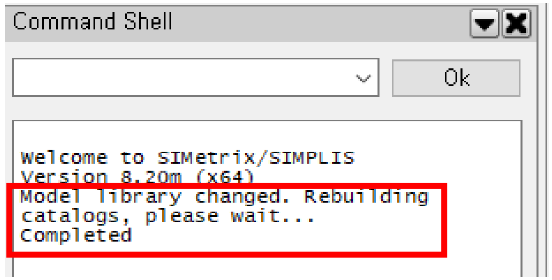
5. Drag and drop the downloaded library files or folder into the command shell of SIMetrix



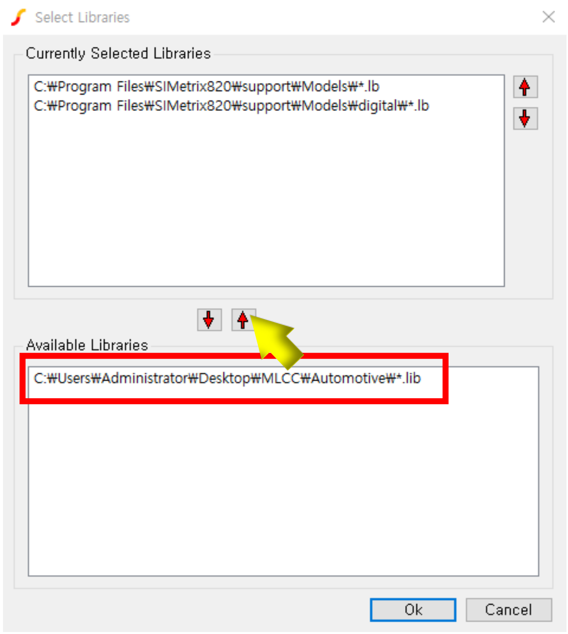
7. How to import netlist file in SIMetrix/SIMPLIS [4/6]

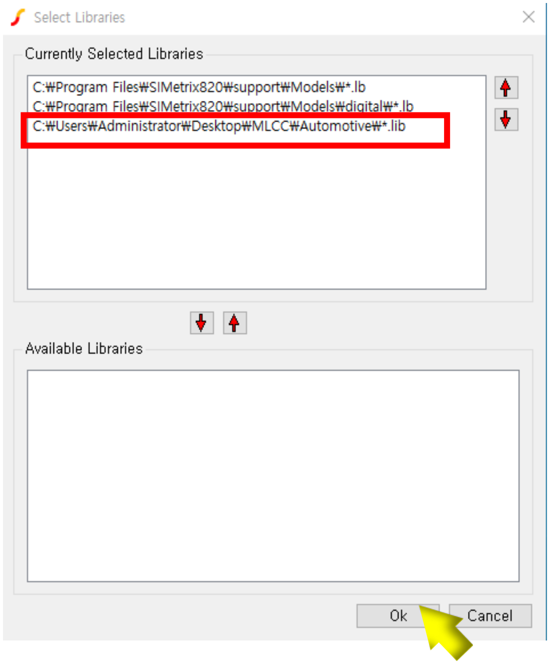
6. When the install or Edit window pop up, Click ‘Ok’ button.
   – files



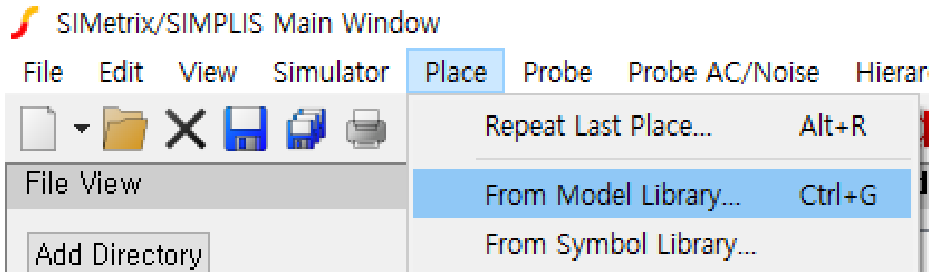


When the Select Libraries window pop up, Click the icon.
The selected folder move to “Currently Selected Libraries” window.
 –folder

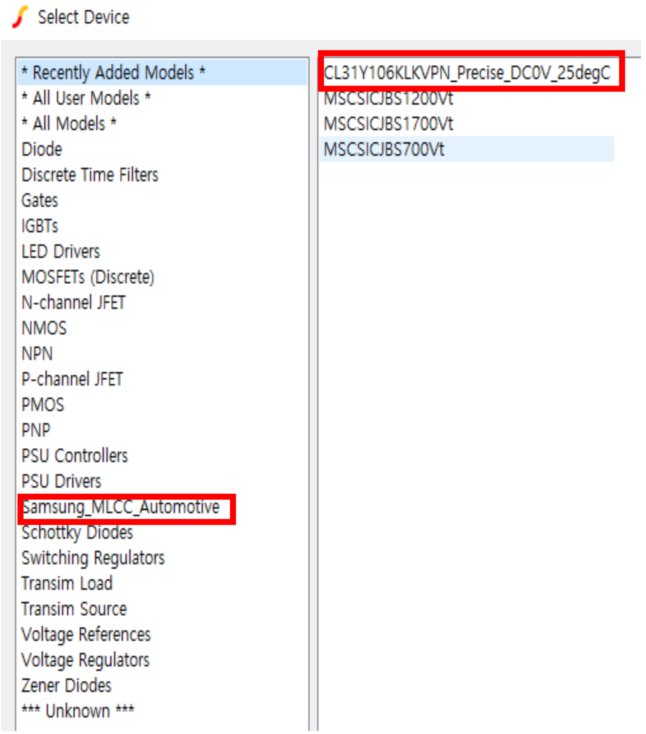




7. Select [Place] 〉 [From Model Library…] or Ctrl + G



8. When the select Device window pop up, Click uploaded file.



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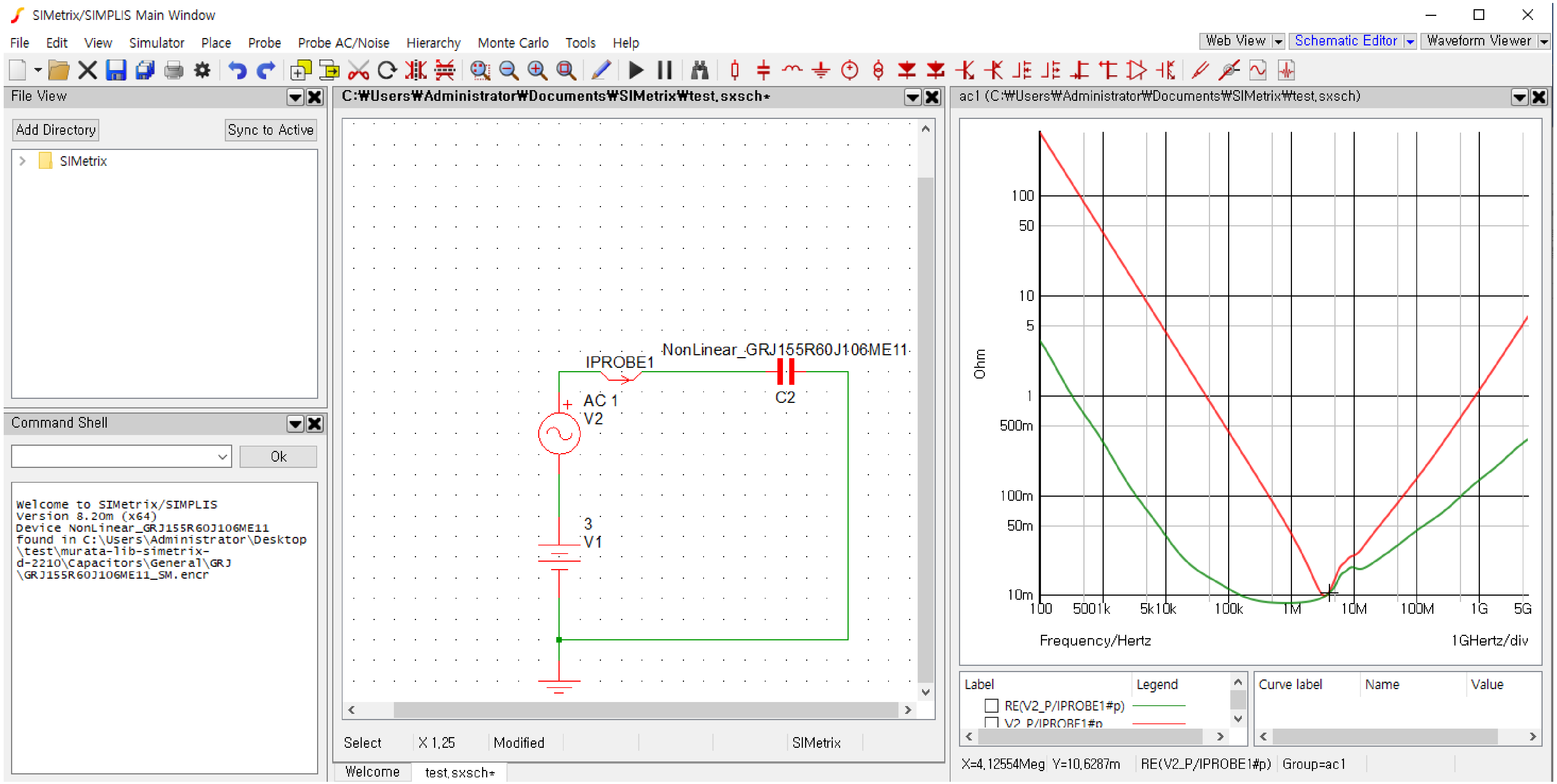
9. Test circuit.



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1. **Applicable condition**

   Pspice Library files and S-parameter files in Web site are obtain by Network Analyzer using small signal.
   Proper result might not be obtained if your condition is different from the above one.

2. **Terms and conditions regarding SPICE simulation Models and S-parameter files.**

   (1) This Simulation Model is provided solely for reference purposes. For the characteristics of products, You have to refer to the Specifications.

   (2) In no event shall SAMSUNG Electro-Mechanics be liable for any loss or damage arising, Directly or indirectly, from, in connection with your reliance on any information contained in the Simulation Model, including, But not limited to any loss or damages arising from any inaccuracies, omissions or errors in connection with such information.

   (3) SAMSUNG Electro-Mechanics does not make any warranty, Express or implied, including but not limited to the correctness, implied warranties of merchantability and fitness for a particular purpose with respect to this Simulation Model. Any information contained in the Simulation Model is subject to modifications or changes by SAMSUNG Electro-Mechanics without any prior notice.

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