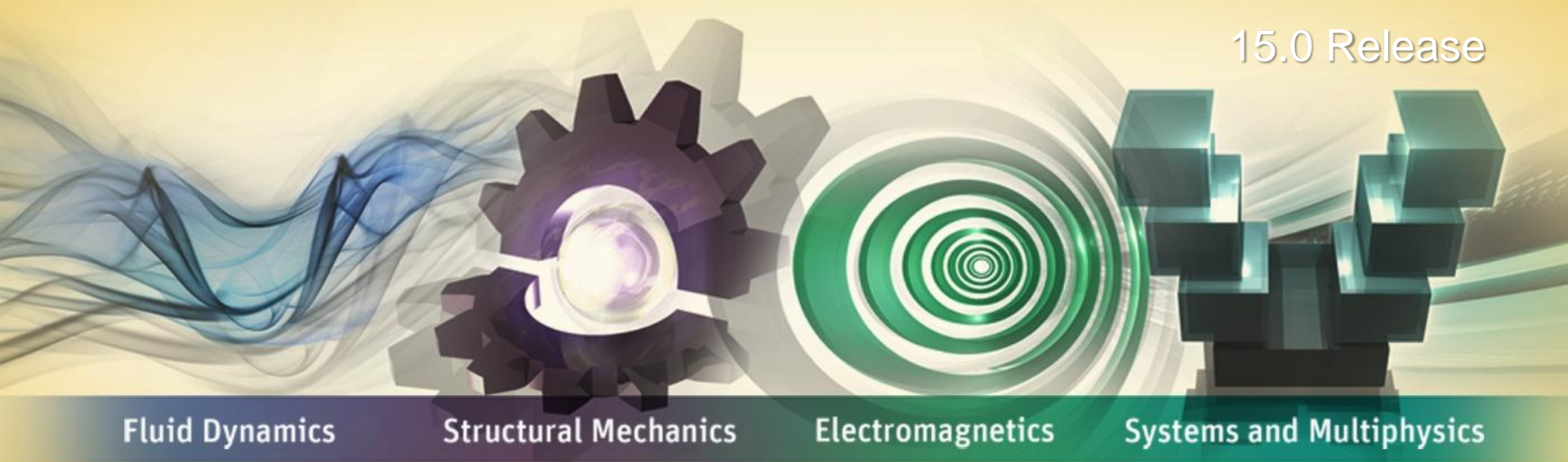


Workshop 12: Siwave PI Advisor

15.0 Release



Introduction to ANSYS Siwave

SIwave PI Advisor – Analysis Exercise

- **PI Advisor**

- Increased device speeds, device miniaturization and decreasing design cycles represent major design challenges. Optimization of today's high-volume printed circuit boards and packages is mostly based on different capacitor models, capacitor price and number of capacitors, and the design goals must be achieved without compromising the design's signal and power-integrity performance.
- This training exercise describes an automated decoupling capacitor analysis process for analog and digital printed circuitry boards. This automatic technique provides an innovative simulation strategy that significantly improves engineering productivity by automating decoupling capacitor selection, placement and optimization for printed circuit boards and packages.
- In SIwave version 5 a new add-on option called PI Advisor was introduced. PI Advisor's goal is to find a set of decoupling capacitors that meet user defined impedance mask and optimization goals.

- **ANSYS SIwave Design Environment**

- The following features of the ANSYS SIwave Design Environment are used to optimize a design using PI Advisor.
 - Verification of board import
 - Check stack up
 - Check nets
 - Check circuit elements
 - Generate pin groups
 - Ports
 - Solution Setup
 - SYZ sweeps
 - Plotting and analyzing results
 - S parameters
 - PI Advisor Optimization Schemes
 - Loop Inductance Plots

SIwave PI Advisor – Analysis Exercise

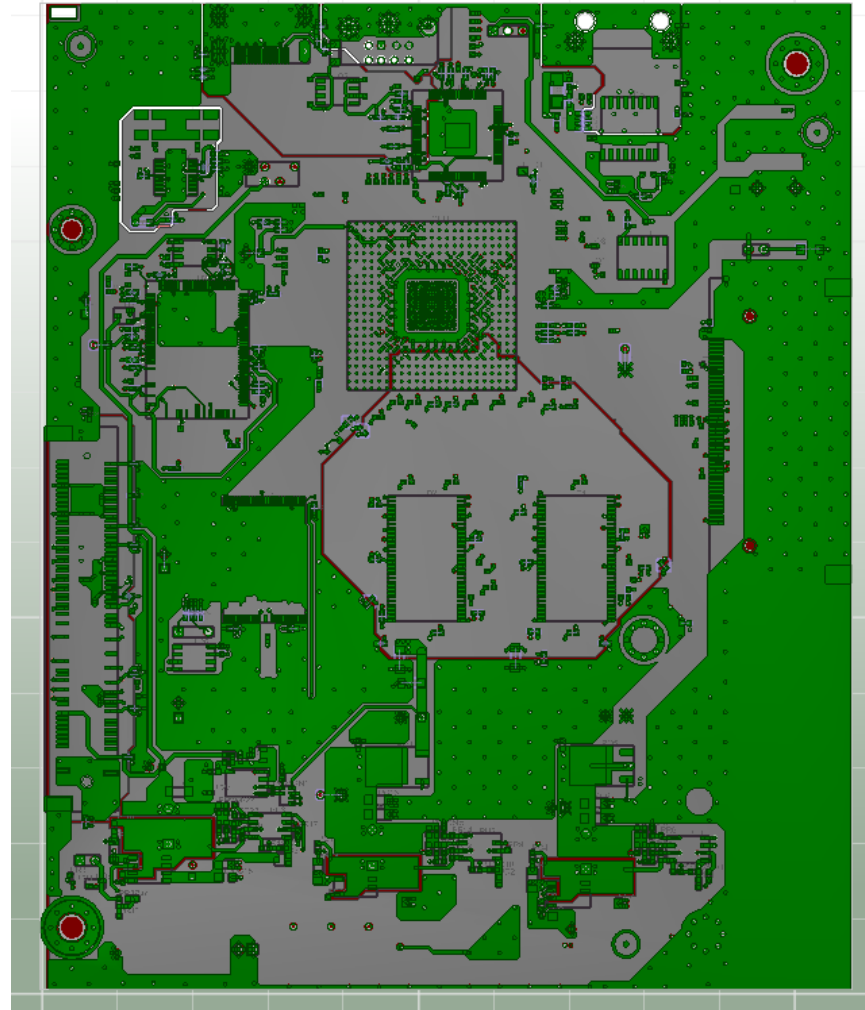
- **Starting SIwave**

- To launch SIwave, click the Microsoft **Start** Button, select:

All Programs > ANSYS Electromagnetics > ANSYS Electromagnetics Suite 15.0 > Windows XX-bit > ANSYS SIwave

- **Open a SIwave Project**

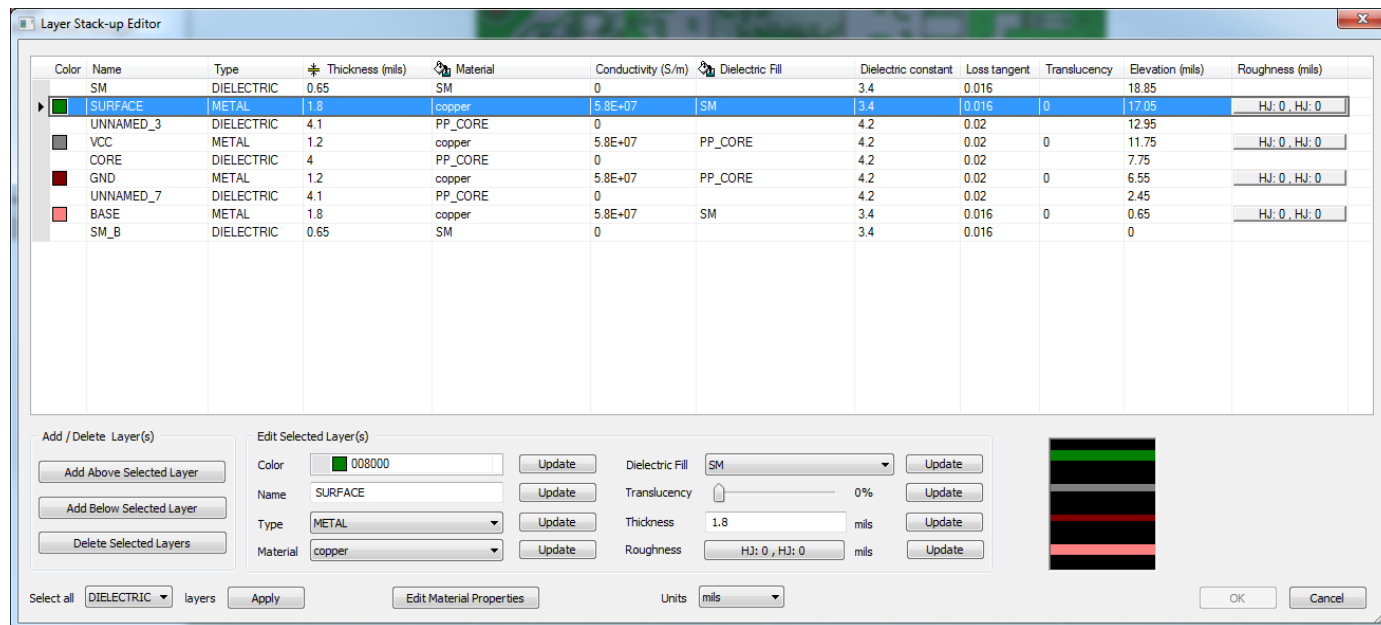
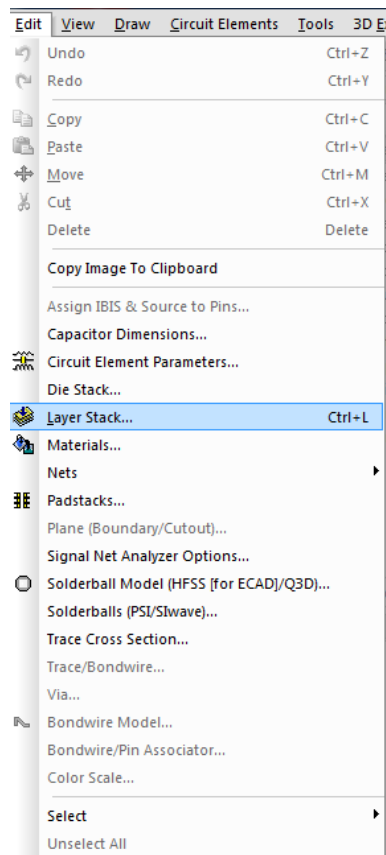
- Select: **File > Open**
 - Browse for file: **PI_Advisor_example.siw**
 - Click the **Open** button



SIwave PI Advisor – Analysis Exercise

• Verification of Board Importation

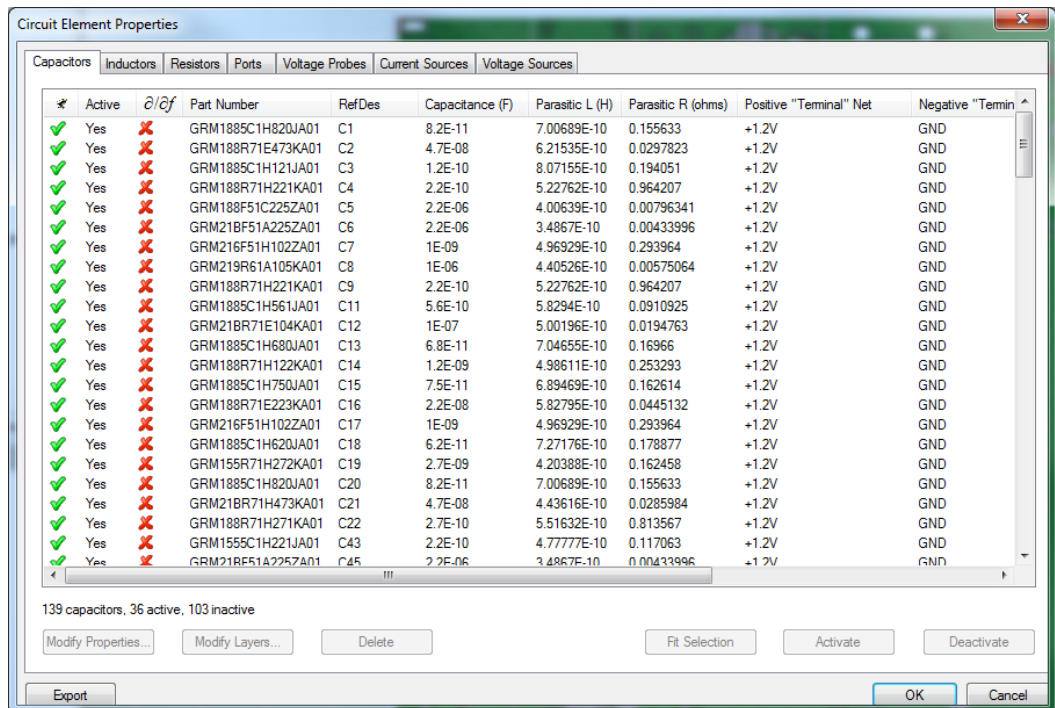
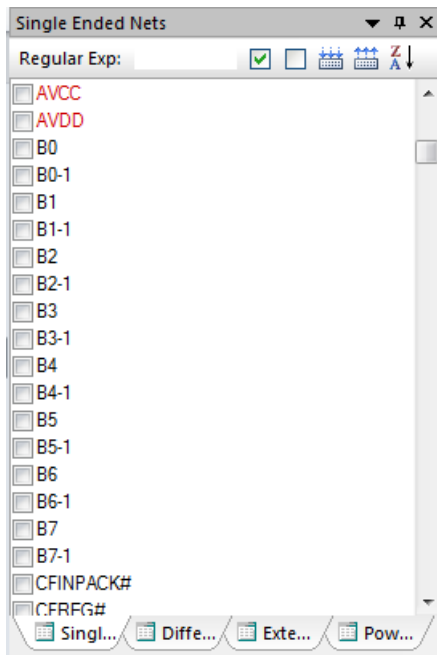
- After importing the layout into SIwave verify the import was performed correctly by checking the following: board geometry, stack up, nets, and circuit elements
- To check the stack up select the menu item **Edit > Layer Stack (Ctrl+L)**. This will open the Layer stack window.



SIwave PI Advisor – Analysis Exercise

• Verification of Board Importation

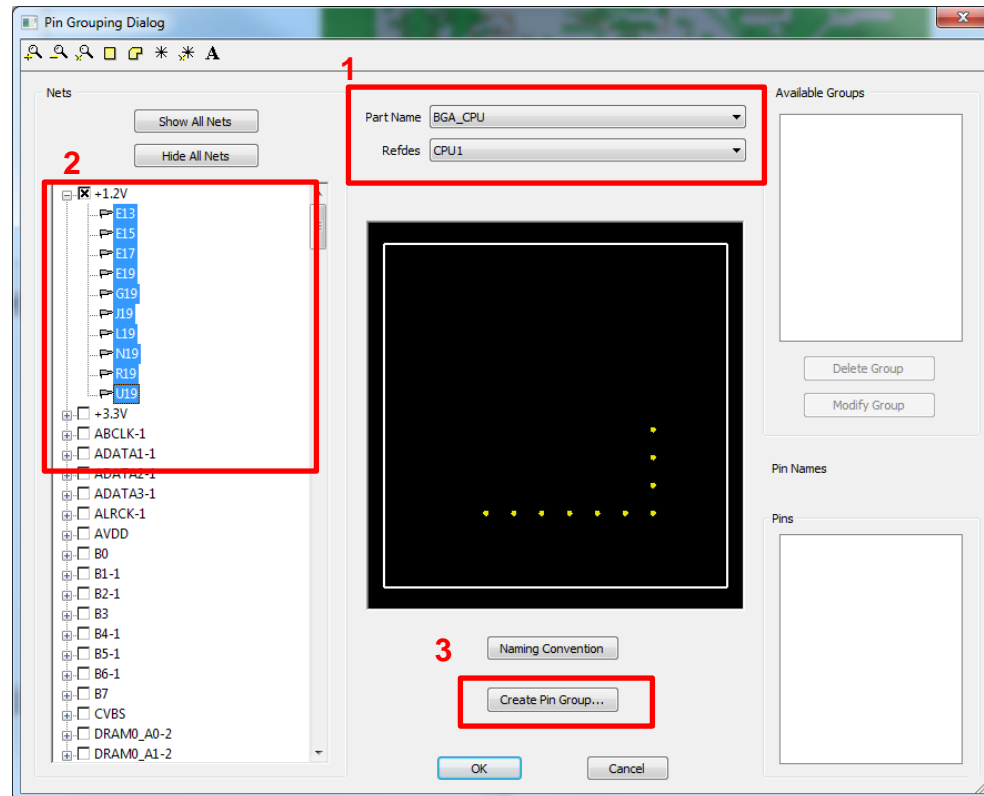
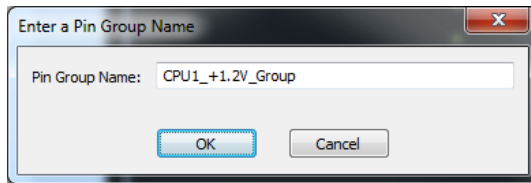
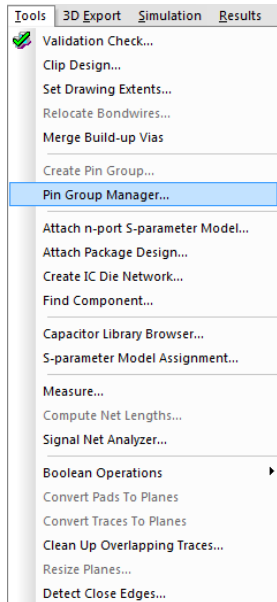
- Check and make sure that the nets imported properly, in the workspace select the **Single Ended Nets** tab and verify that all of the nets are present. (For the example assume they are there)
- To check the circuit elements select the menu item **Edit > Circuit Element Parameters....** This displays the circuit elements. Please verify that **36** different capacitors are listed as active.
- If there are not **36** active capacitors then do the following:
 - Click on the **Positive “Terminal” Net** column and sort by net name.
 - Find all caps connected to **+1.2V** and **GND** and select them and press the **Activate** button.
 - Repeat this for the **Negative “Terminal” Net** as well by selecting all caps with **+1.2V** and **GND**.



Siwave PI Advisor – Analysis Exercise

• Pin Group Manager

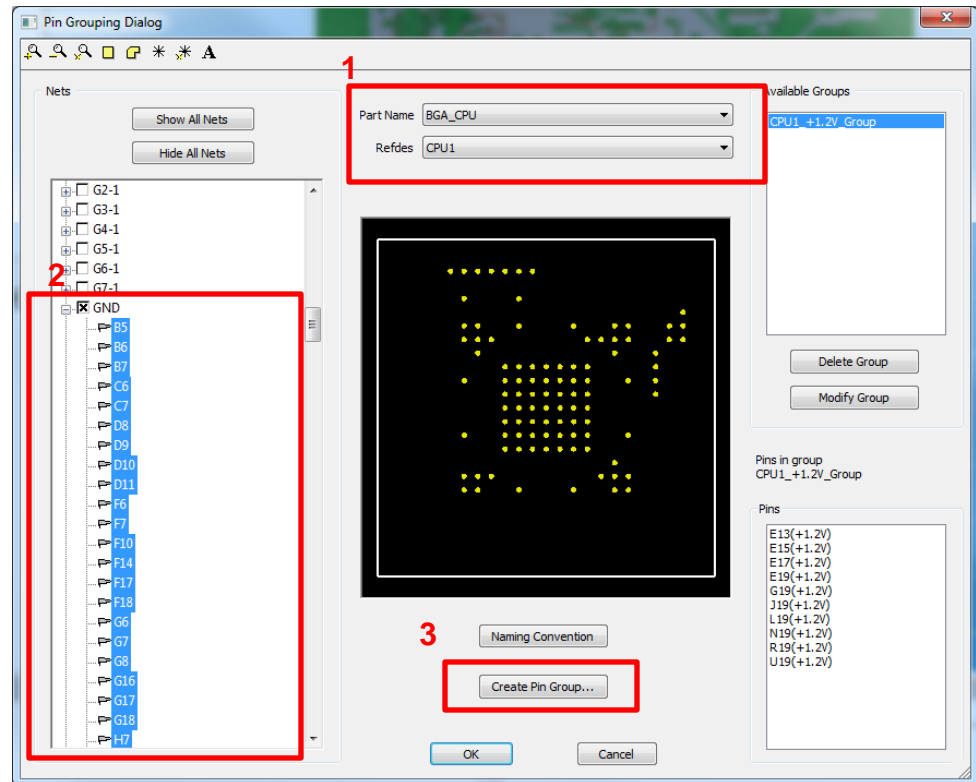
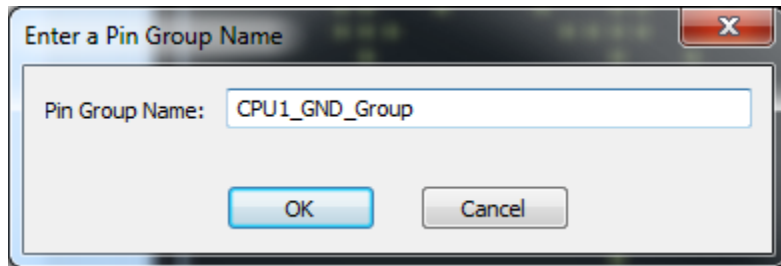
- Create pin groups out of the 1.2V and the GND nets on BGA_CPU and DRAM D1 and D2 components
 - Select the menu item **Tools > Pin Group Manager...**
 - Select the IC device and Pins that we will place sources on, click the following:
 - Part Name: **BGA_CPU**
 - RefDes: **CPU1**
 - Nets: **+1.2V**
 - Select all +1.2 V pins (**E13, E15, E17, E19, G19, J19, L19, N19, R19 and U19**). Use the **Ctrl** key to select multiple pins.
 - Click on **Create Pin Group**
 - Pin Group Name: **CPU1_+1.2V_Group**
 - Press the **OK** button
 - Unselect pins.



Siwave PI Advisor – Analysis Exercise

• Pin Group Manager

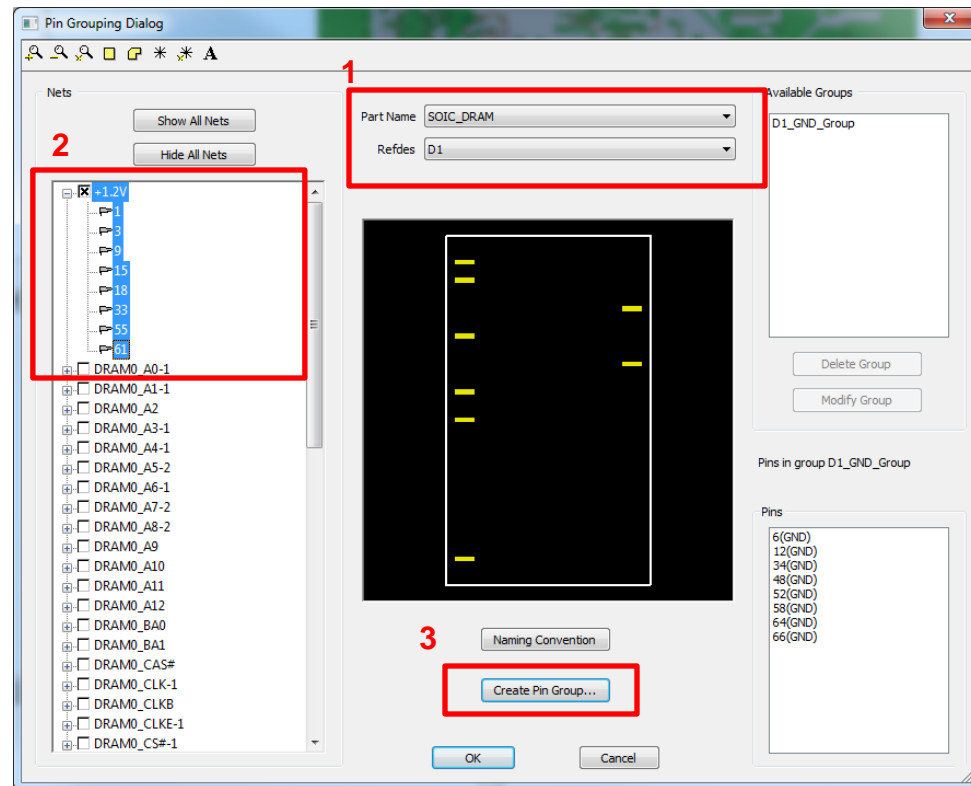
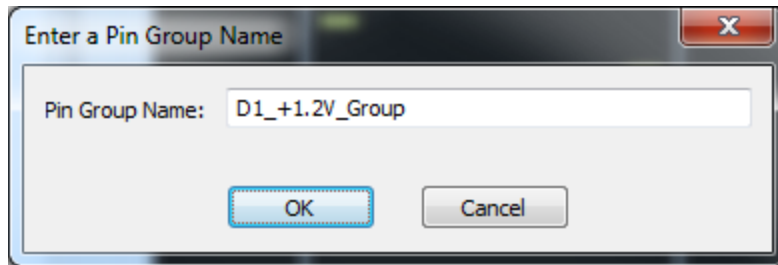
- While still in the **Pin Group Manager**
 - Select the following IC and Pin group:
 - Part Name: **BGA_CPU**
 - RefDes: **CPU1**
 - Nets: **GND**
 - Select all **GND** pins (**B5 thru W2**). Use the **Ctrl** or **Shift** key to select multiple pins.
 - Click on **Create Pin Group**
 - Pin Group Name: **CPU1_GND_Group**
 - Press the **OK** button
 - Unselect pins



Siwave PI Advisor – Analysis Exercise

• Pin Group Manager

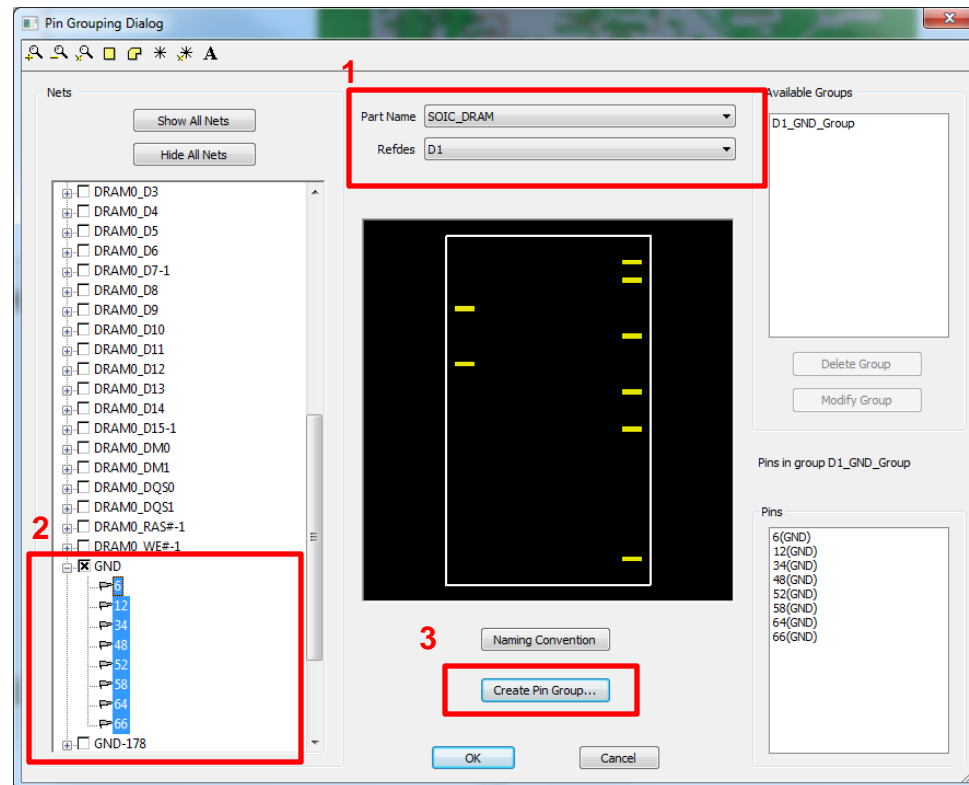
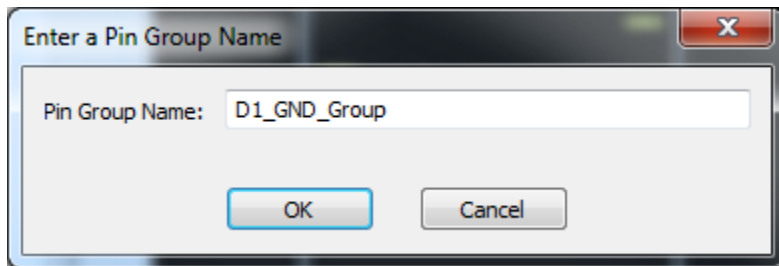
- While still in the **Pin Group Manager**
 - Select the following IC and Pin group:
 - Part Name: **SOIC_DRAM**
 - RefDes: **D1**
 - Nets: **+1.2V**
 - Select all +1.2V pins (**1, 3, 9, 15, 18, 33, 55, and 61**). Use the Ctrl or Shift key to select multiple pins.
 - Click on **Create Pin Group**
 - Pin Group Name: **D1_+1.2V_Group**
 - Press the **OK** button
 - Unselect pins.



Siwave PI Advisor – Analysis Exercise

• Pin Group Manager

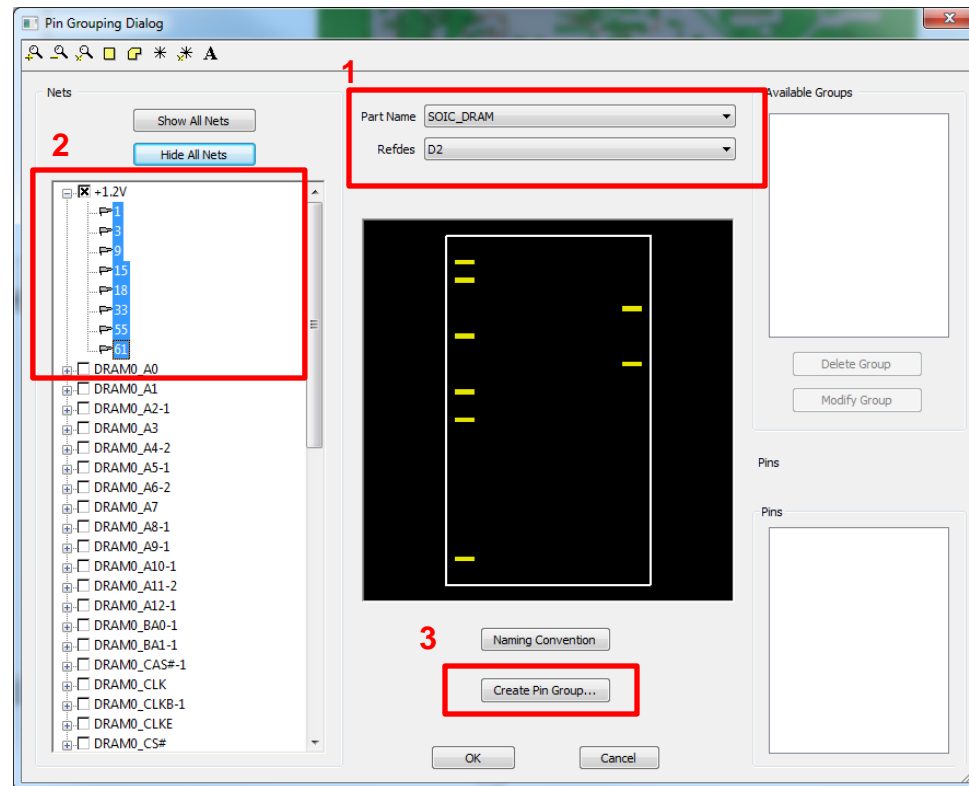
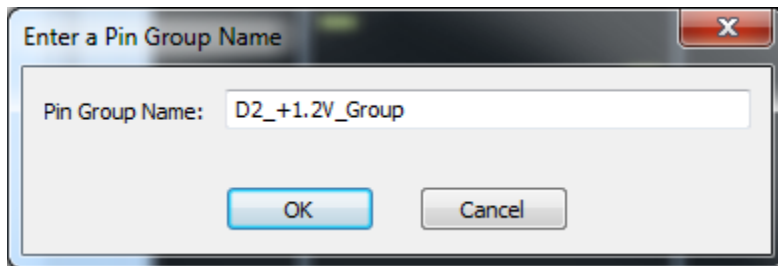
- While still in the **Pin Group Manager**
 - Select the following IC and Pin group:
 - Part Name: **SOIC_DRAM**
 - RefDes: **D1**
 - Nets: **GND**
 - Select all GND pins (**6, 12, 34, 48, 52, 64, and 66**). Use the **Ctrl** or **Shift** key to select multiple pins.
 - Click on **Create Pin Group**
 - Pin Group Name: **D1_GND_Group**
 - Press the **OK** button
 - Unselect Pins.



Siwave PI Advisor – Analysis Exercise

• Pin Group Manager

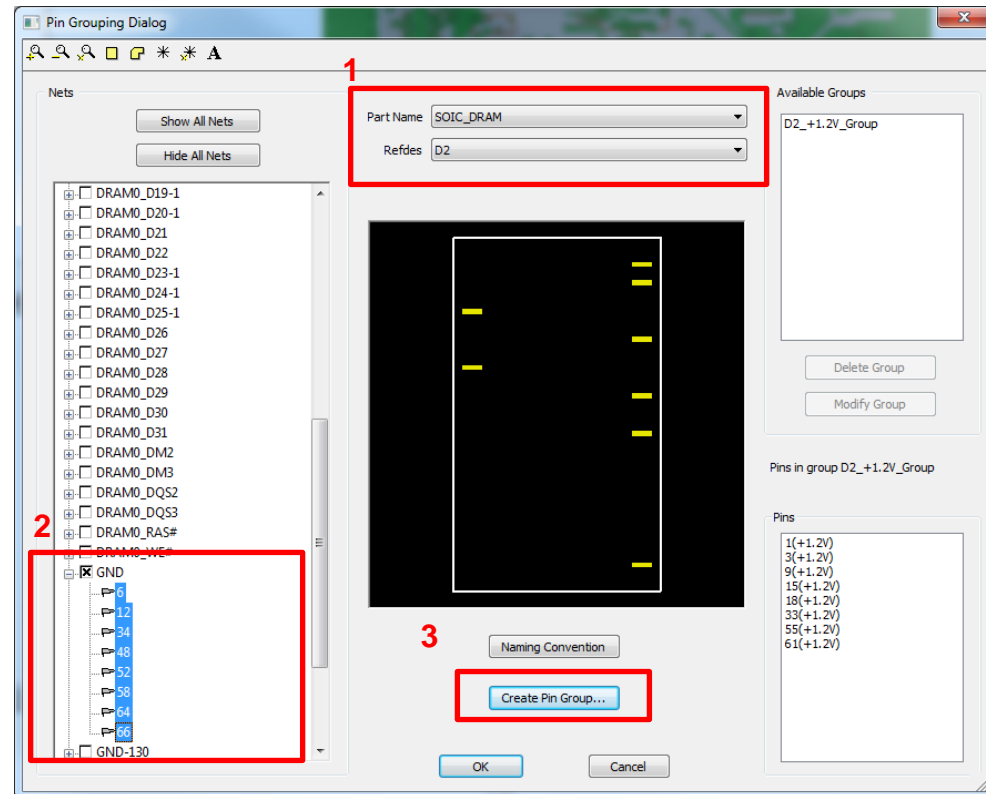
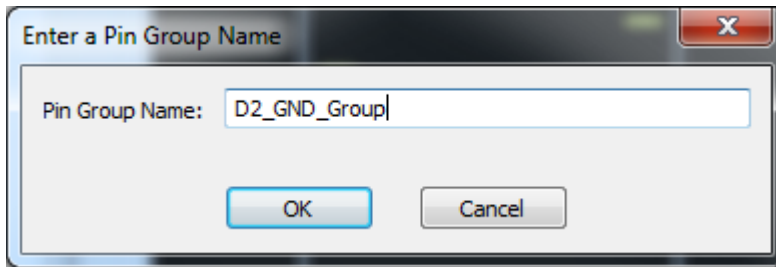
- While still in the **Pin Group Manager**
 - Select the following IC and Pin group:
 - Part Name: **SOIC_DRAM**
 - RefDes: **D2**
 - Nets: **+1.2V**
 - Select all +1.2V pins (1, 3, 9, 15, 18, 33, 55, and 61). Use the Ctrl or Shift key to select multiple pins.
 - Click on **Create Pin Group**
 - Pin Group Name: **D2_+1.2V_Group**
 - Press the **OK** button
 - Unselect Pins.



Siwave PI Advisor – Analysis Exercise

• Pin Group Manager

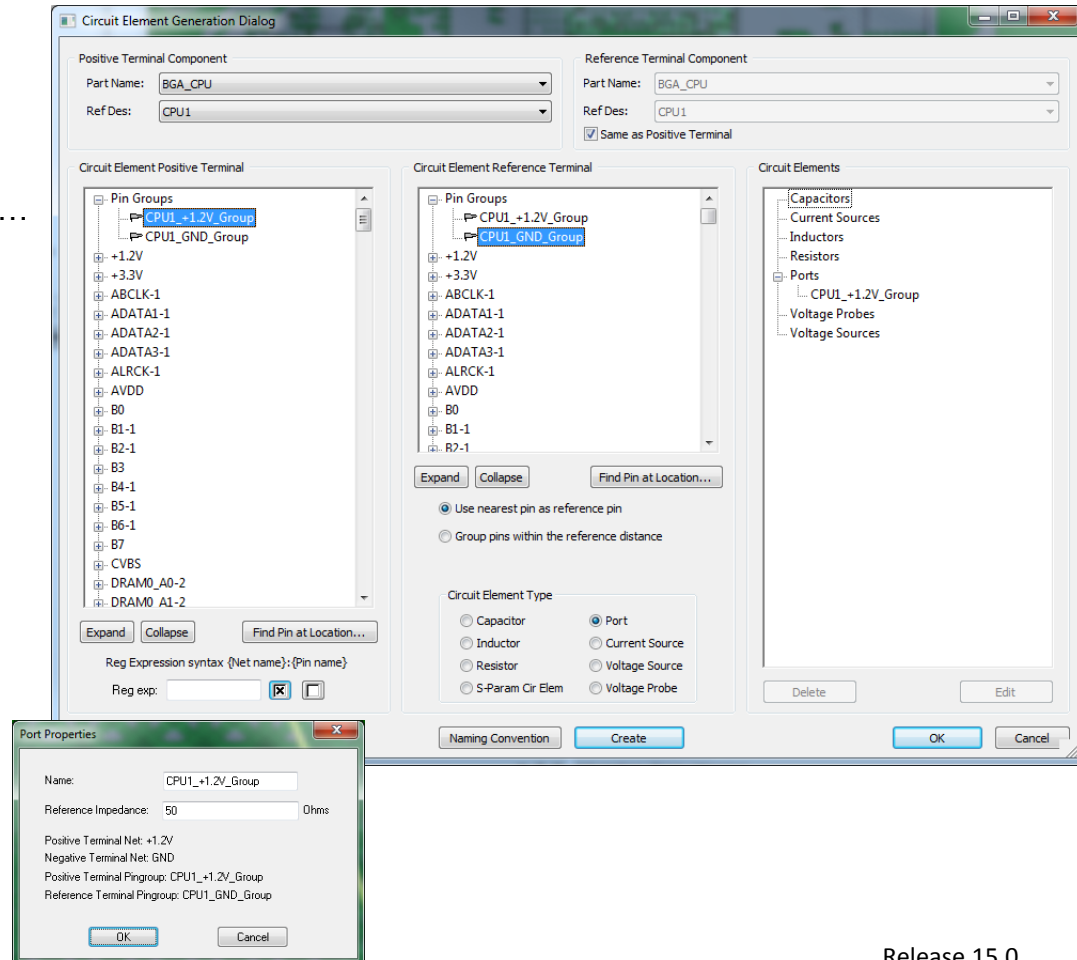
- While still in the **Pin Group Manager**
 - Select the following IC and Pin group:
 - Part Name: **SOIC_DRAM**
 - RefDes: **D2**
 - Nets: **GND**
 - Select all GND pins (**6, 12, 34, 48, 52, 64, and 66**). Use the **Ctrl** or **Shift** key to select multiple pins.
 - Click on **Create Pin Group**
 - Pin Group Name: **D2_GND_Group**
 - Press the **OK** button
 - Press the **OK** button



Siwave PI Advisor – Analysis Exercise

• Generation of Ports

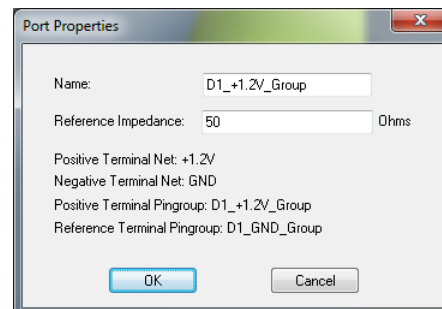
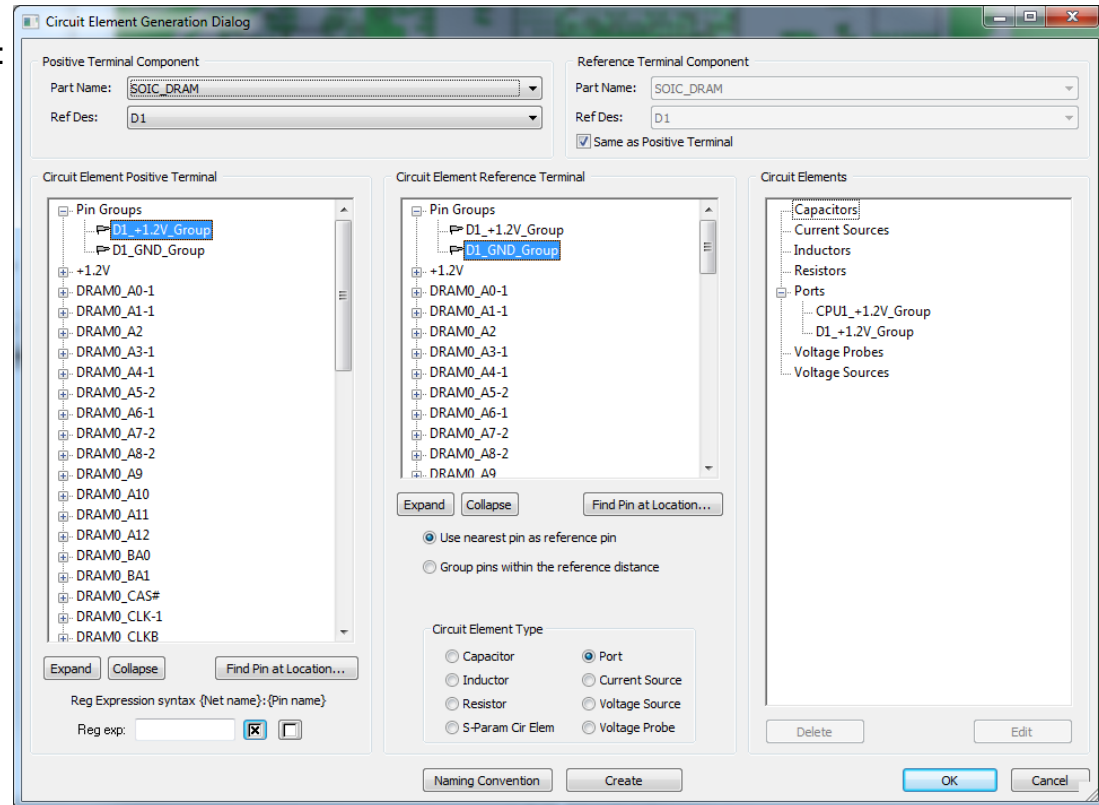
- To perform a SYZ parameter simulation, appropriate ports must be defined. These ports will be defined between power and ground groups of pins that were created on the **BGA_CPU** and **DRAM D1** and **D2** components.
- To Select the IC device that sources will be placed on, click the following:
 - Select the menu item **Circuit Elements > Generate on Components...**
 - Positive Terminal Component:
 - Part Name: **BGA_CPU**
 - Ref Des: **CPU1**
 - Reference Terminal Component:
 - ☒ **Same as Positive Terminal or...**
 - Part Name: **BGA_CPU**
 - Ref Des: **CPU1**
 - Circuit Element Positive Terminal
 - Pin Groups: **CPU1_+1.2V_Group**
 - Circuit Element Reference Terminal
 - Pin Groups: **CPU1_GND_Group**
 - Circuit Element Type: **Port**
 - Click the **Create** button
 - Port Properties:
 - Name: **CPU1_+1.2V_Group**
 - Reference Impedance: **50 Ohms**
 - Click on the **OK** button



Siwave PI Advisor – Analysis Exercise

• Generation of Ports (Continued)

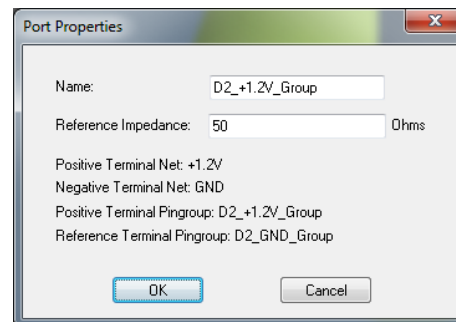
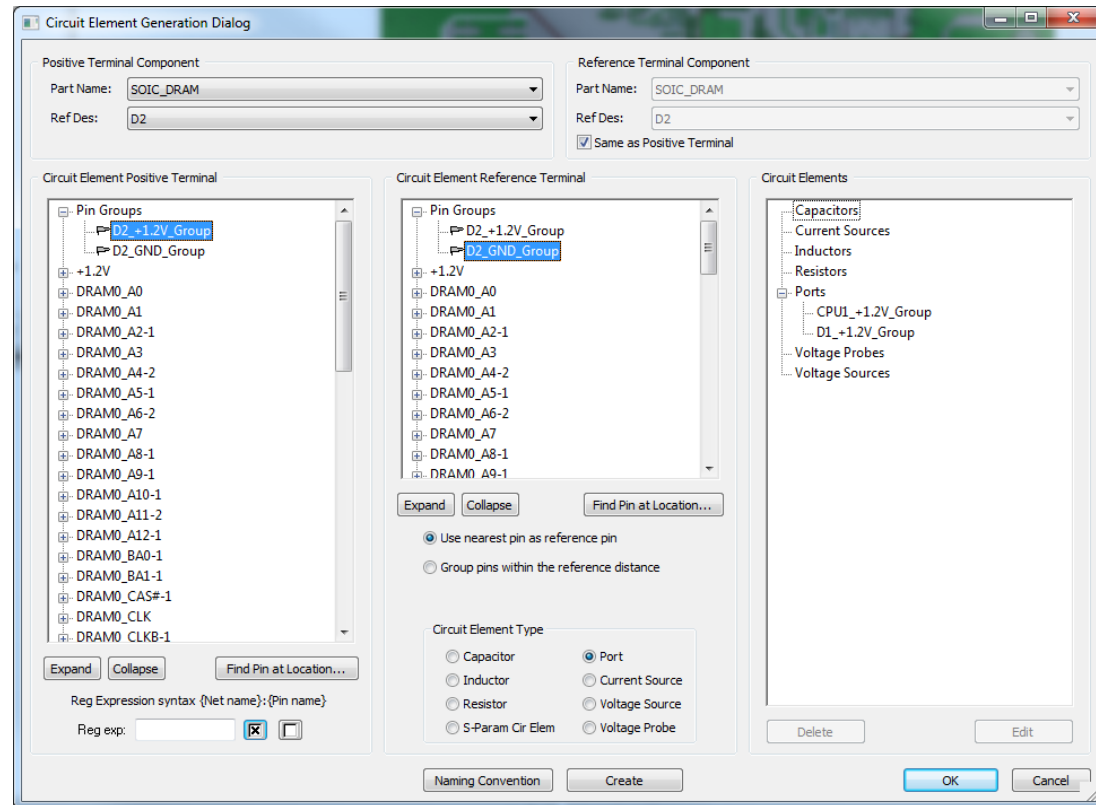
- While still in the Circuit Element Generator:
- Positive Terminal Component:
 - Part Name: **SOIC_DRAM**
 - Ref Des: **D1**
- Reference Terminal Component:
 - ☒ **Same as Positive Terminal or...**
 - Part Name: **SOIC_DRAM**
 - Ref Des: **D1**
- Circuit Element Positive Terminal
 - Pin Groups: **D1_+1.2V_Group**
- Circuit Element Reference Terminal
 - Pin Groups: **D1_GND_Group**
- Circuit Element Type: **Port**
- Click the **Create** button
- Port Properties:
 - Name: **D1_+1.2V_Group**
 - Reference Impedance: **50 Ohms**
- Click on the **OK** button



Siwave PI Advisor – Analysis Exercise

• Generation of Ports (Continued)

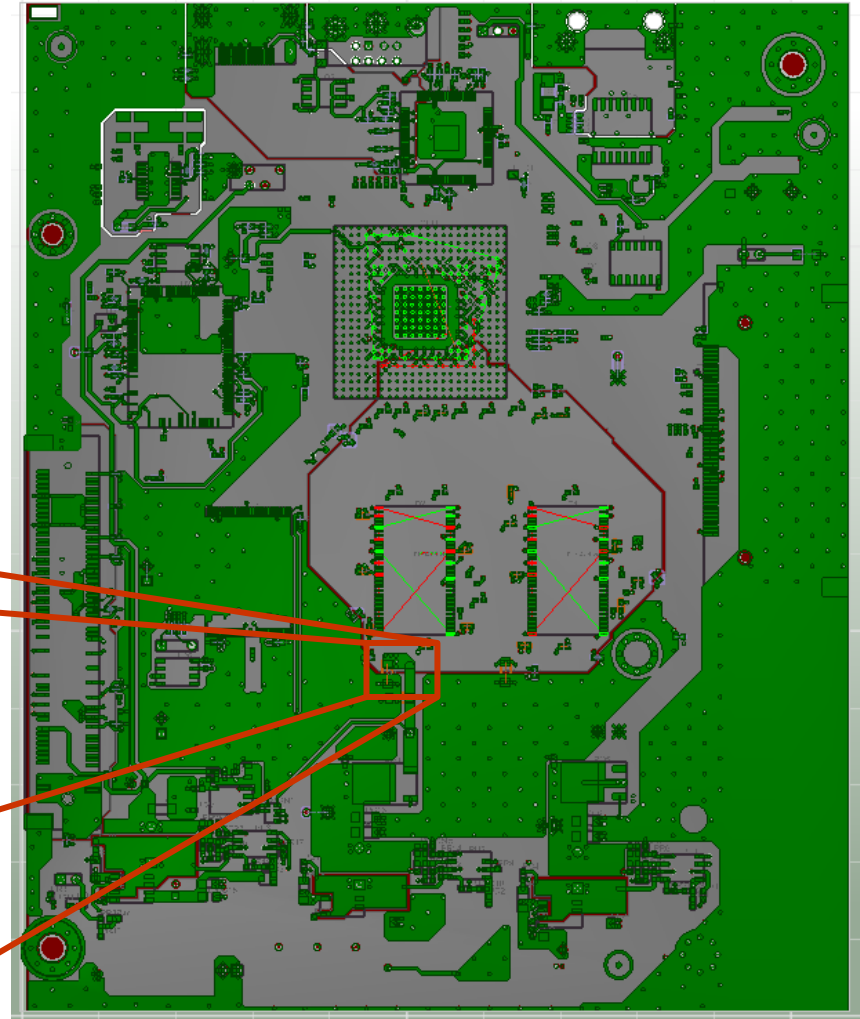
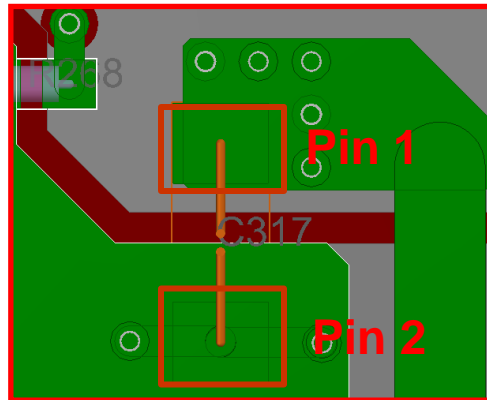
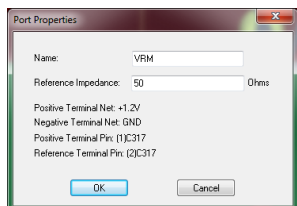
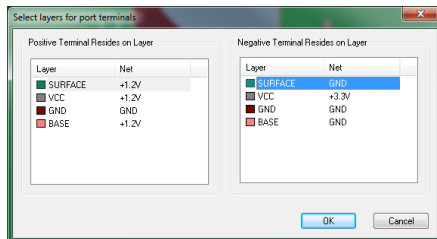
- While still in the Circuit Element Generator:
- Positive Terminal Component:
 - Part Name: **SOIC_DRAM**
 - Ref Des: **D2**
- Reference Terminal Component:
 - ☒ **Same as Positive Terminal** or...
 - Part Name: **SOIC_DRAM**
 - Ref Des: **D2**
- Circuit Element Positive Terminal
 - Pin Groups: **D2_+1.2V_Group**
- Circuit Element Reference Terminal
 - Pin Groups: **D2_GND_Group**
- Circuit Element Type: **Port**
- Click the **Create** button
- Port Properties:
 - Name: **D2_+1.2V_Group**
 - Reference Impedance: **50 Ohms**
- Click on the **OK** button
- Click on the **OK** button to exit the GUI.



SIwave PI Advisor – Analysis Exercise

• Generation of VRM port

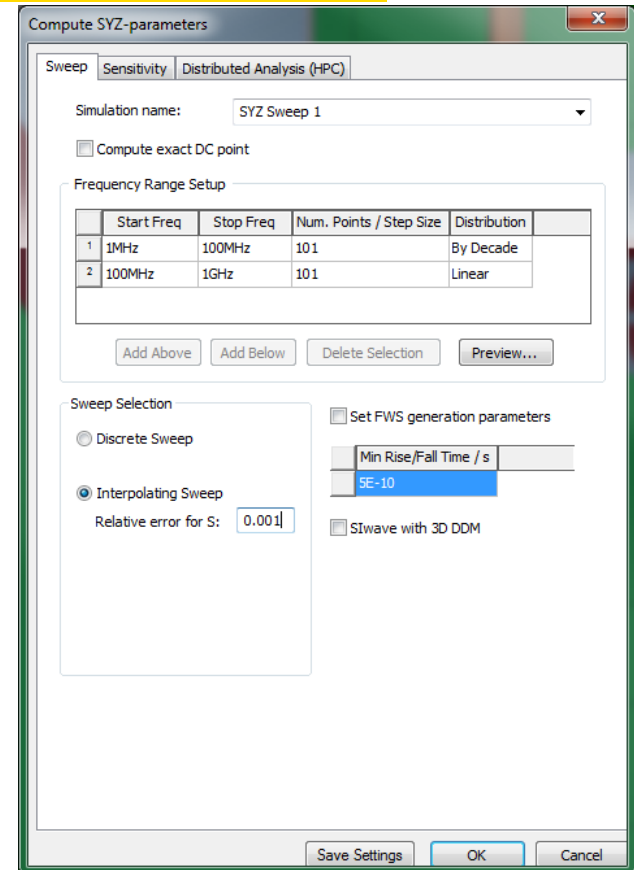
- Select the menu item **View > Interaction > Top-Down View**
- Zoom in highlighted area below **DRAM1**
 - Zoom to Component **C317**
- Select the menu item **Circuit Elements > Port**
 - For the Positive Terminal click on **Pin 1**
 - For the Negative Terminal click on **Pin 2**
- In the **Select layers for port terminals** select:
 - Positive Terminal Layer : **Surface**
 - Negative Terminal Layer : **Surface**
- Click the **OK** button
- Port Properties:
 - Name: **VRM**
 - Reference Impedance: **50 Ohms**
- Click the **OK** button



SIwave PI Advisor – Analysis Exercise

• Run an SYZ Simulation

- Exit Port generation mode: **Circuit Elements > Port**
- Click **Simulation > SIwave > Compute S-, Y-, Z-parameters...**
 - Simulation Name: **SYZ Sweep 1**
 - Setup Frequency Sweep
 - Start Frequency: **1 MHz**
 - Stop Frequency: **100 MHz**
 - Number of Points: **101**
 - Distribution: **By Decade**
 - Click on: **Add Below** button
 - Start Frequency: **100 MHz**
 - Stop Frequency: **1 GHz**
 - Number of Points: **101**
 - Distribution: **Linear**
 - Sweep Selection: **Interpolating Sweep**
 - Set Relative error for S: **0.001**
 - Click the **OK** button



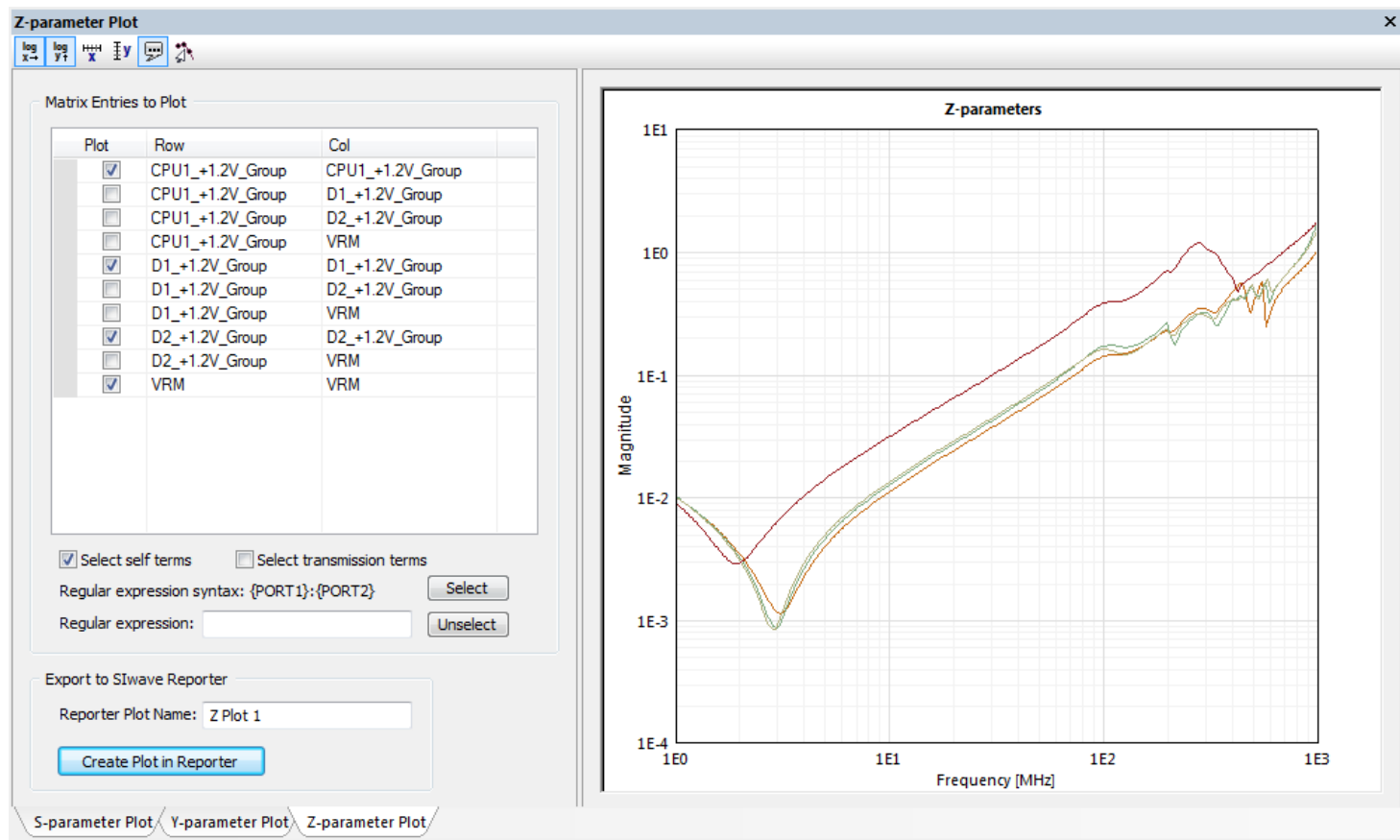
Note: SIwave will not solve explicitly at all points, but will solve for sufficient points to create a rational interpolation function on the frequency interval.

Note: Click the **Preview** button to see a listing of the frequencies which will be solved.

Note: The Min Rise/Fall Time value is tied to the Stop Frequency and does not need to be modified once the Stop Frequency is set.

- **Plot the results**

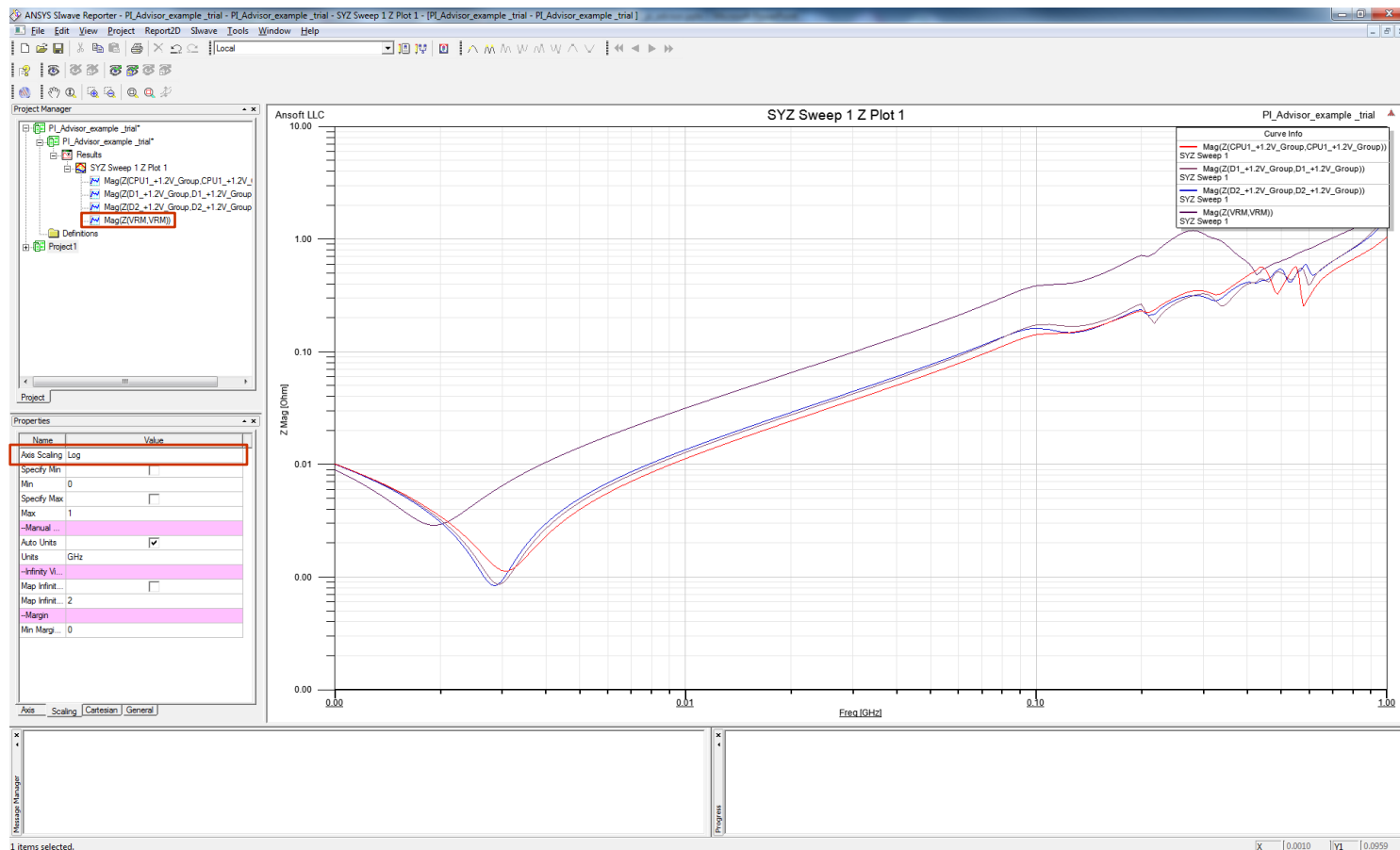
- When the simulation is finished, plot the results
- Click **Results > SIwave > SYZ > SYZ Sweep 1 > Plot Magnitude/Phase...**
- Click on **Z-parameters** Plot Tab
- Click the **Create Plot in Reporter** button



SIwave PI Advisor – Analysis Exercise

• Plot the results in SIwave Reporter

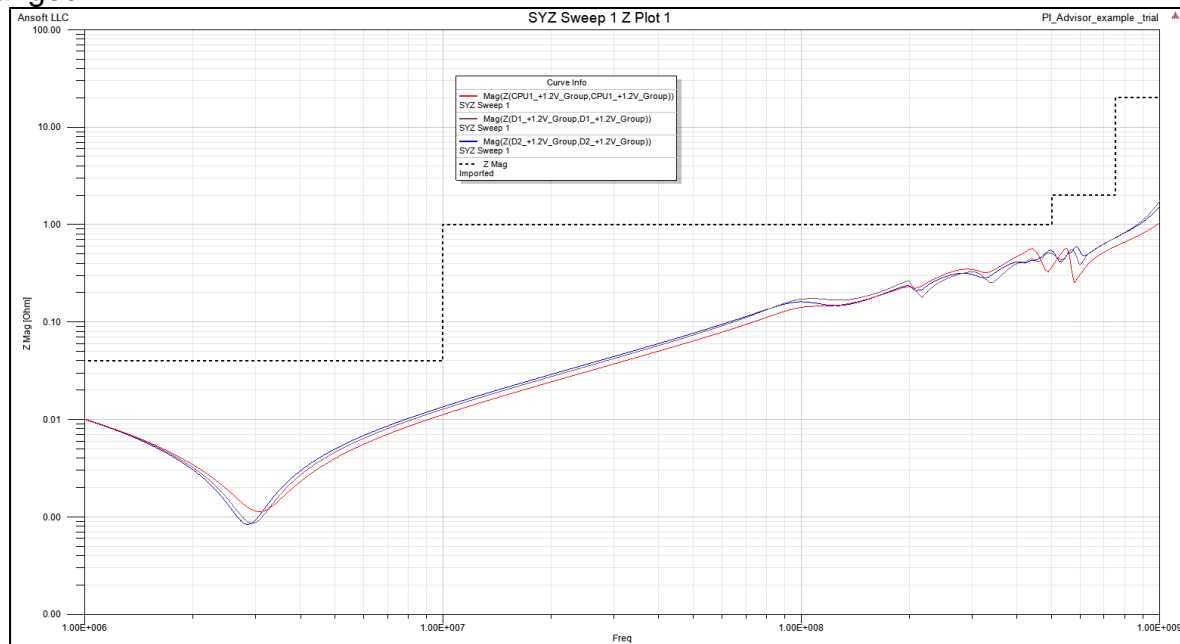
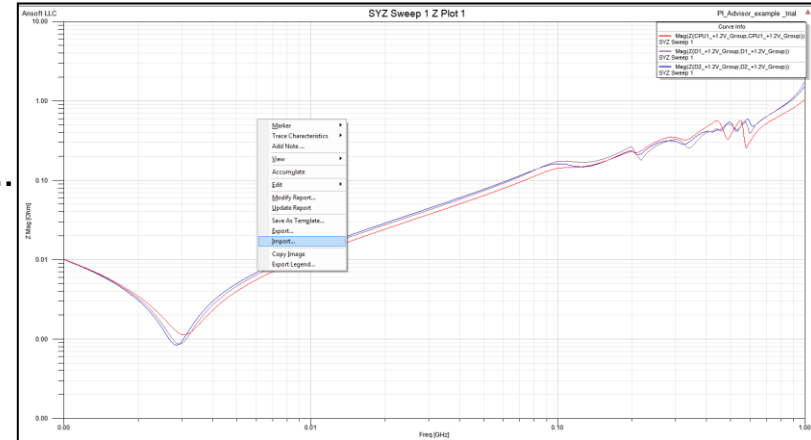
- When **SIwave Reporter** opens:
- Click on **X-axis** on plot and in the lower left corner of **Properties** window
- In **Scaling** tab change scale from **Linear** to **Log** (If not already in Log format)
- In SIwave Reporter click on **Mag (Z(VRM,VRM))** trace and press **Delete**



Slwave PI Advisor – Analysis Exercise

• Plot the results in Slwave Reporter

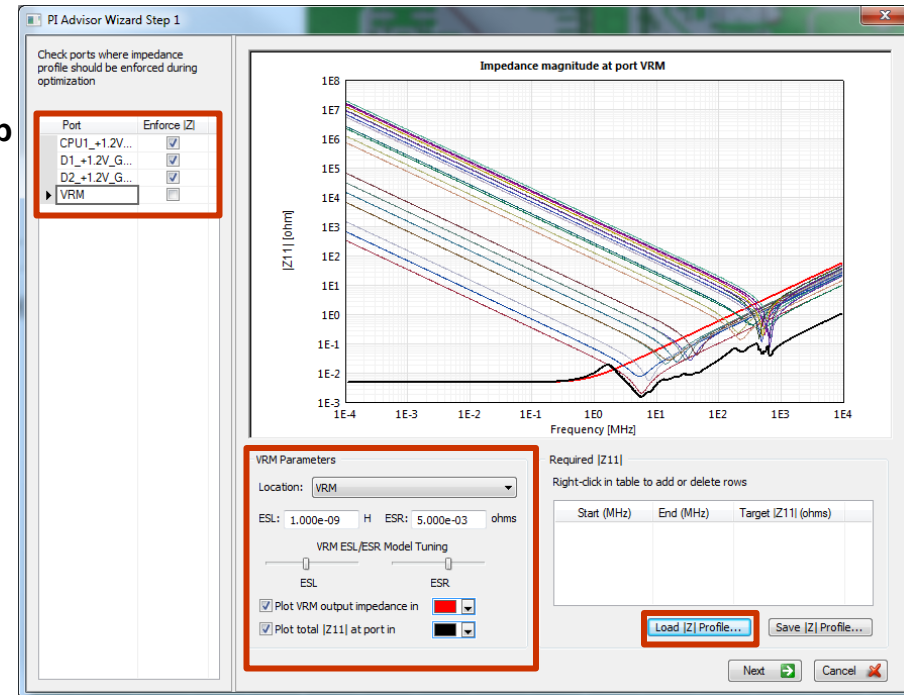
- Z-parameters plot in Slwave Reporter
- Import Impedance mask in Slwave Reporter
 - Right Mouse Click in Reporter window and choose **Import...**
 - Browse to **Zmask.csv** file
 - Click on **Zmask** trace in reporter
 - In the Property Window click on Attributes Tab:
 - Color : **Black**
 - Line Style: **ShortDash**
 - Line Width: **2**
- **X-Axis** Zoom may need to be changed
 - Click on **X-Axis**
 - Set min to: **1e6**



SIwave PI Advisor – Analysis Exercise

• PI Advisor Step 1:

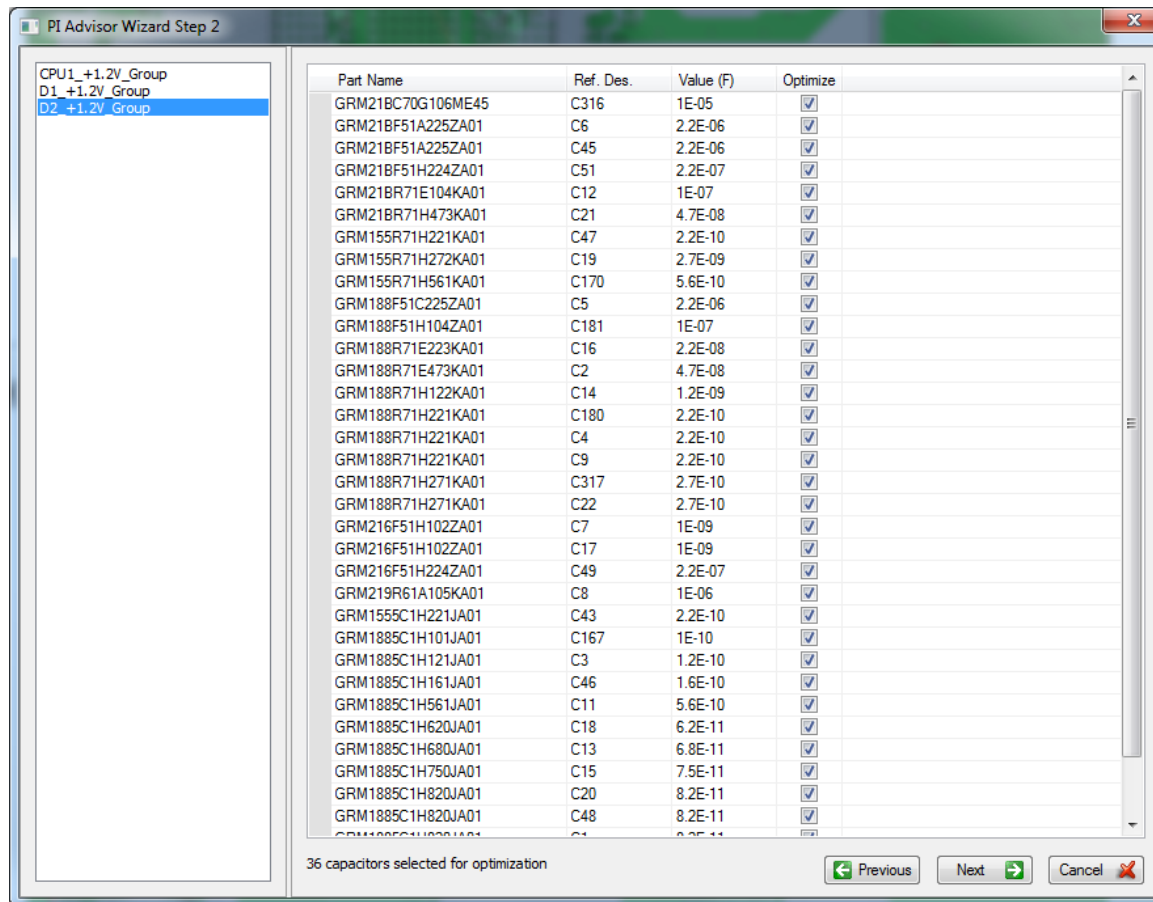
- Return to SIwave GUI
- Close results window.
- Next the **PI Advisor** will Select Ports for Optimization, Define VRM model and Load Impedance mask
 - Click on **Simulation > PI Advisor...**
 - In **PI Advisor Wizard Step1** window
 - Highlight **CPU1_+1.2V_Group**
 - Check box **Enforce |Z|** for **CPU1_+1.2V_Group**
 - VRM parameters
 - Location: **VRM**
 - ESL: **1e-9 H**
 - ESR: **5e-3 ohms**
 - Press **Load |Z| Profile...** button
 - Browse to and import **1v2.zprof** file
 - Repeat steps from above for other two ports:
 - **D1_+1.2V_Group**
 - **D2_+1.2V_Group**
 - **Note:** Do not enable VRM in port window.
 - Click **Next**



SIwave PI Advisor – Analysis Exercise

• PI Advisor Step 2:

- Select Capacitors for Optimization
 - Click on **Optimize** column header to select all available 36 capacitors for Optimization
 - Click **Next** button



SIwave PI Advisor – Analysis Exercise

• PI Advisor Step 3:

Select Candidate Capacitors for Optimization

1. Capacitors Selected for Optimizations : Highlight all using the **Shift** key
2. Filters:
 - Uncheck all by clicking on **Show** column header
 - Select only Vendor: **Murata** ☒ checked
3. Select Series:
 - Uncheck all by clicking on Show
 - **GRM18** and **GRM21** ☒ checked
4. Highlight all Murata capacitors (Click on the grey bar on the left hand side and use Shift key)
5. Enter Price: **0.01**
6. Click : **Update**
7. Click: **Assign Selected Candidate(s)**
8. Click : **Next**

1. Part Name, Ref. Des., Val.

2. Vendor, Series, Part Name

3. Series

4. Vendor, Series, Part Name, Plot, Candidate, Value (F), EIA Size, Price, L_mnt (H), R_mnt (ohms), SRF (Hz)

5. Price

6. Update

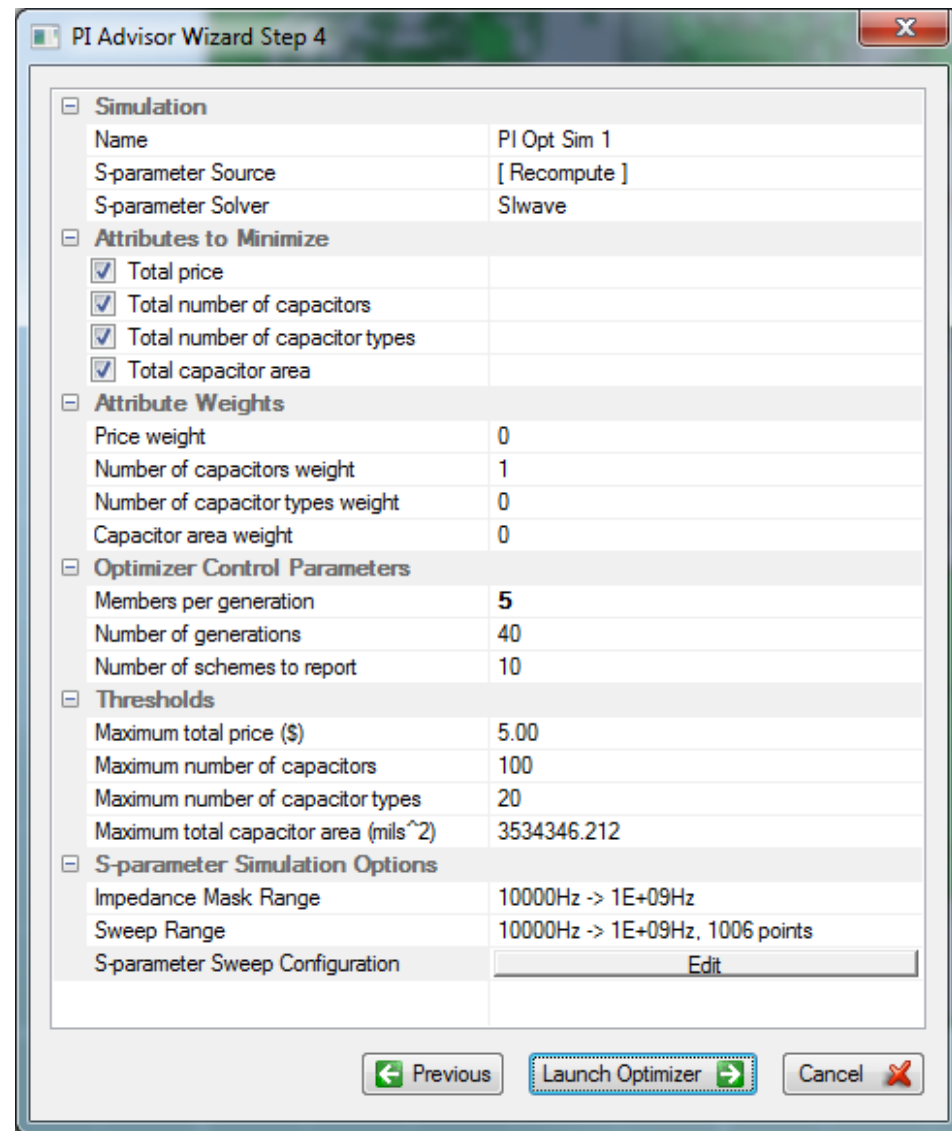
7. Assign Selected Candidate(s)

8. Next

SIwave PI Advisor – Analysis Exercise

• PI Advisor Step 4:

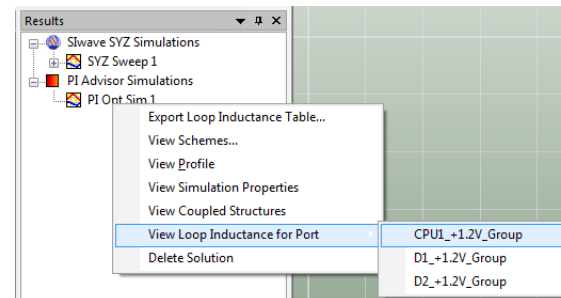
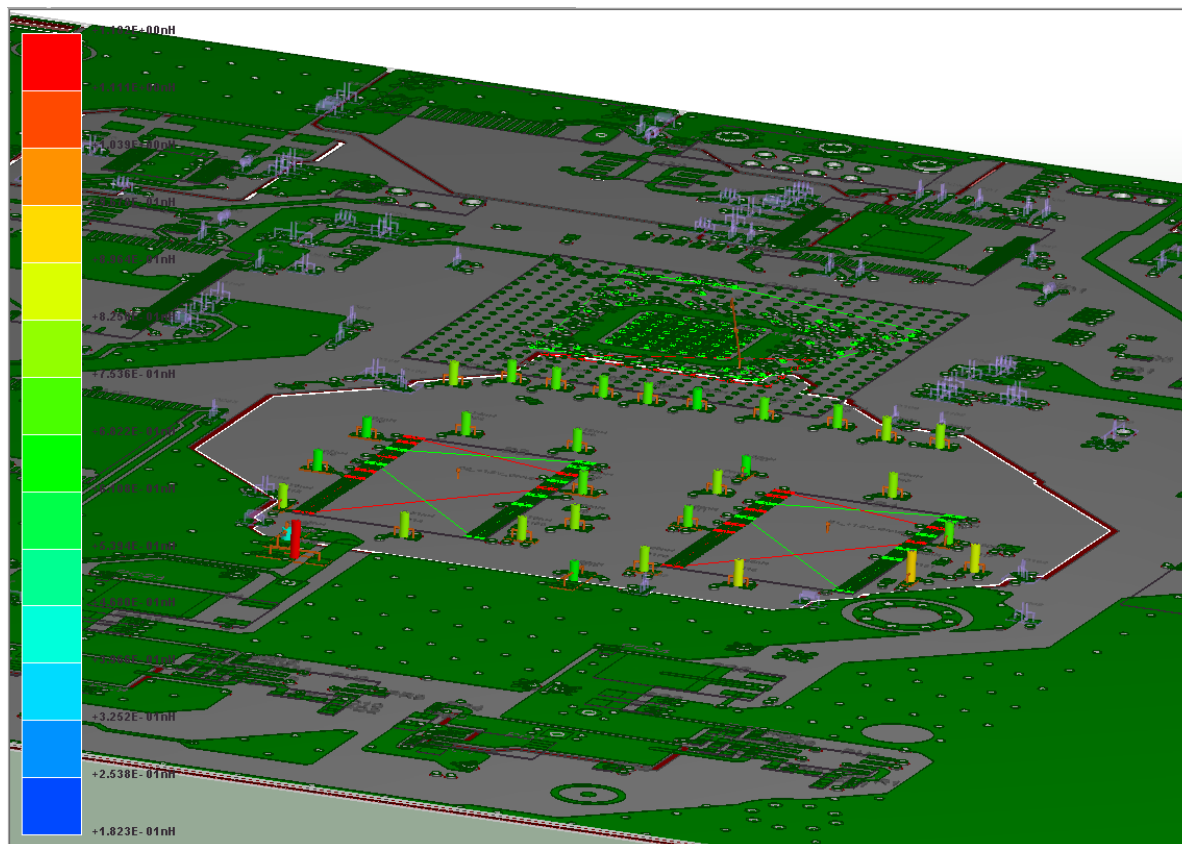
- Attributes to Minimize:
 - Total Price ☒ **checked**
 - Total Number of Capacitors ☒ **checked**
 - Total Number of Capacitors types ☒ **checked**
 - Total Capacitor Area ☒ **checked**
- Number of Capacitors weight: 1
- Members per generation: 5
- Numbers of generation: 40
- Number of schemes to report: 10
- **Note:** Genetic Algorithm is used for optimization
- Click **Edit** on **S-parameter Sweep Configuration**
 - Start Frequency: **10 KHz**
 - Stop Frequency: **1 GHz**
 - Number of Points: **201**
 - Distribution: **By Decade**
 - Sweep Selection:
 - **Interpolating Sweep**
 - Relative Error for S: **0.001**
 - Click: **OK**
- Click on **Launch Optimizer**



SIwave PI Advisor – Analysis Exercise

• Loop Inductance

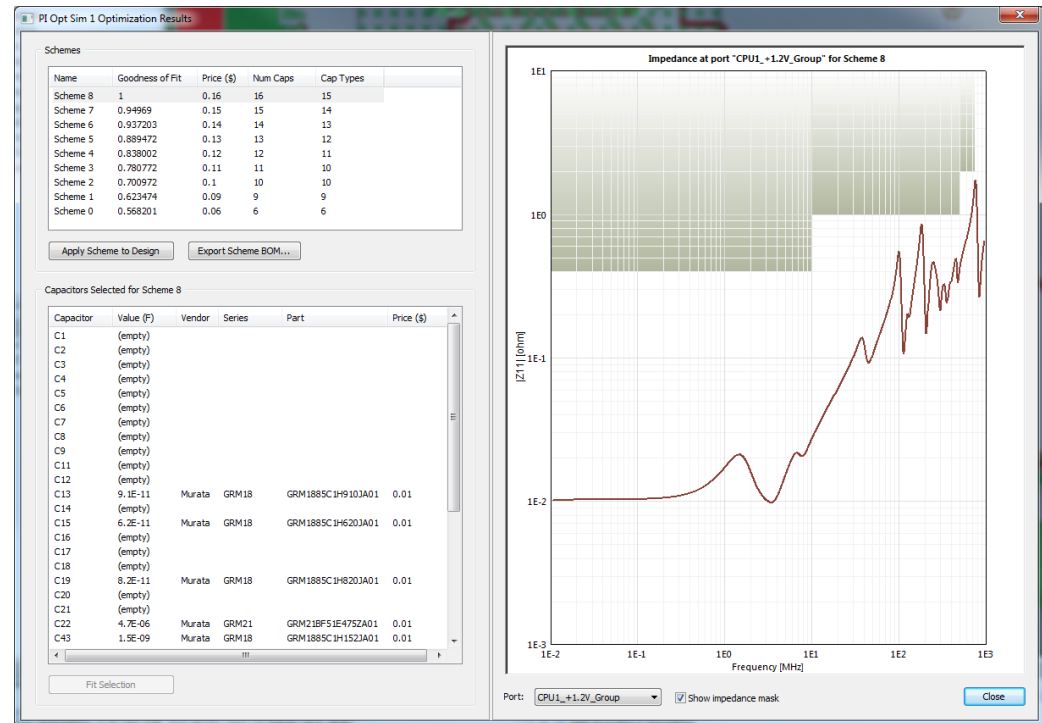
- Loop inductance values between each port and each capacitor are calculated based on the layout geometry.
 - Capacitors with high loop inductance values would be expected to be less effective in reducing the impedance at the associated port.
- In the Results window Right Mouse Click on **PI Opt Sim 1** and select:
 - **View Loop Inductance for Port > CPU1_+1.2V_Group**



SIwave PI Advisor – Analysis Exercise

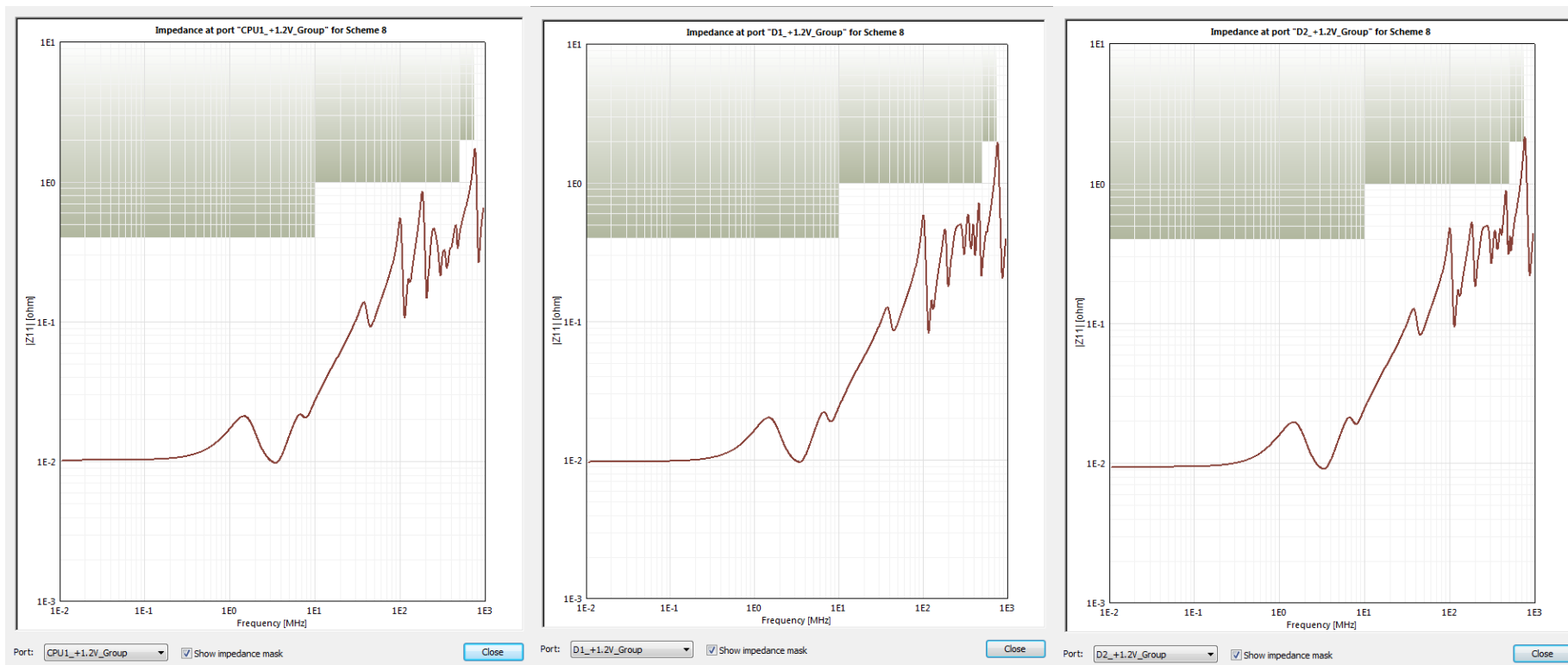
• PI Advisor Simulation Results

- In the Results Window Right Mouse Click on **PI Opt Sim 1**
- Select : **View Schemes...**
 - **Show Impedance Mask** ☒ checked
 - Highlight: **Scheme 8**
- Browse thru nine available schemes
 - Goodness of fit expressed in percentage
 - Goodness of fit 1 = 100%
- Best Optimized Solution : **Scheme: #8**
 - Total # Caps: **16**
 - Price: **\$0.16**
 - Capacitor Types: **15**



• View Schemes

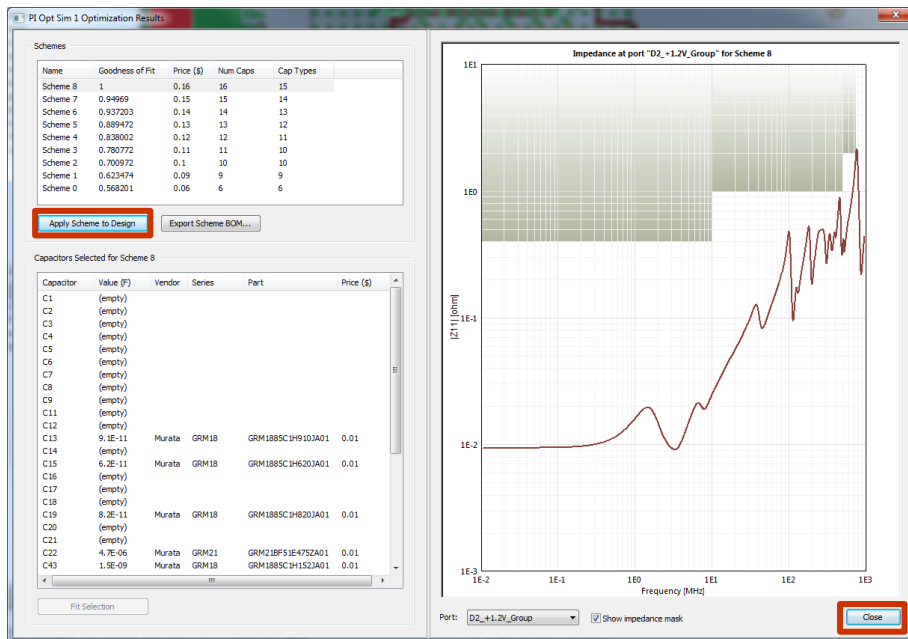
- Highlight **Scheme #8**
- Enable **Show Impedance Mask** ☒ checked
- View Z-profile for all three available ports
 - CPU1_+1.2V_Group, D1_+1.2V_Group, D2_+1.2V_Group



SIwave PI Advisor – Analysis Exercise

• Apply PI Advisor Simulation Results: Capacitor count reduction

- Select and Highlight **Scheme #8**
- Click **Apply scheme to Design**
- Click the **Close** button
- From the SIwave GUI select:
 - **Edit > Circuit Element Parameters...**
 - Please verify that 16 different capacitors are listed as active.



Circuit Element Properties

CapacitorsInductorsResistorsPortsVoltage ProbesCurrent SourcesVoltage Sources

Active	d/dt	Part Number	RefDes	Capacitance (F)	Parasitic L (H)	Parasitic R (ohms)	Positive Terminal	
✓	Yes	✗	GRM1885C1H910JA01	C13	9.1E-11	8.7849E-10	0.143556	+1.2V
✓	Yes	✗	GRM1885C1H620JA01	C15	6.2E-11	7.27176E-10	0.178877	+1.2V
✓	Yes	✗	GRM1885C1H820JA01	C19	8.2E-11	2.12802E-11	0.155633	+1.2V
✓	Yes	✗	GRM218F51E475ZA01	C22	4.7E-06	4.35687E-06	0.0121492	+1.2V
✓	Yes	✗	GRM1885C1H152JA01	C43	1.5E-09	4.56705E-09	0.0597616	+1.2V
✓	Yes	✗	GRM1885C1H122JA01	C45	1.2E-09	3.82826E-13	0.057963	+1.2V
✓	Yes	✗	GRM1885C1H511JA01	C47	5.1E-10	1.42672E-09	0.0729442	+1.2V
✓	Yes	✗	GRM216R61A225KE24	C48	2.2E-06	9.91469E-06	0.00936137	+1.2V
✓	Yes	✗	GRM188R71E123KA01	C49	1.2E-08	3.21343E-11	0.0622767	+1.2V
✓	Yes	✗	GRM188R71H391KA01	C51	3.9E-10	9.5526E-13	0.59068	+1.2V
✓	Yes	✗	GRM188R71H331KA01	C52	3.3E-10	1.84657E-09	0.647839	+1.2V
✓	Yes	✗	GRM1885C1H151JA01	C167	1.5E-10	1.30805E-09	0.170406	+1.2V
✓	Yes	✗	GRM188F51E474ZA01	C170	4.7E-07	3.90429E-07	0.0182974	+1.2V
✓	Yes	✗	GRM1885C1H750JA01	C180	7.5E-11	2.35046E-10	0.162614	+1.2V
✓	Yes	✗	GRM1885C1H101JA01	C181	1E-10	8.22615E-13	0.203464	+1.2V
✓	Yes	✗	GRM1885C1H151JA01	C312	1.5E-10	1.30805E-09	0.170406	+1.2V
✓	No	✗	GRM1885C1H820JA01	C1	8.2E-11	2.12802E-11	0.155633	+1.2V
✓	No	✗	GRM188R71E473KA01	C2	4.7E-08	6.21535E-10	0.0297823	+1.2V
✓	No	✗	GRM1885C1H121JA01	C3	1.2E-10	8.07155E-10	0.194051	+1.2V

139 capacitors, 16 active, 123 inactive

Modify Properties...Modify Layers...DeleteFit SelectionActivateDeactivate

ExportOKCancel

SIwave PI Advisor – Analysis Exercise

- **Re-run an SYZ Simulation**

- Select **Simulation > SIwave > Compute S-, Y-, Z-parameters...**

- Simulation Name: **SYZ Sweep - Scheme 8**

- Setup Sweep:

- Start Frequency: **1MHz**
 - Stop Frequency: **100Mhz**
 - Number of Points: **101**
 - Distribution: **By Decade**

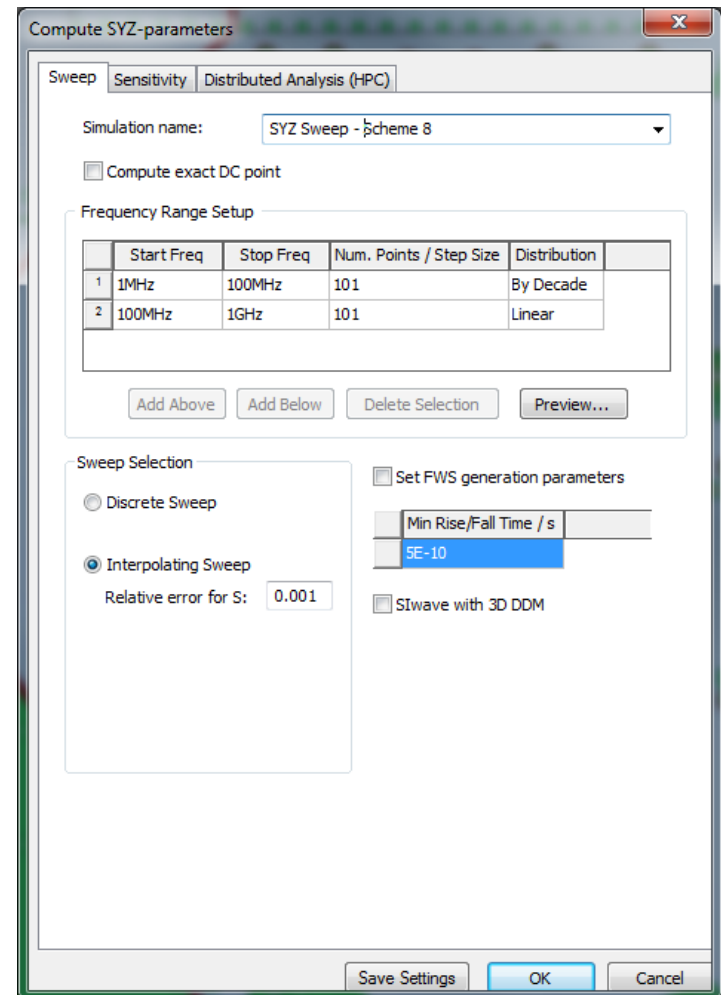
- Click on: **Add Below button**

- Start Frequency: **100MHz**
 - Stop Frequency: **1GHz**
 - Number of Points: **101**
 - Distribution: **Linear**

- Sweep Selection: **Interpolating Sweep**

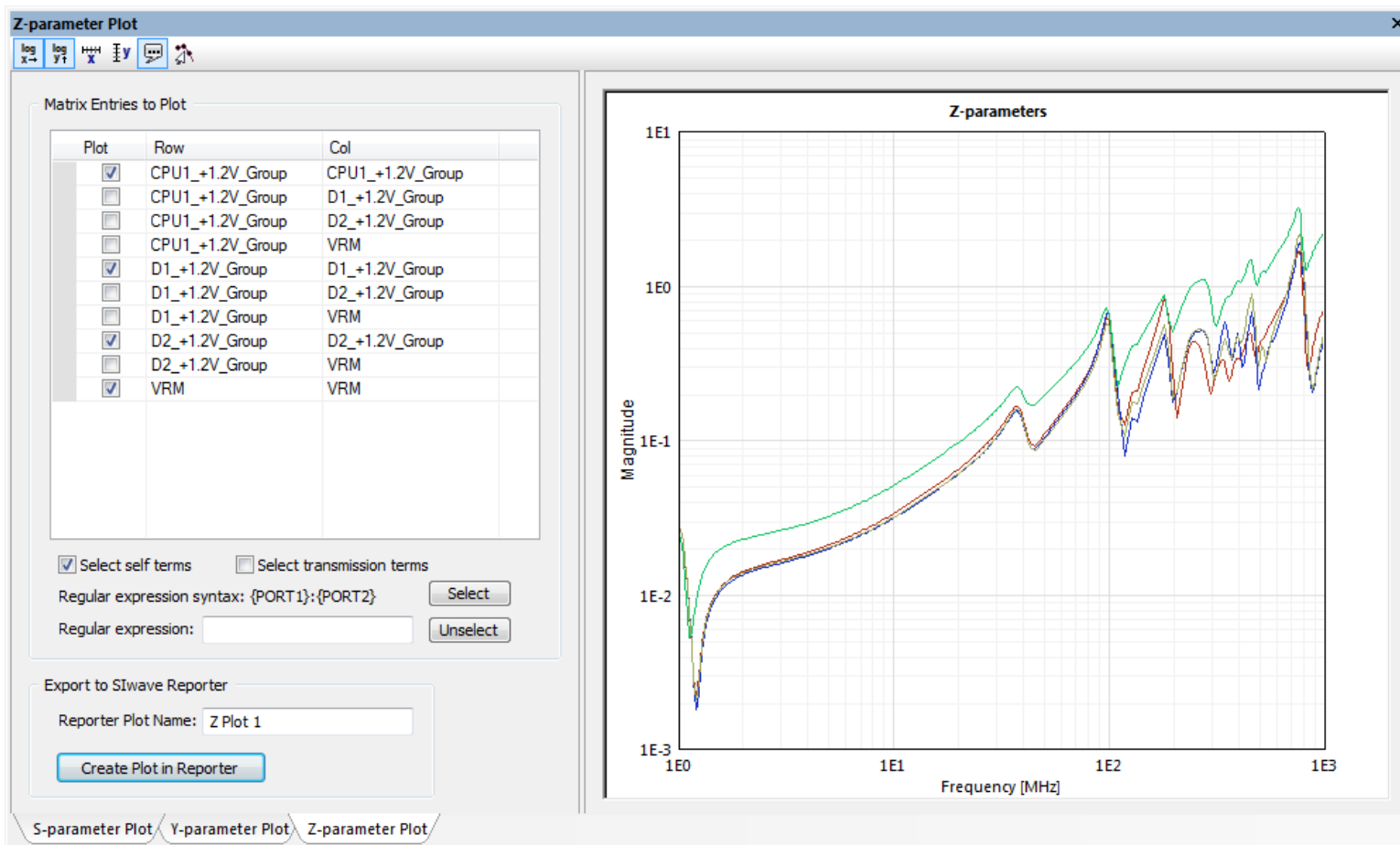
- Relative Error for S: **0.001**

- Click the **OK** button



- **Plot the results**

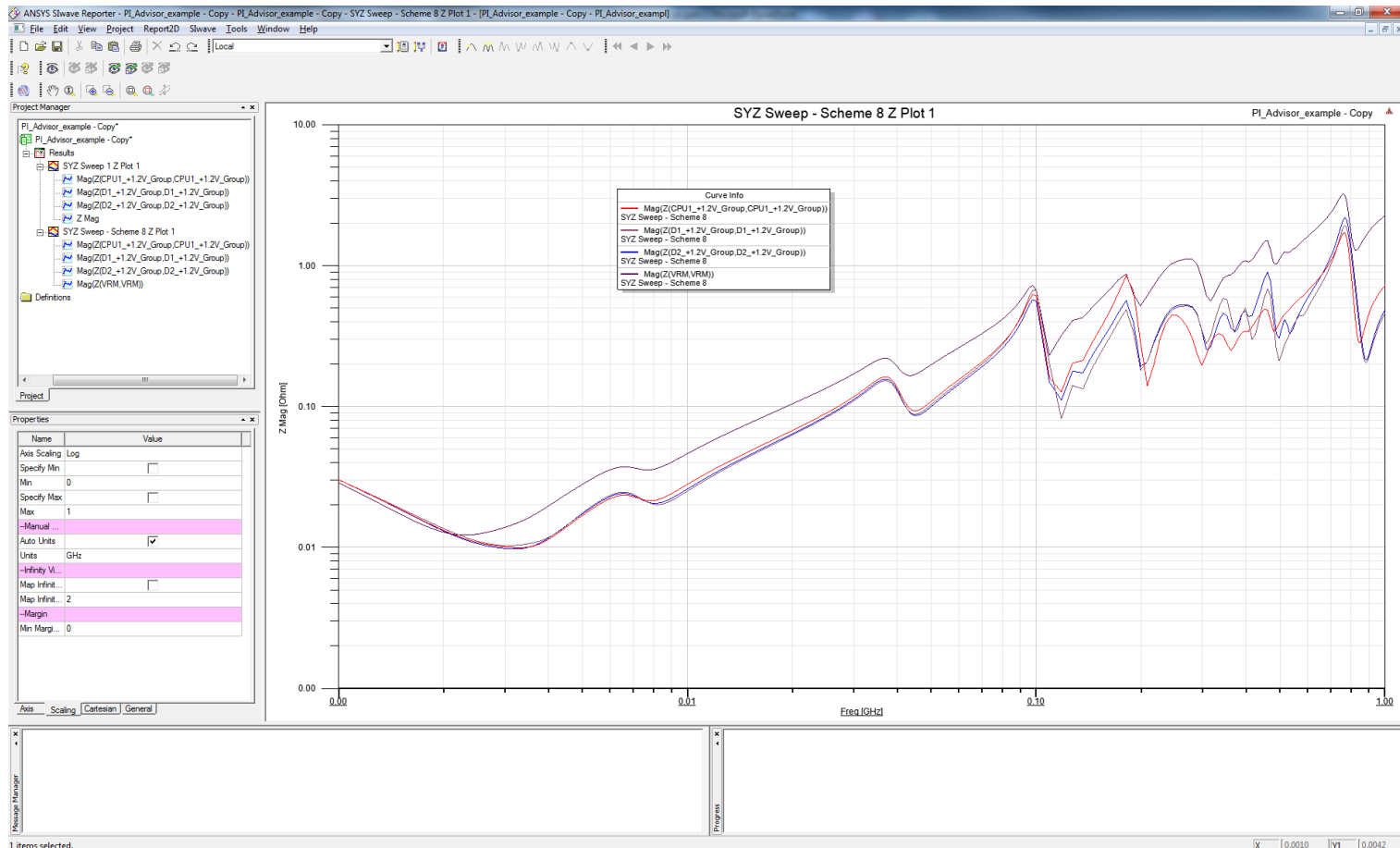
- When the simulation is finished, plot the results
- Click **Results > SIwave > SYZ > SYZ Sweep – Scheme 8 > Plot Magnitude/Phase...**
- Click on **Z-parameters** Plot Tab
- Click the **Create Plot in Reporter** button



SIwave PI Advisor – Analysis Exercise

• Plot the results in SIwave Reporter

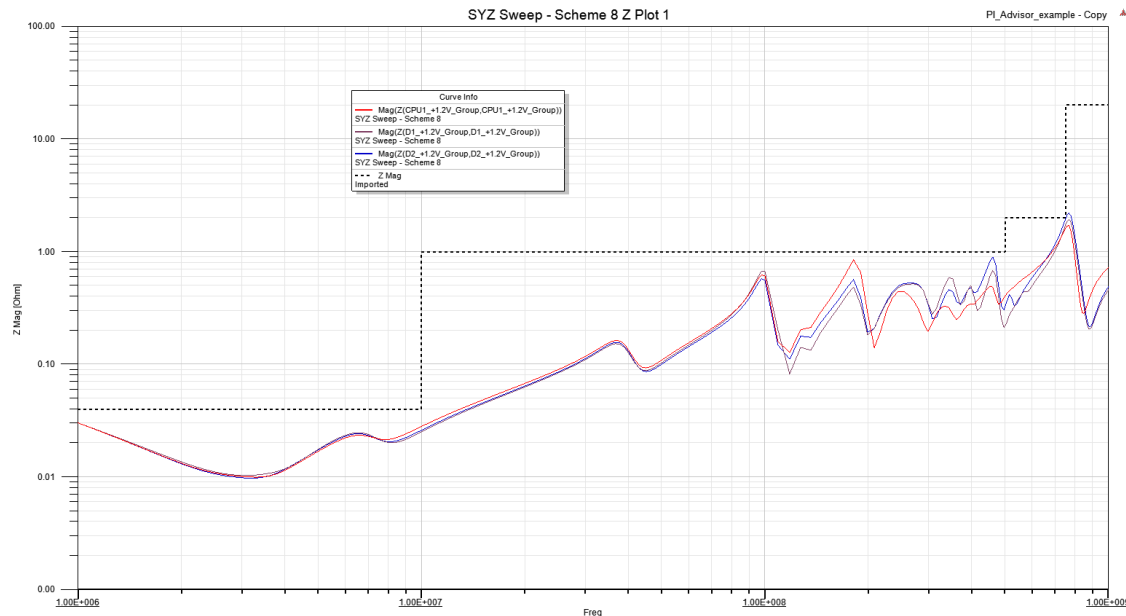
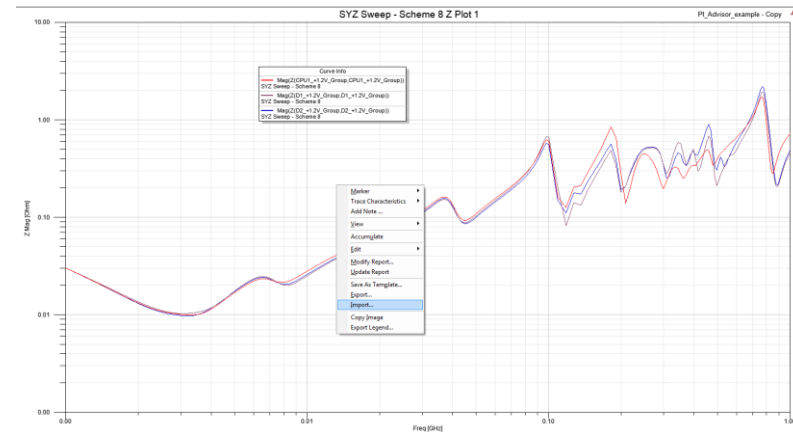
- When SIwave Reporter opens:
 - Click on **X-axis** on plot and in the lower left corner of **Properties** window.
 - In the scaling tab change scale from **Linear** to **Log**.
 - In SIwave Reporter click on **Mag (Z(VRM,VRM))** trace and press **Delete** key.



SIwave PI Advisor – Analysis Exercise

• Plot the results in SIwave Reporter

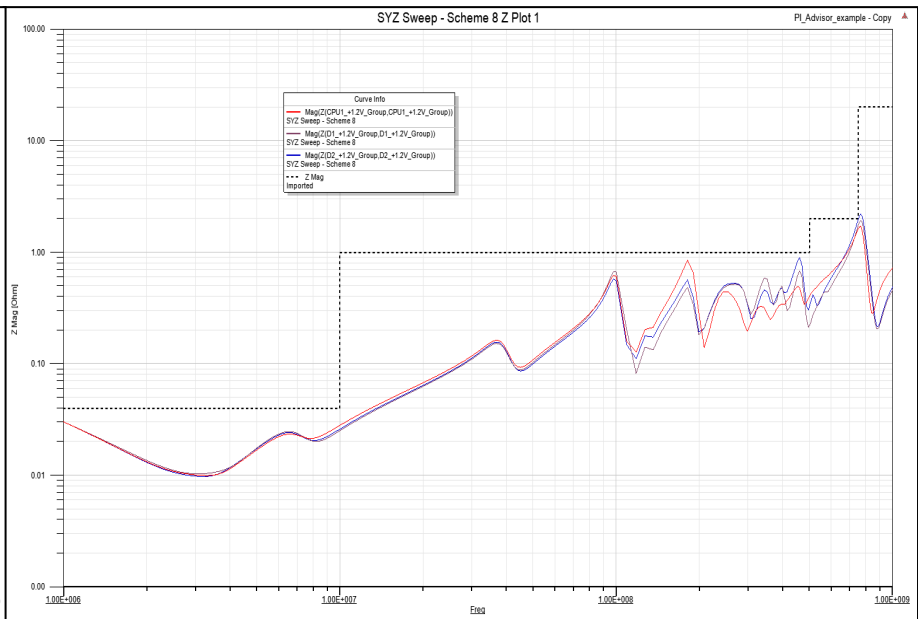
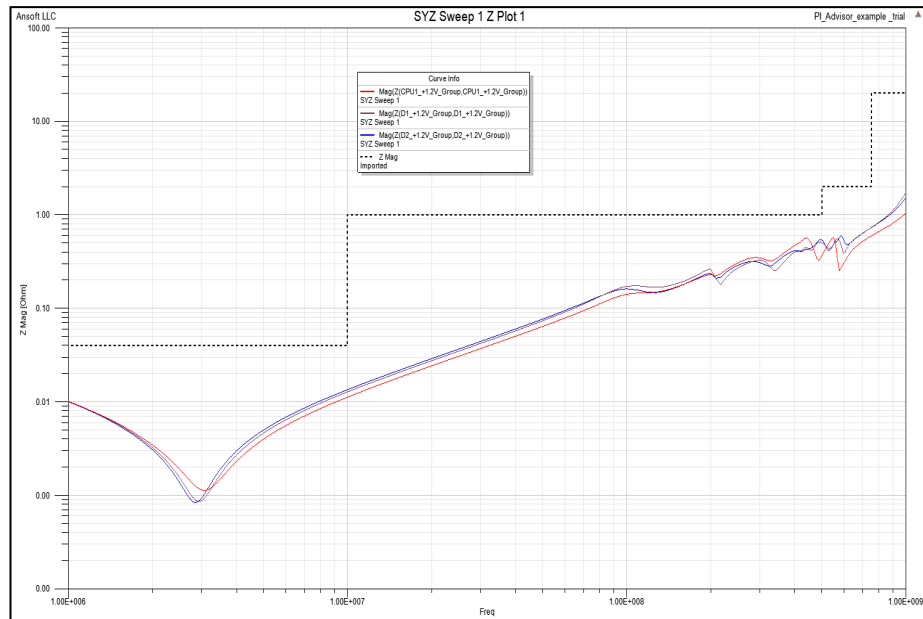
- View the Z-parameters plot in SIwave Reporter
- Import Impedance mask in SIwave Reporter
 - Right Mouse Click in Reporter window and choose **Import...**
 - Browse to **Zmask.csv** file
- Click on **Zmask** trace in reporter
 - In the Property Window click on Attributes Tab:
 - Color : **Black**
 - Line Style: **ShortDash**
 - Line Width: **2**



• **Note: No VRM model was used in this simulation.**

- **Z-parameter comparison**

- Original vs. Optimized design
- Compare number of capacitors and cost savings
- 36 caps vs 16 caps



Note: No VRM models were used in these simulations.

SIwave PI Advisor – Analysis Exercise
