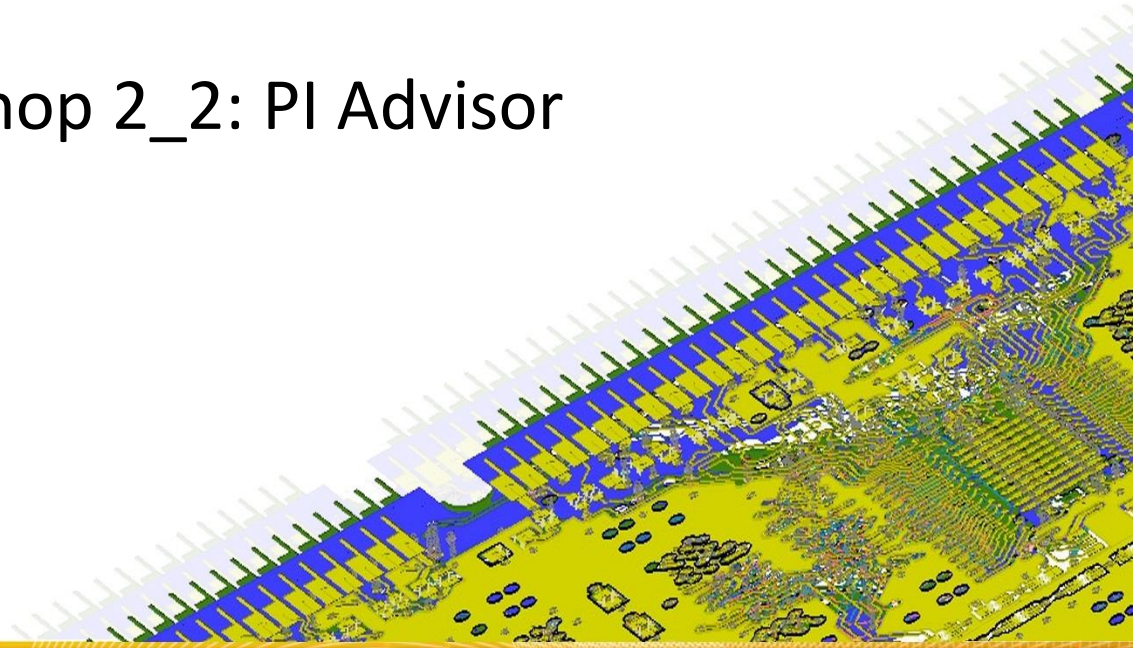
SIwave for Power Integrity Analysis

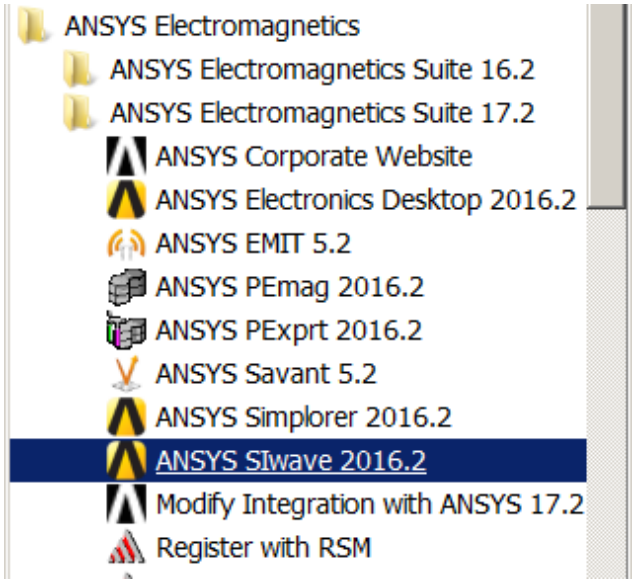
Workshop 2_2: PI Advisor



Opening or Importing a Project

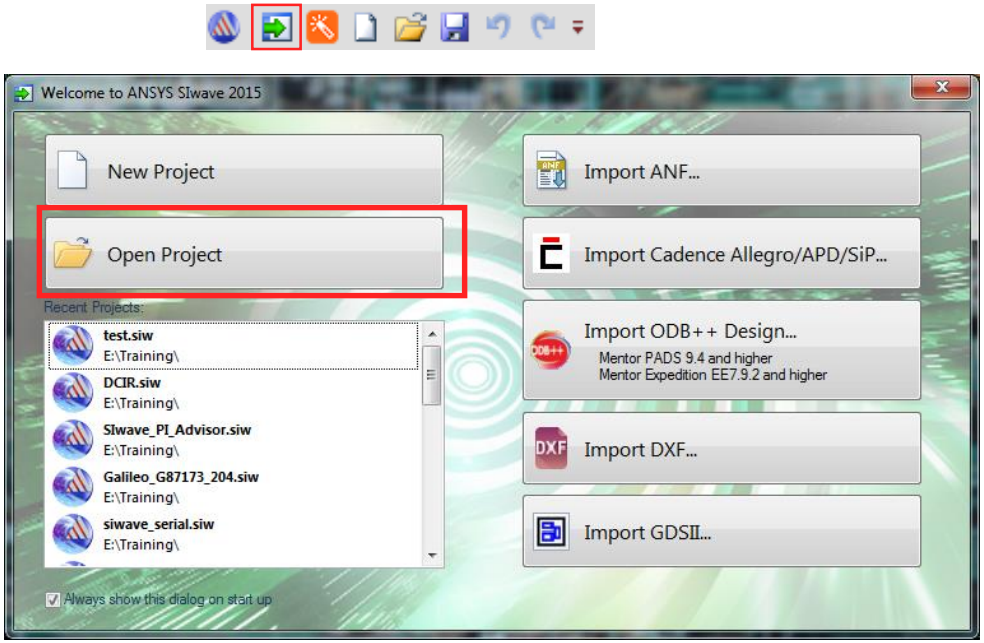
Starting SIwave

- To launch SIwave, click the Microsoft **Start** Button > **ALL Programs** > **ANSYS Electromagnetics** > **ANSYS Electromagnetics Suite 17.2**.
- Select the **ANSYS SIwave 2016** executable.



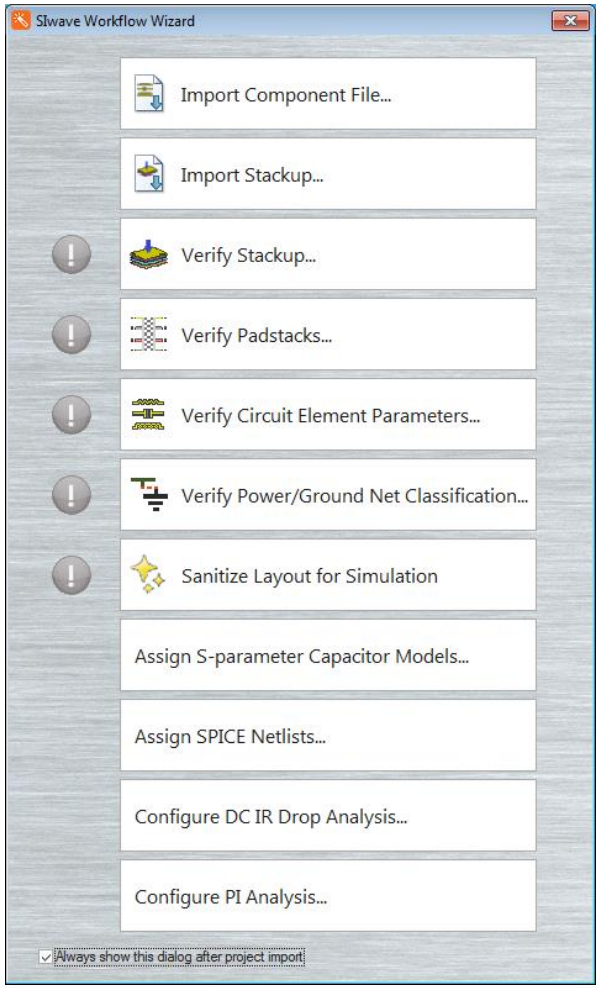
Open a SIwave Project

- Select the **Open Project** button
  - Browse for the file: **PI.siw**,
  - Click the **Open** button



SIwave Workflow Wizard Dialogue

- **Opening the Workflow Wizard**
  - In the Common Functions menu, choose the **SIwave Workflow Wizard Dialogue**.



(Optional) Import Settings from Previous Simulation

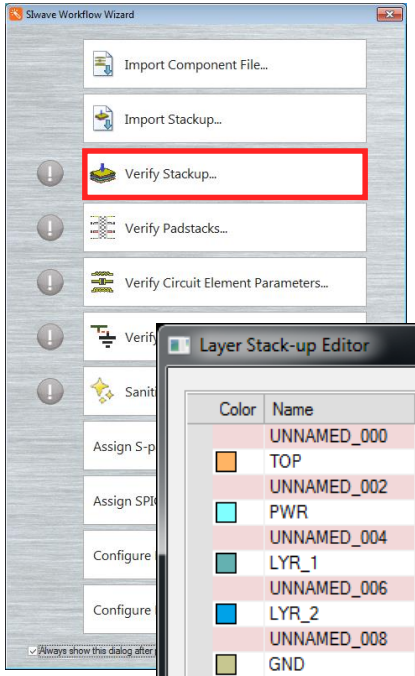
Verify / Modify Geometry, Materials, and Circuit Elements

(Optional) Pre-process Overlapping Geometry

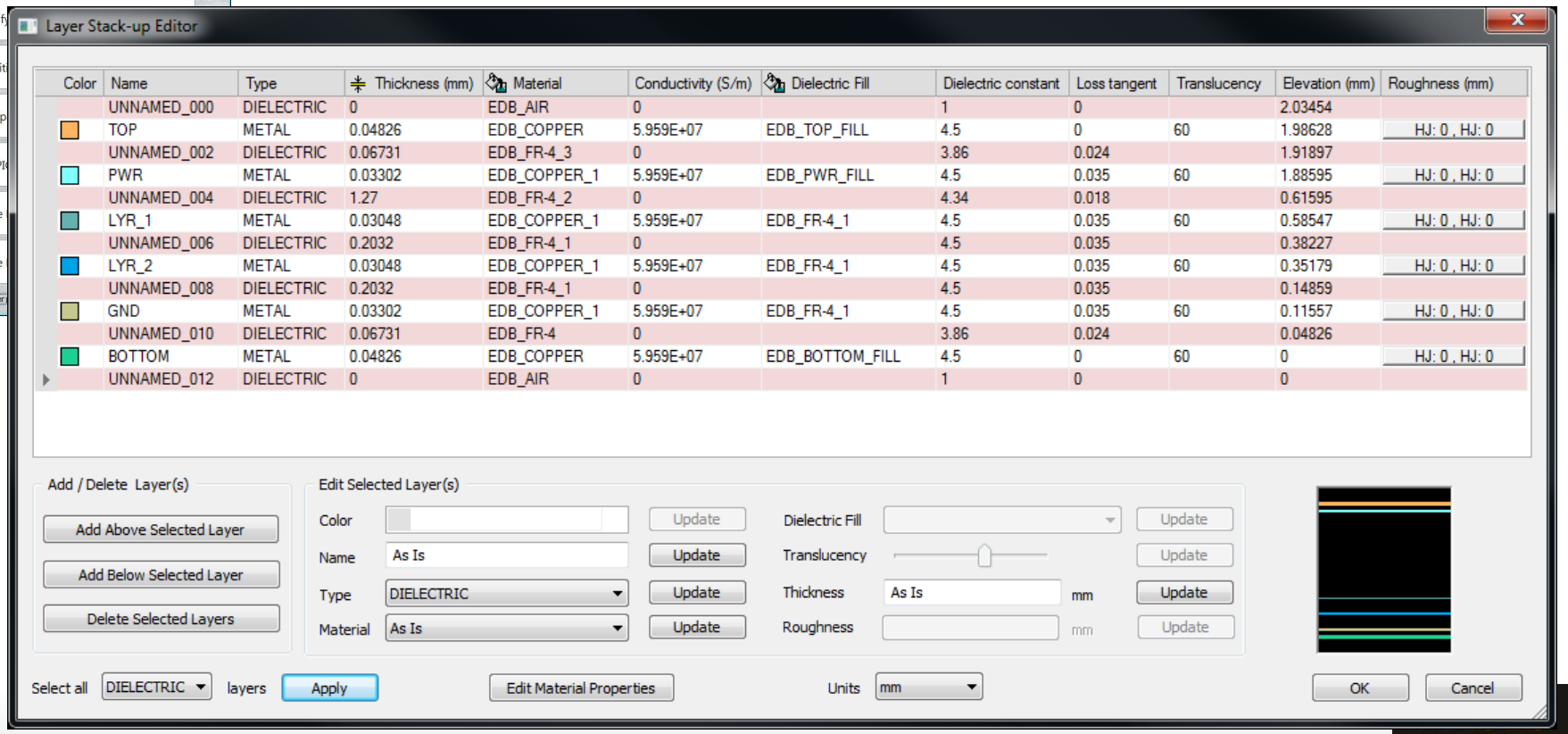
(Optional) Assign Broadband Models

Setup Simulation

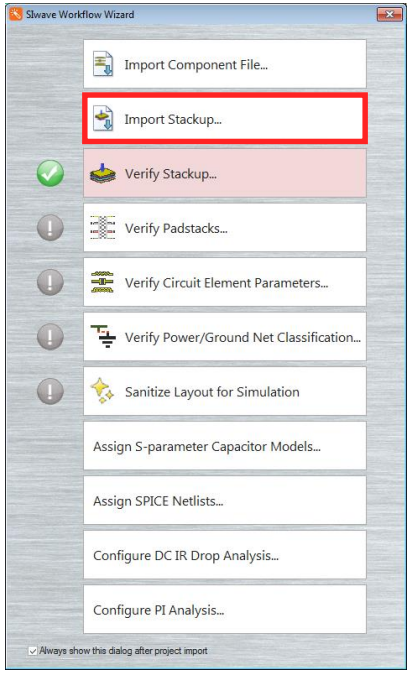
Verify Stackup



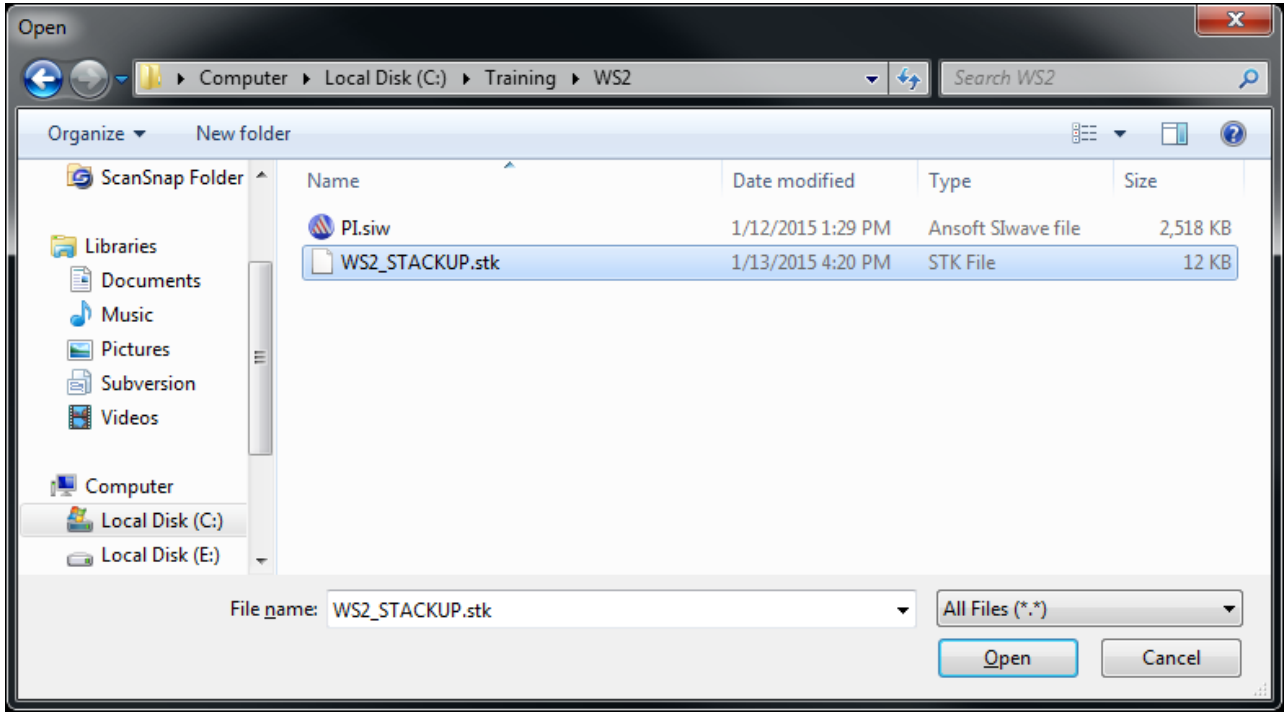
- **Modify Stackup and Material Properties**
  - Click on the **Verify Stackup** button.
    - This is the stackup from the original import. We would like to use a stackup generated from a previous design.
  - Click **Cancel** to close this window.



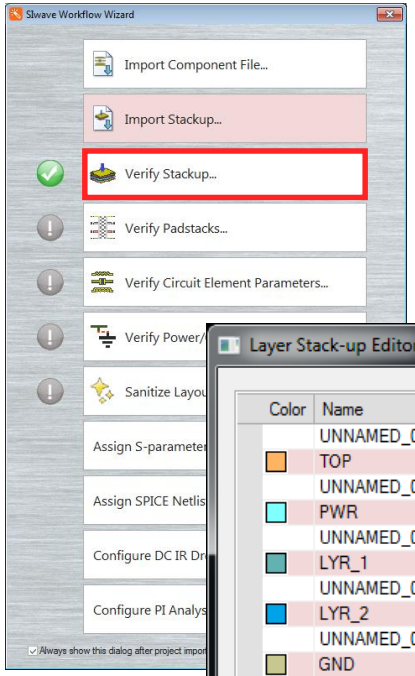
Import Stackup



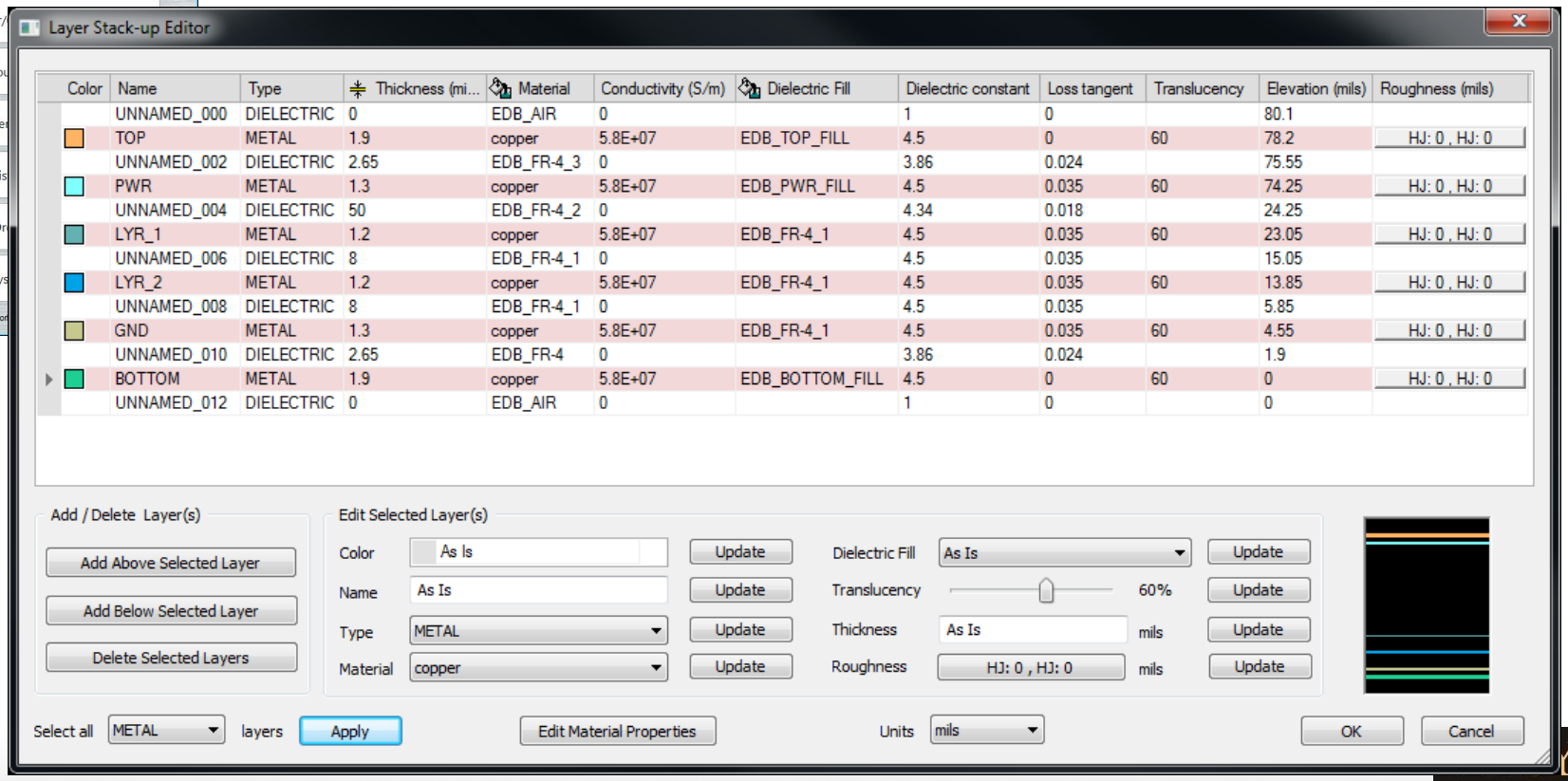
- **Importing a Stackup from a Previous Design**
  - Click the **Import Stackup** button.
  - Locate **WS2_STACKUP.stk** in the same directory as PI.siw.
  - Click **Open** to apply the stackup.



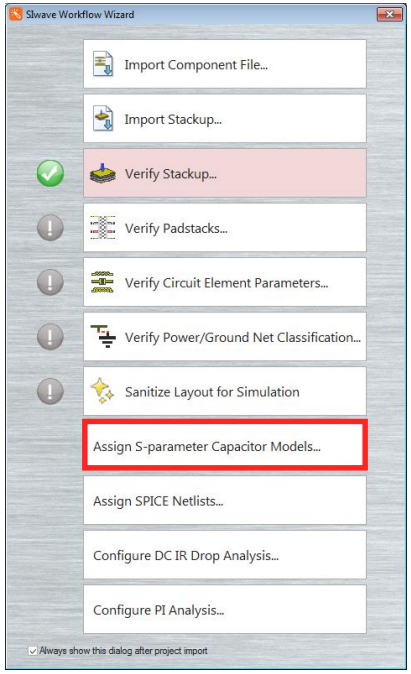
Verify Stackup



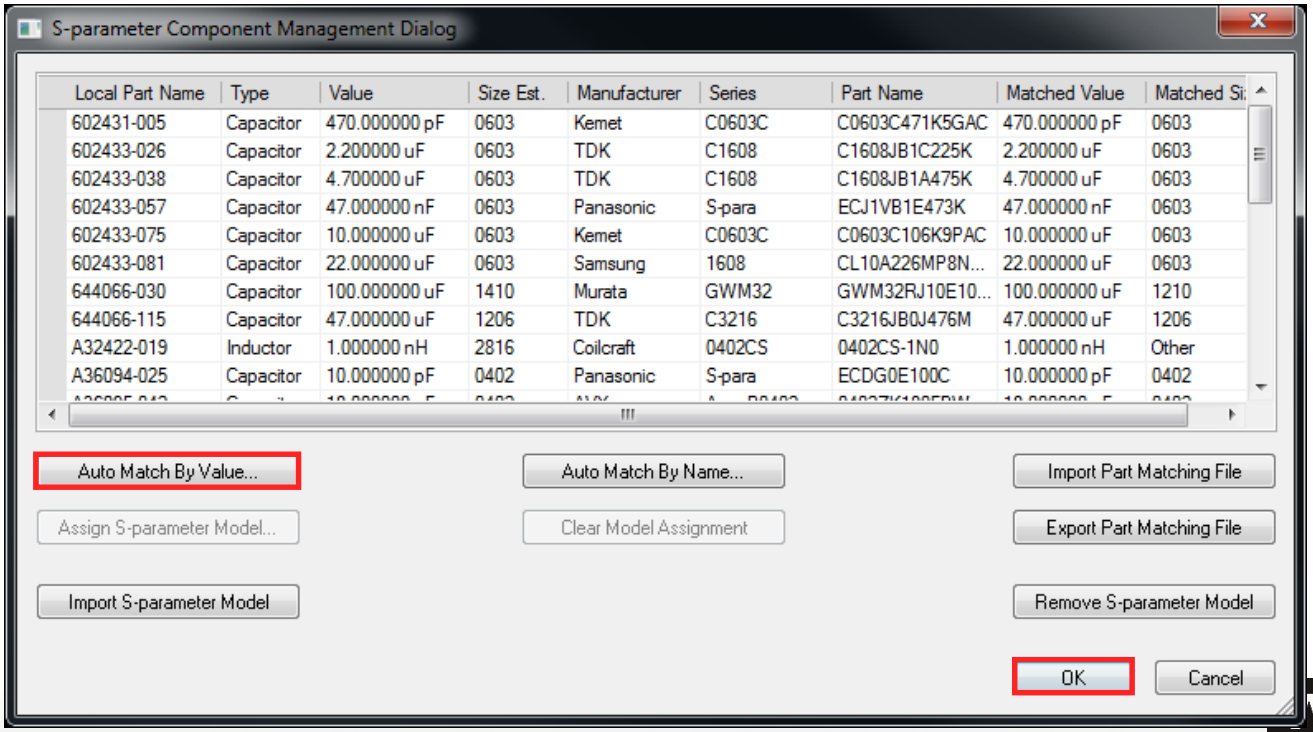
- **Verify Imported Stackup**
  - Click on the **Verify Stackup** button once again.
    - Importing the stackup from the last step has modified the material for metal layers. Importing the stackup can modify any and all parameters in this window.
    - Verify that copper is assigned to all of the metal layers.
  - Click **Cancel** to close this window.



Assign S-parameter Capacitor (and Inductor) Models

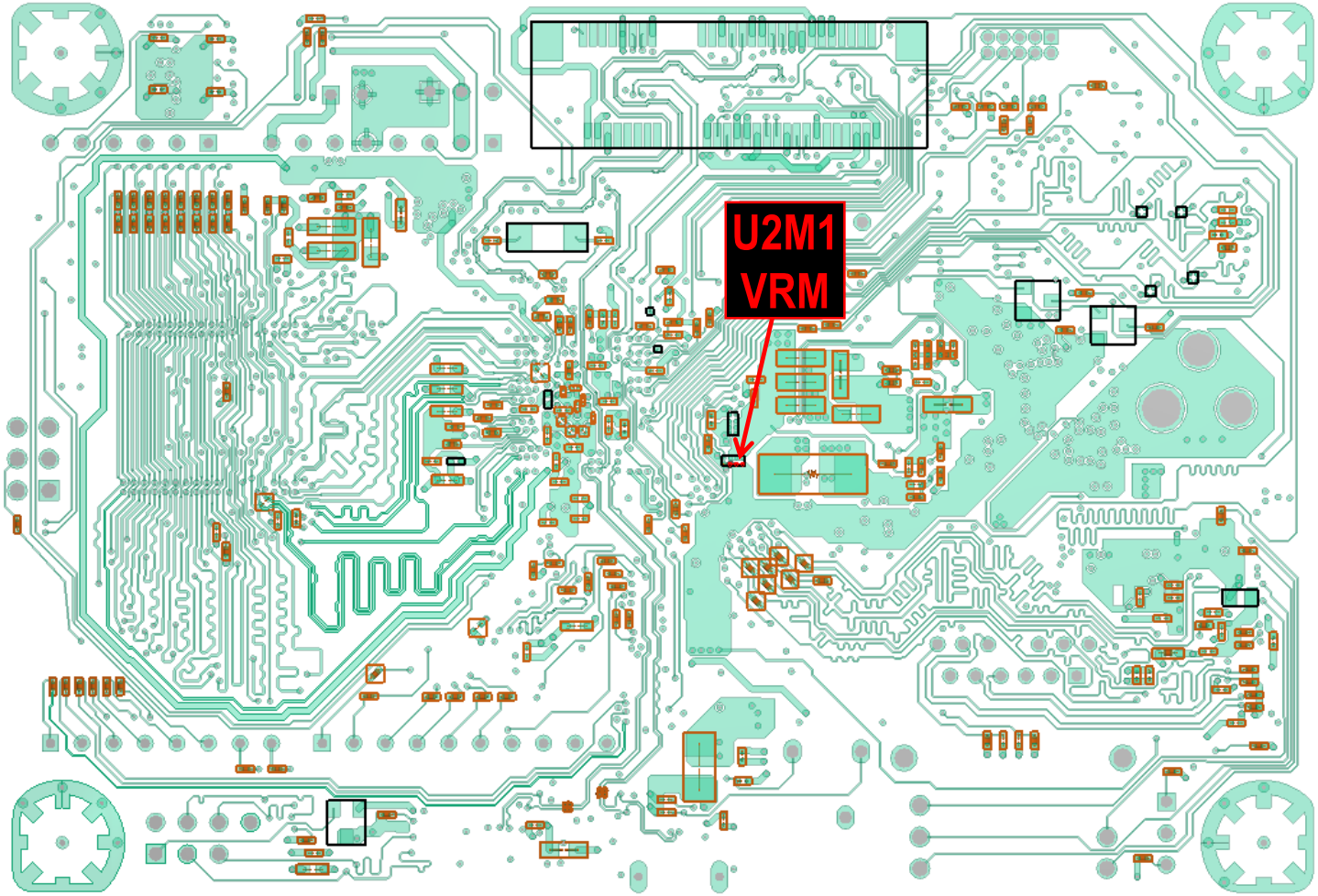


- **Assigning Broadband Models to Capacitor Locations**
  - For this exercise, we will assume that the Padstacks, Circuit Elements, and Power/Ground Net Classification has been handled properly during import.
  - Click on the **Assign S-parameter Capacitor Models** button.
  - Click **Auto Match By Value**.
    - The auto-match function looks at the original capacitance value and the estimated size and attempts to choose a suitable part from SIwave's vendor library. The vendor library includes over 20,000 capacitor and inductor models directly from 12 of the major vendors.
  - Click **OK** to commit changes.



PI Simulation Ports

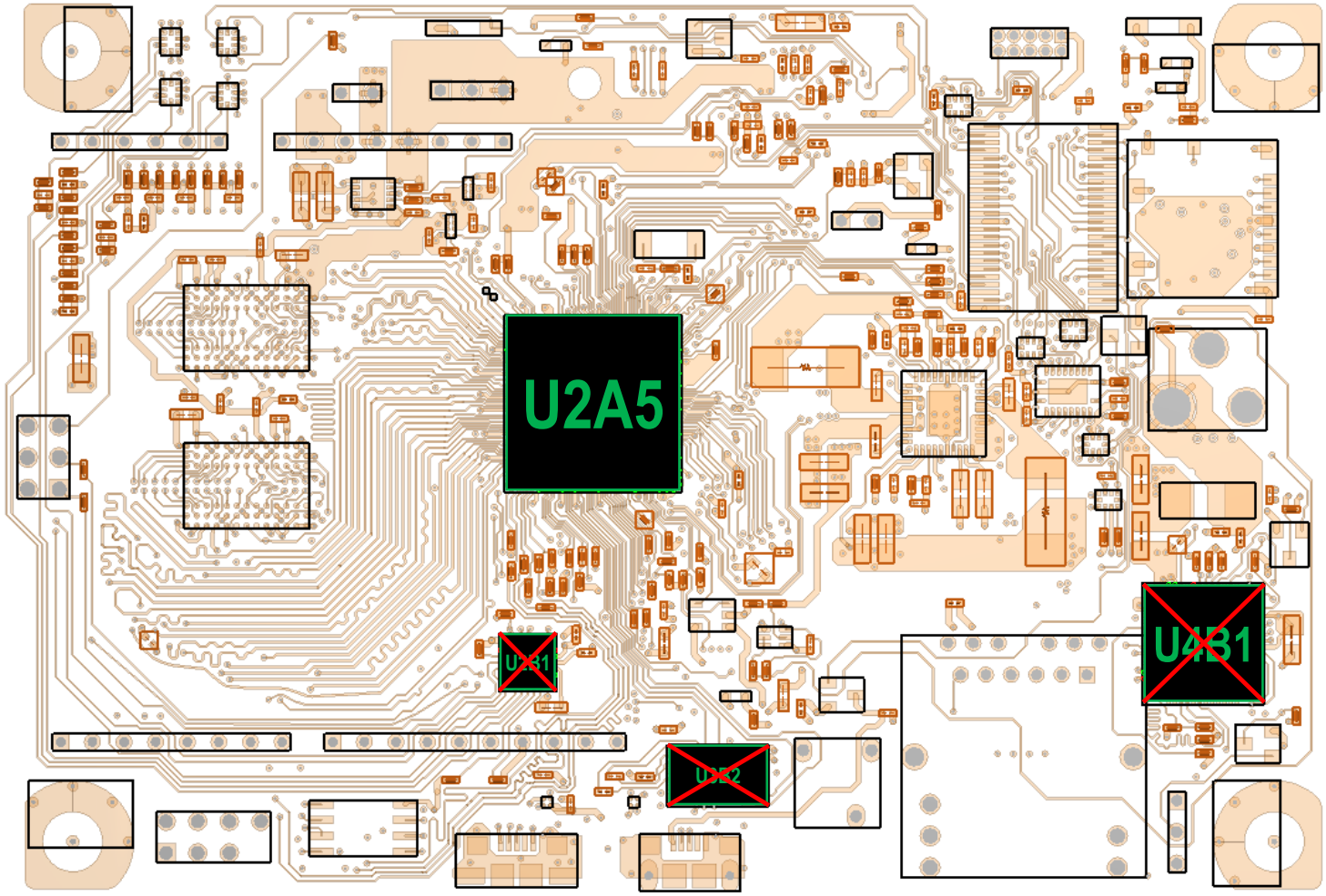
Layer Bottom



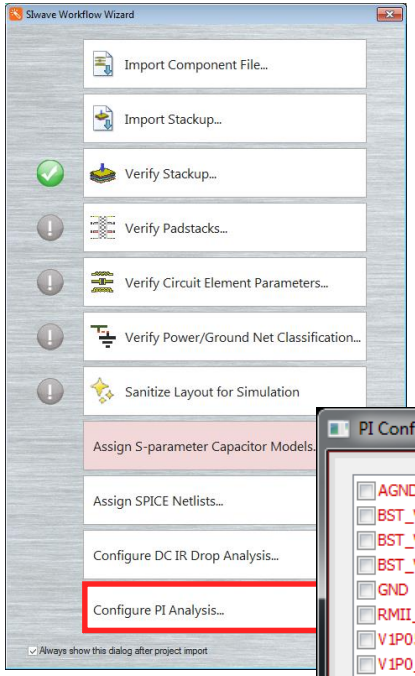
PI Simulation Ports

Single active device to simplify simulation results.

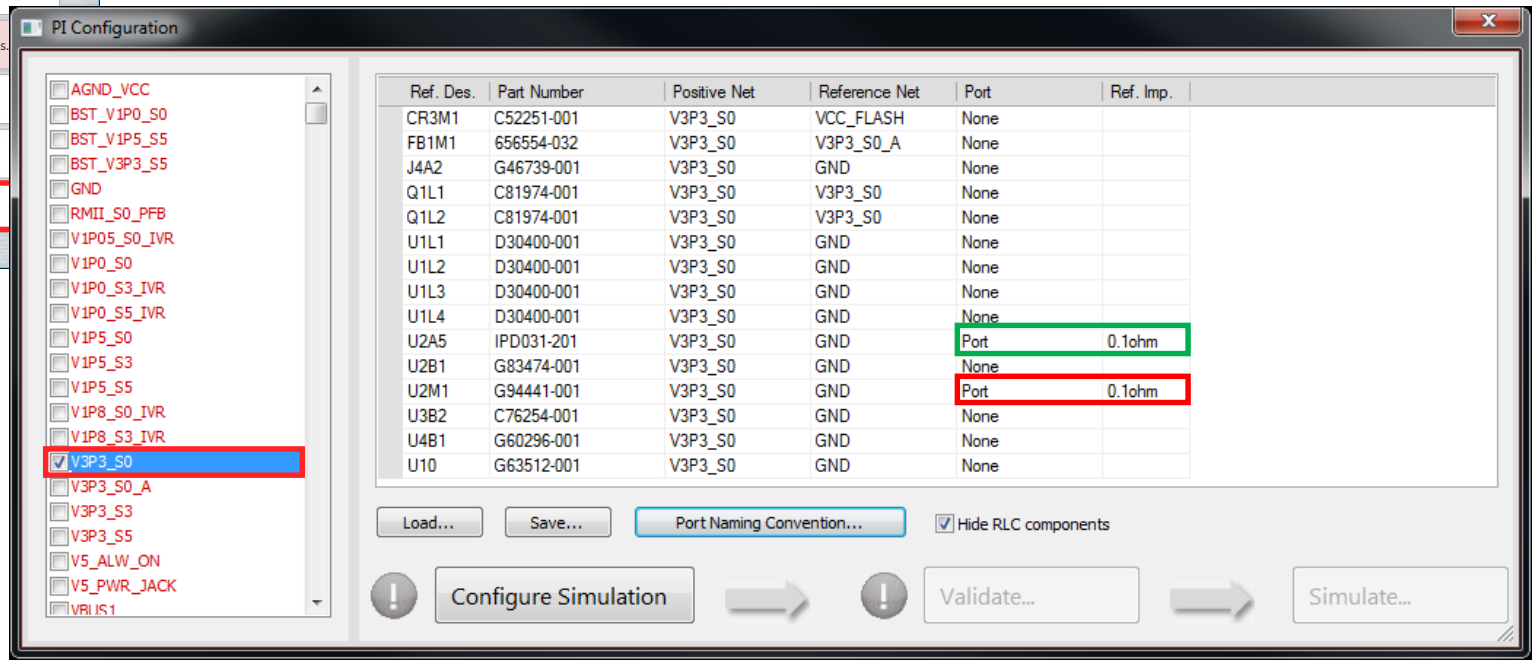
Layer Top



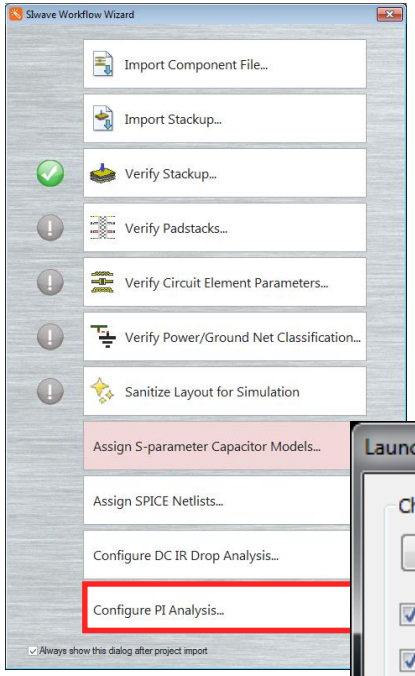
Configure PI Analysis



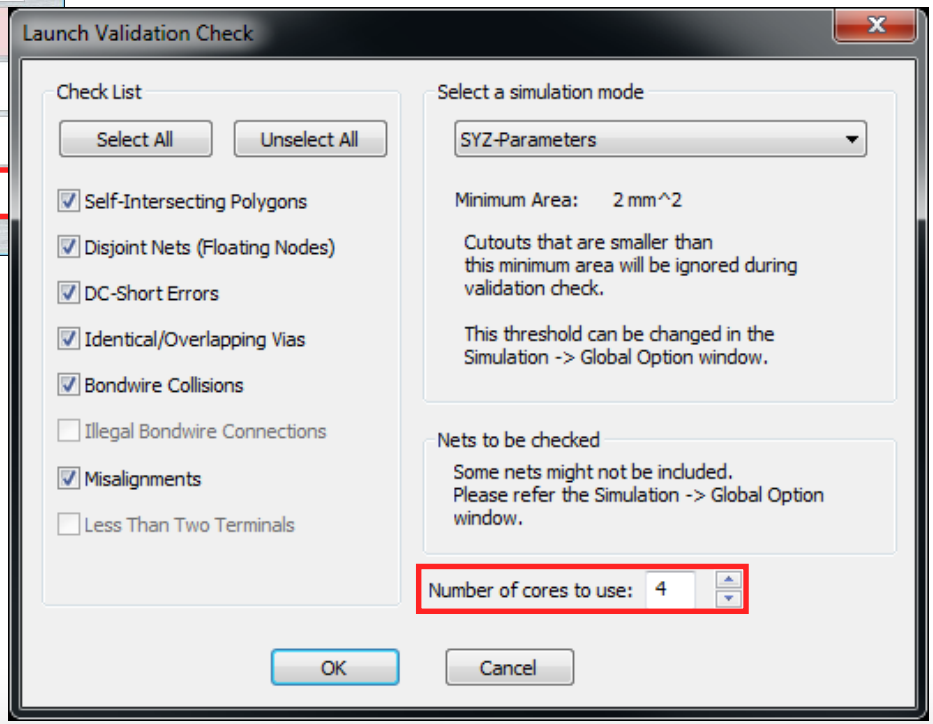
- **Table Driven Schematic**
  - Place a check mark next to net **V3P3_S0**.
    - This displays any active devices connected to this net.
    - Check and uncheck **Hide RLC components** to see passive devices.
  - Assign a **Port** to **U2A5** and **U2M1**.
    - This was chosen only for simplification. It is possible to create ports for any and all components.
    - The default reference impedance is 0.1ohm to resolve very small impedances.
  - Click **Configure Simulation**.

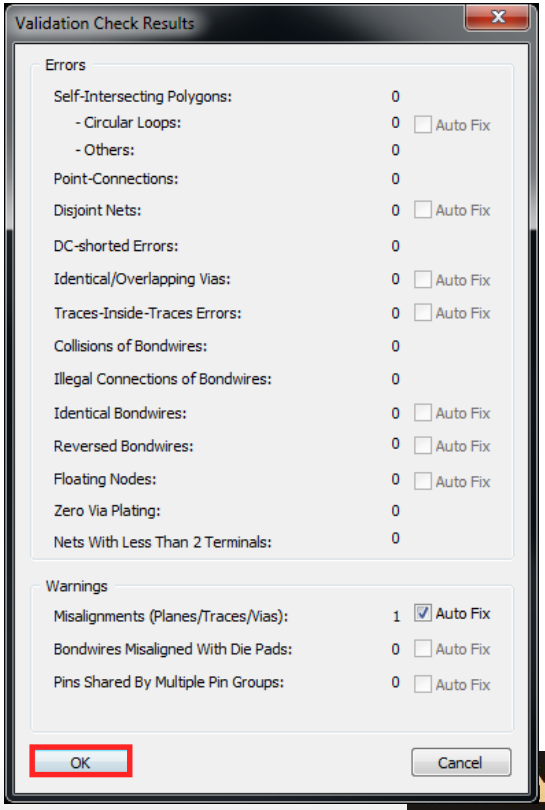


Validation Check

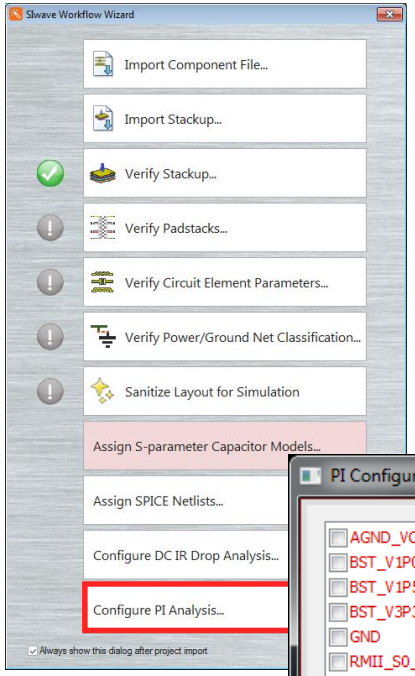


- **Validation Check**
  - The validation check analyzes the entire setup to ensure it is ready for simulation.
  - Increase the **Number of cores to use** for this validation step by pressing the up button.
  - Click **OK** to start the validation check.
- **Validation Check Results**
  - The Validation Check can automatically repair certain geometry problems such as disjoint nets and overlapping vias.
  - Press **OK** to close this window and apply any Auto Fix.

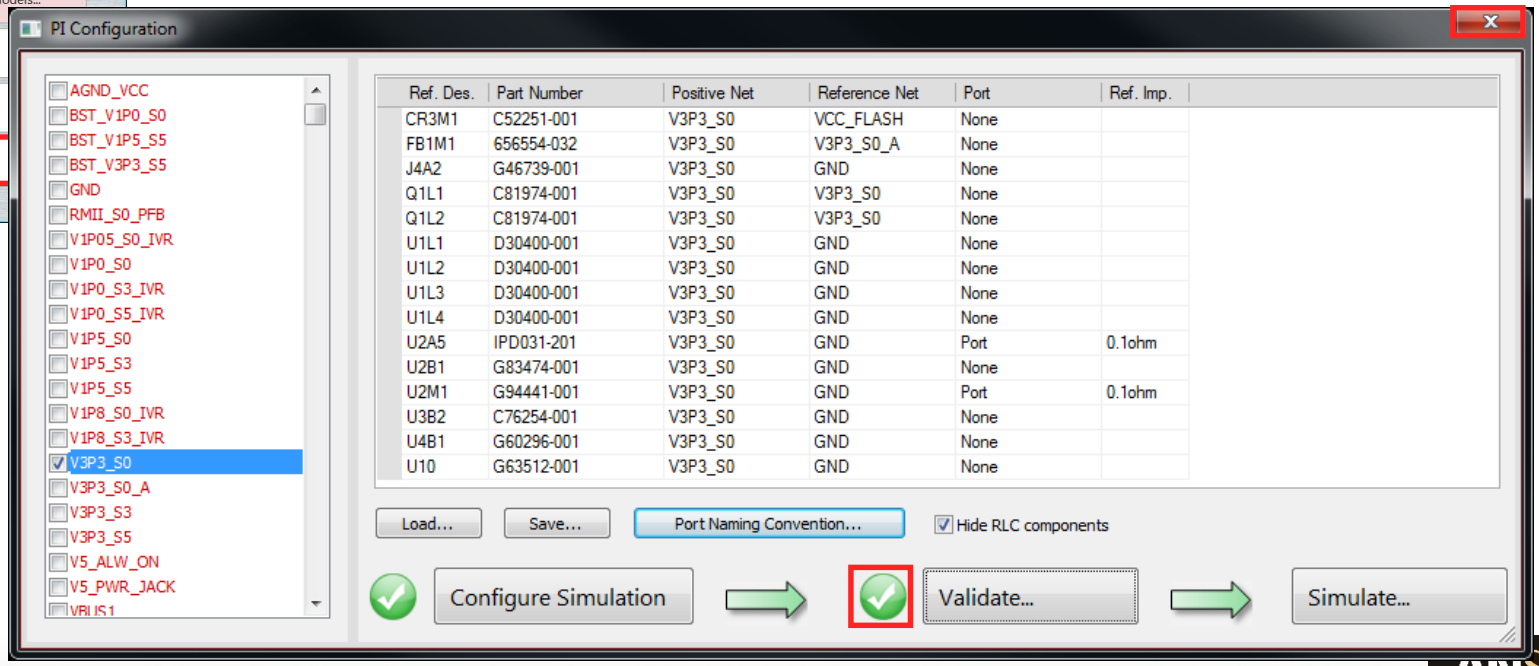




Configure PI Analysis, cont.

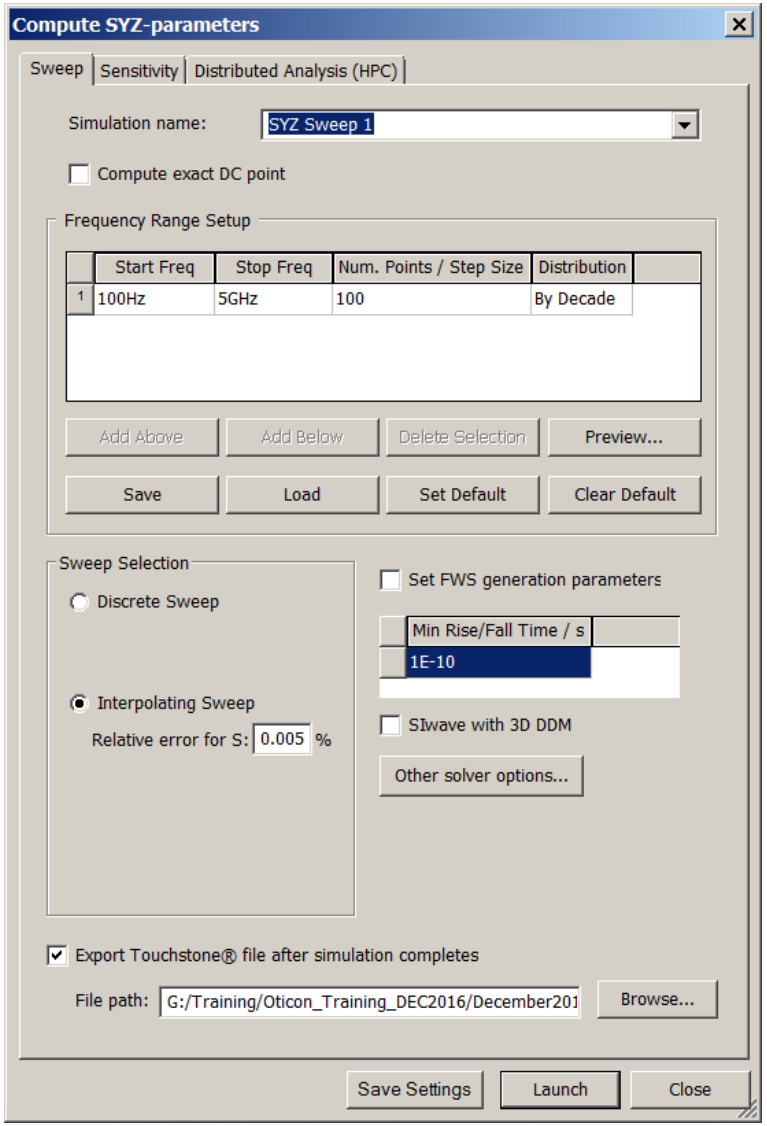


- **Simulation**
  - The check mark next to validation check will continue to display as a warning sign until it detects zero warnings or errors. Warnings will not stop simulation progress, but errors most likely will.
  - (Optional) Run the validation check again to get a green check mark next to the Validate button.
  - At this point, it is possible to run the SYZ sweep to obtain S-parameters. The results obtained here can be exported in touchstone or Full Wave SPICE formats and run in a circuit simulation. This exercise, however, is geared towards optimizing capacitor selection.
  - Click **Simulate** to extract impedance profile
  - Both the PI Configuration and SIwave Workflow Wizard windows will close.



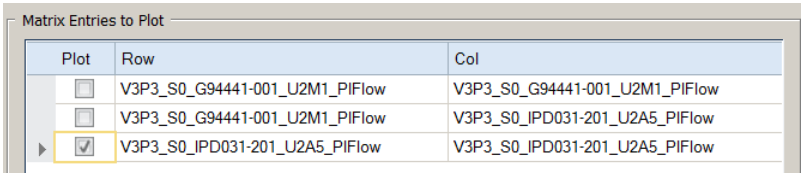
Setup and Launch Simulation

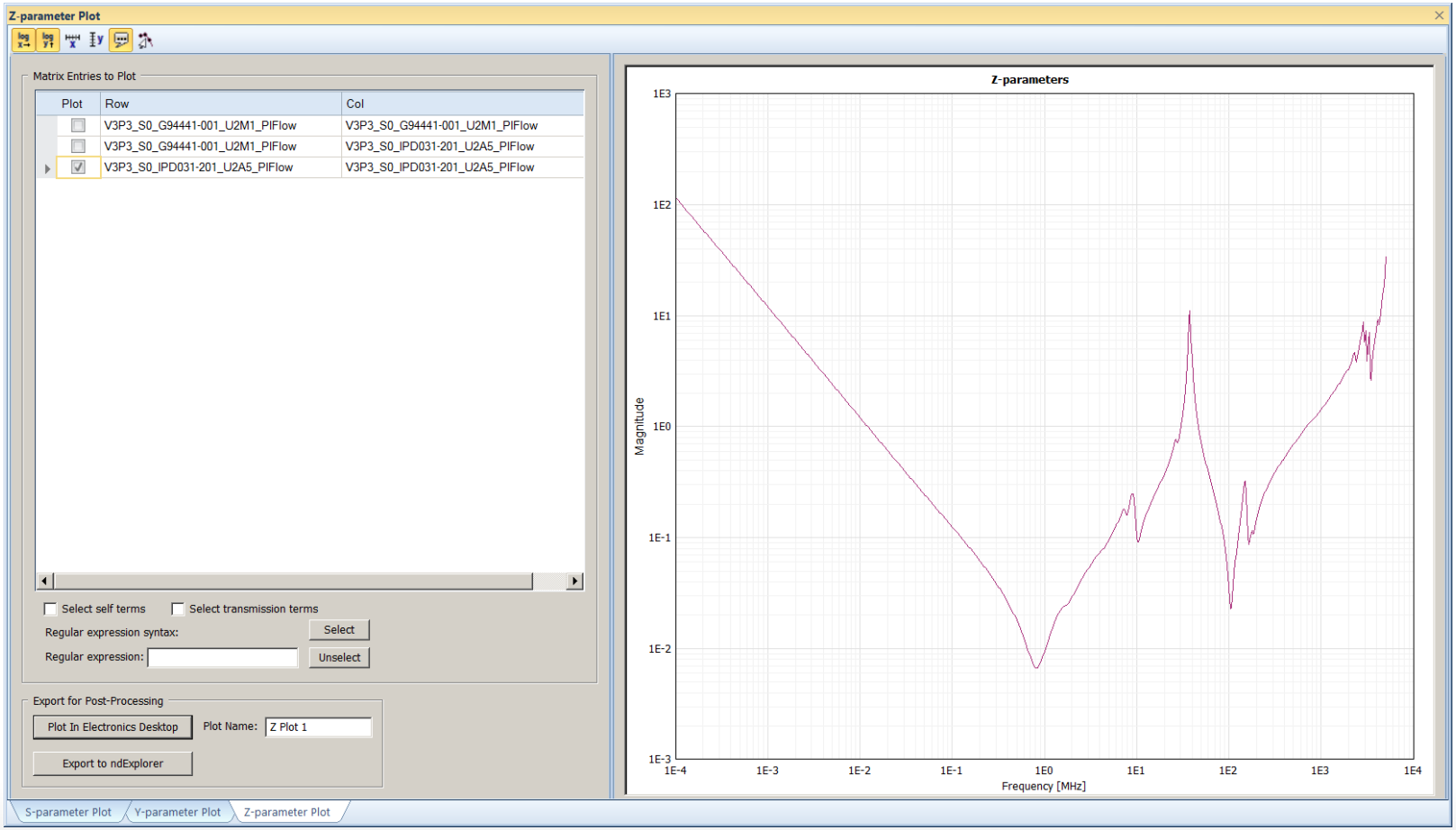
- **Set Frequency Sweep as follow**
  - Start Freq 100HZ
  - Stop Freq 5GHZ
  - Number of point 100
  - Distribution By Decade
  - Interpolating Sweep relative error 0.005%
- **Click Launch**
- **Wait for simulation to complete**



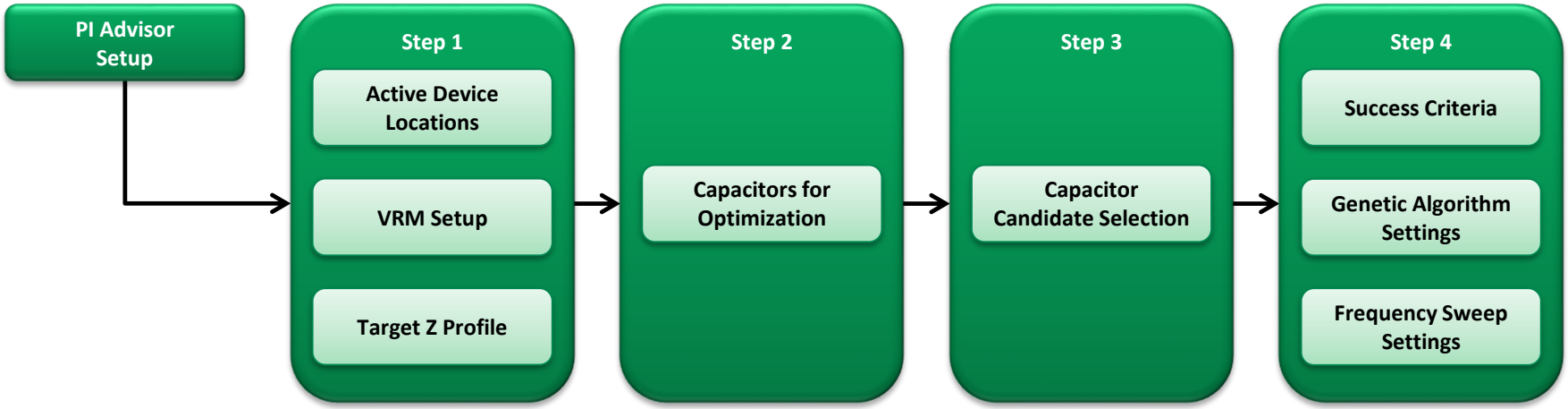
Extract Impedance Profile

- **In results window**
  - Double click on **SYZ Sweep 1**
  - Select tab **Z-parameter Plot**
  - Check only the plot as shown beside to extract impedance profile at U2A5





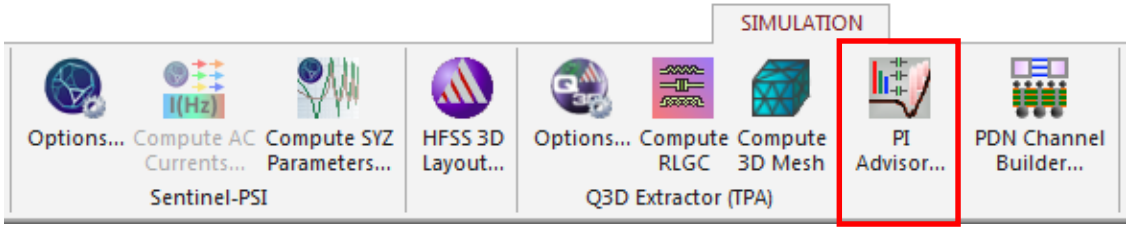
PI Advisor Workflow Diagram



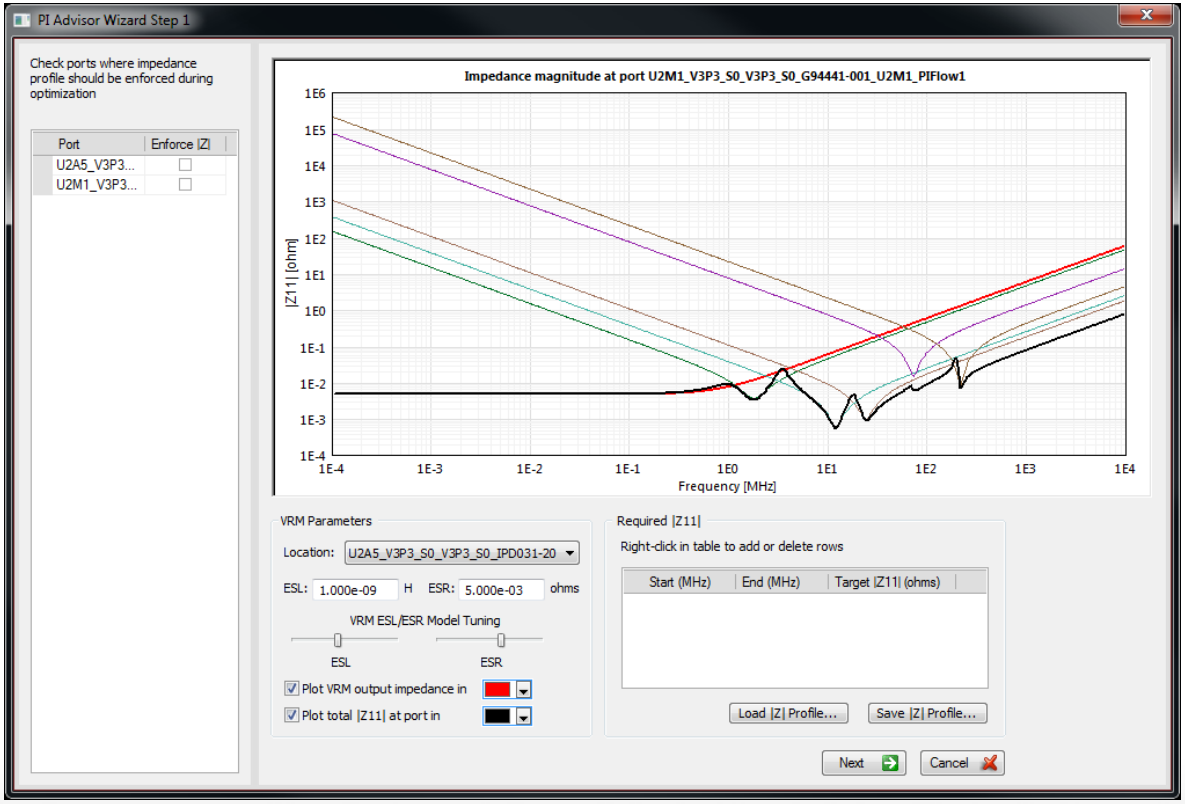
Launching PI Advisor

Starting PI Advisor

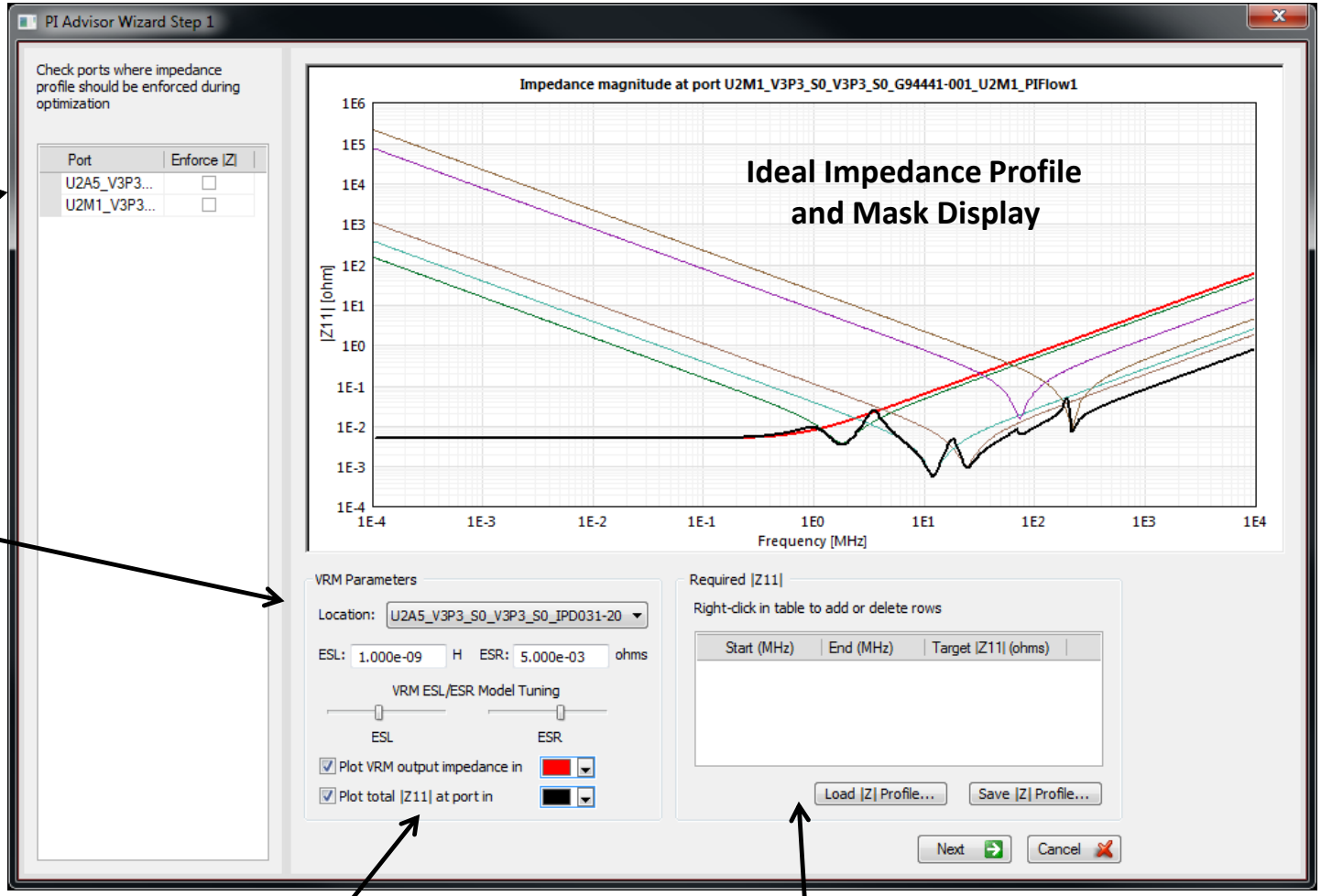
- Click on the **Simulation** menu tab.
- Click the PI Advisor button to start PI Advisor.



- This will put you into the first step of PI Advisor.



PI Advisor: Step 1



Ports / Active Devices

VRM Settings

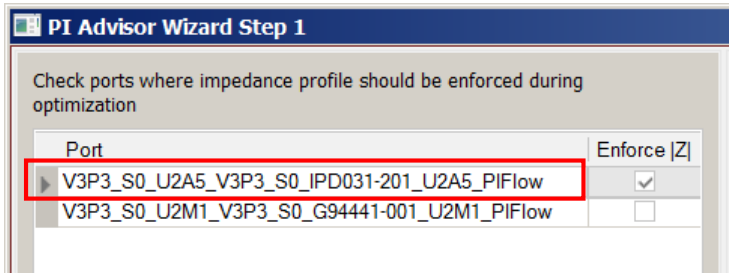
Plot Visibility and Coloring

Impedance Mask Setup

PI Advisor: Step 1, cont.

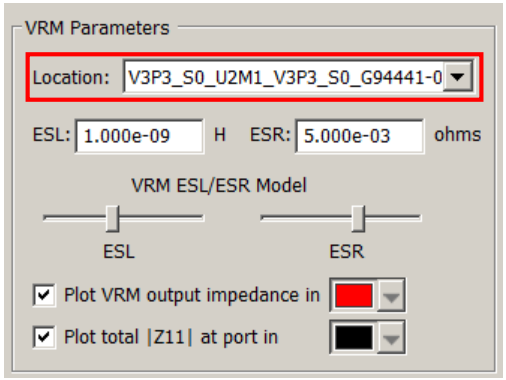
Choose Ports / Active Devices to Optimize

- Click the **Enforce |Z|** check box next to **V3P3_S0_IPD031-201_U2A5_PIFlow1**.
  - This is indicated by the ▶ graphic next to the port name
- Do not check the box for U2M1.



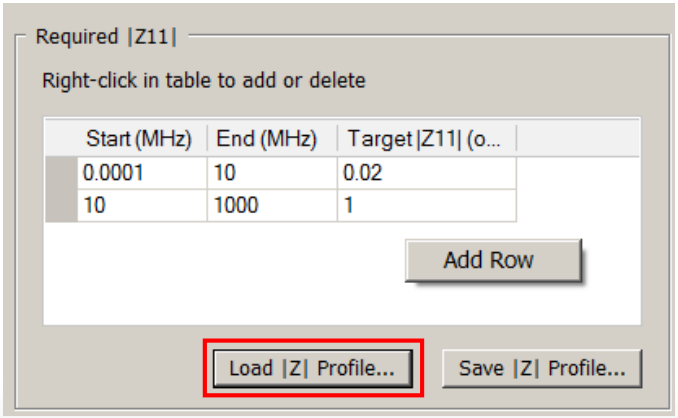
VRM Setup

- Change the Location of the VRM to **U2M1**.
  - ESL and ESR can be modified to match the VRM parameters.
  - The graph will update indicating the shift in impedance.

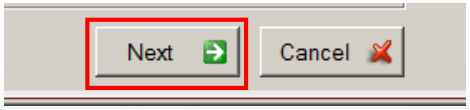


Impedance Mask Setup

- Click the Load |Z| Profile button.
- Choose the **Z_target.zprof** file and click **OK**.
- Alternatively, it is possible to right-click and add rows.



- Click the **Next** button to proceed to Step 2.

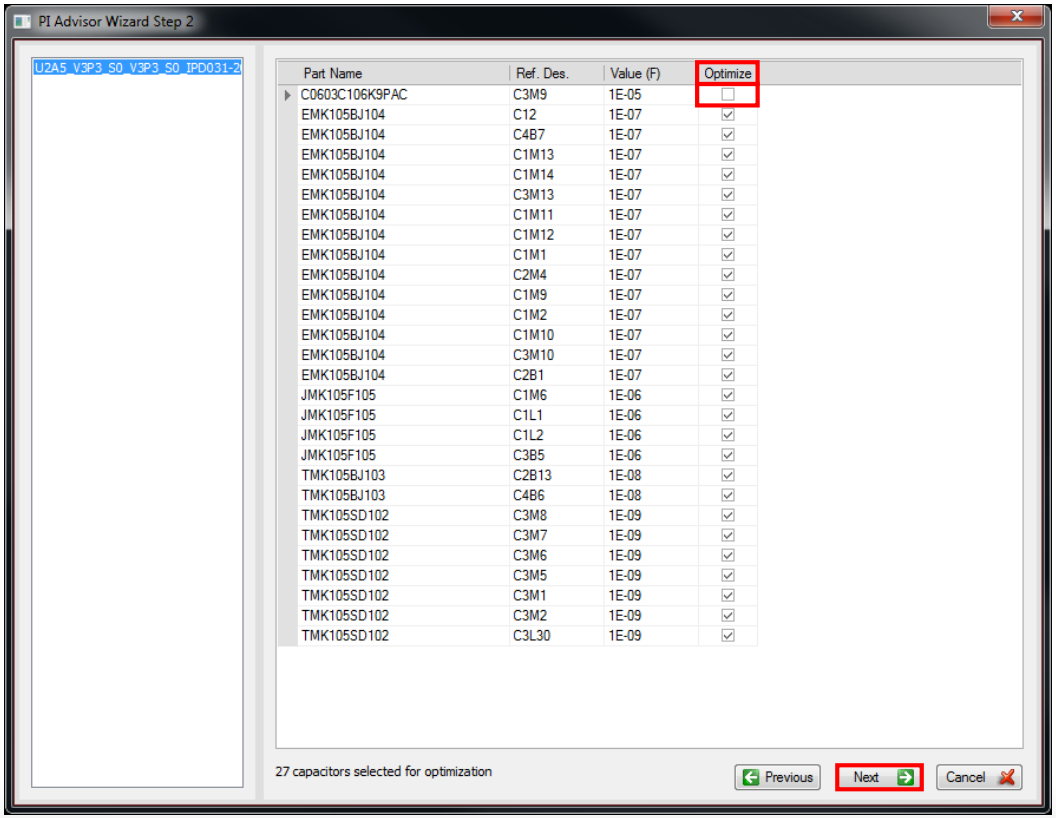


PI Advisor: Step 2

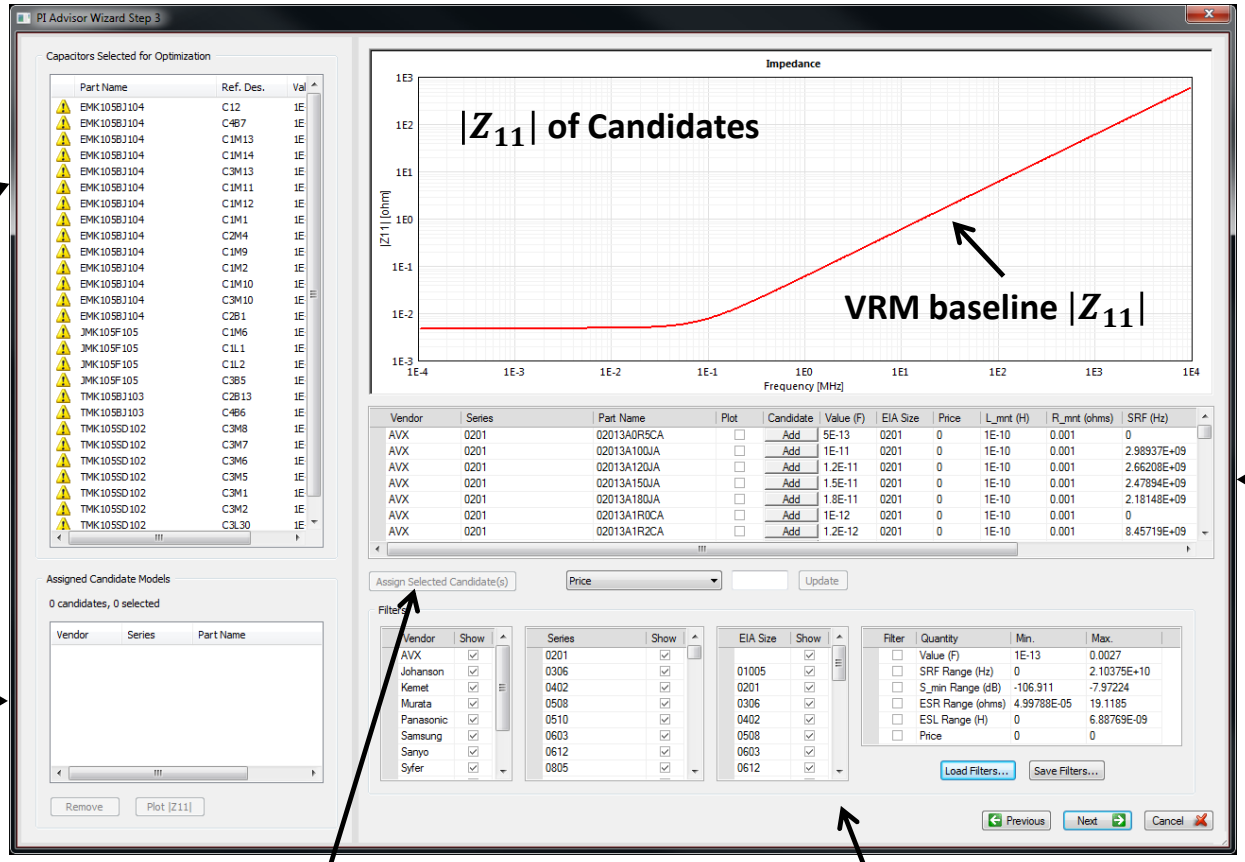
Choosing Capacitors to Optimize

- Click on the **Optimize** column header to place a check mark next to all capacitor instances.
- **Uncheck** the Optimize check box next to Reference Designator **C3M9**.
  - This is a 0603 part that we do not want to optimize. The remainder are 0402 parts.

- Click the **Next** button to proceed to Step 3.



PI Advisor: Step 3



Capacitor Instances from Step 2

Candidates for Selected Instances

Filtered List

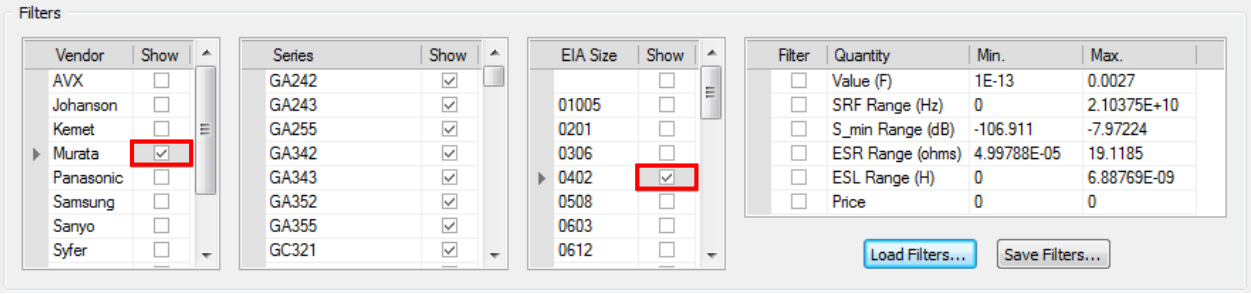
Assign Selected Candidates to Selected Capacitor Instances

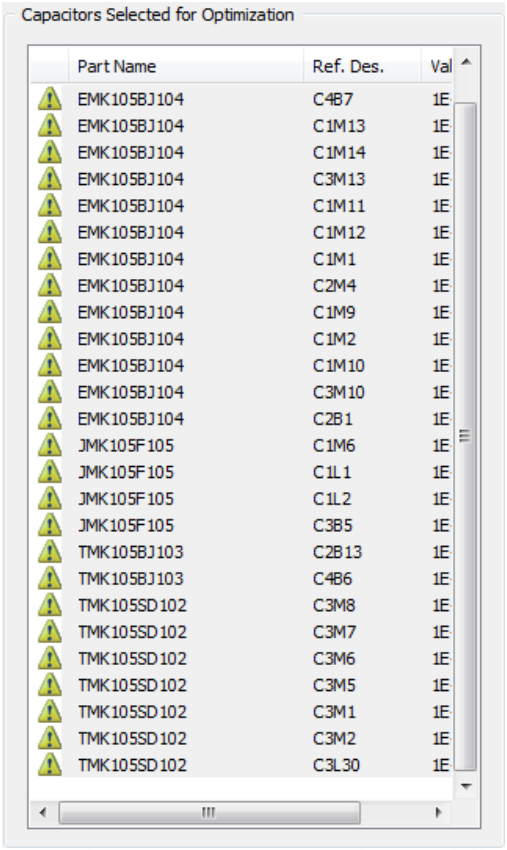
Filter Library Components

PI Advisor: Step 3, cont.

Potential Candidate Filter

- Select only **Murata** as a **Vendor**
- Select only **0402** for the **EIA Size**



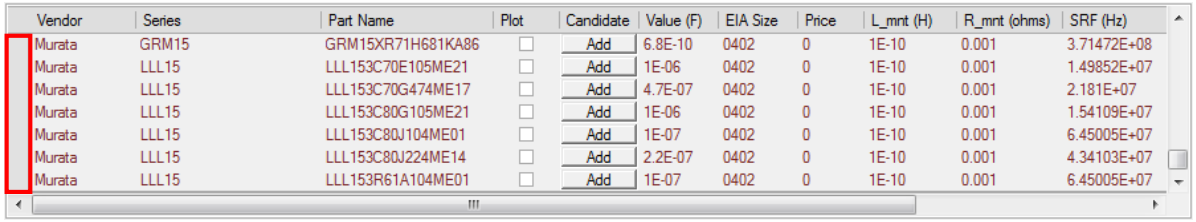


Select Capacitor Instances

- Select all Capacitor Instances by using **Shift+Click** or **Ctrl+Click**. The warning icon indicates that there are no candidates assigned to the capacitor instances.

Select Candidates

- Select all filtered candidate instances by using **Shift+Click** or **Ctrl+Click** in the row indicator.



Assign Selected Candidate(s)

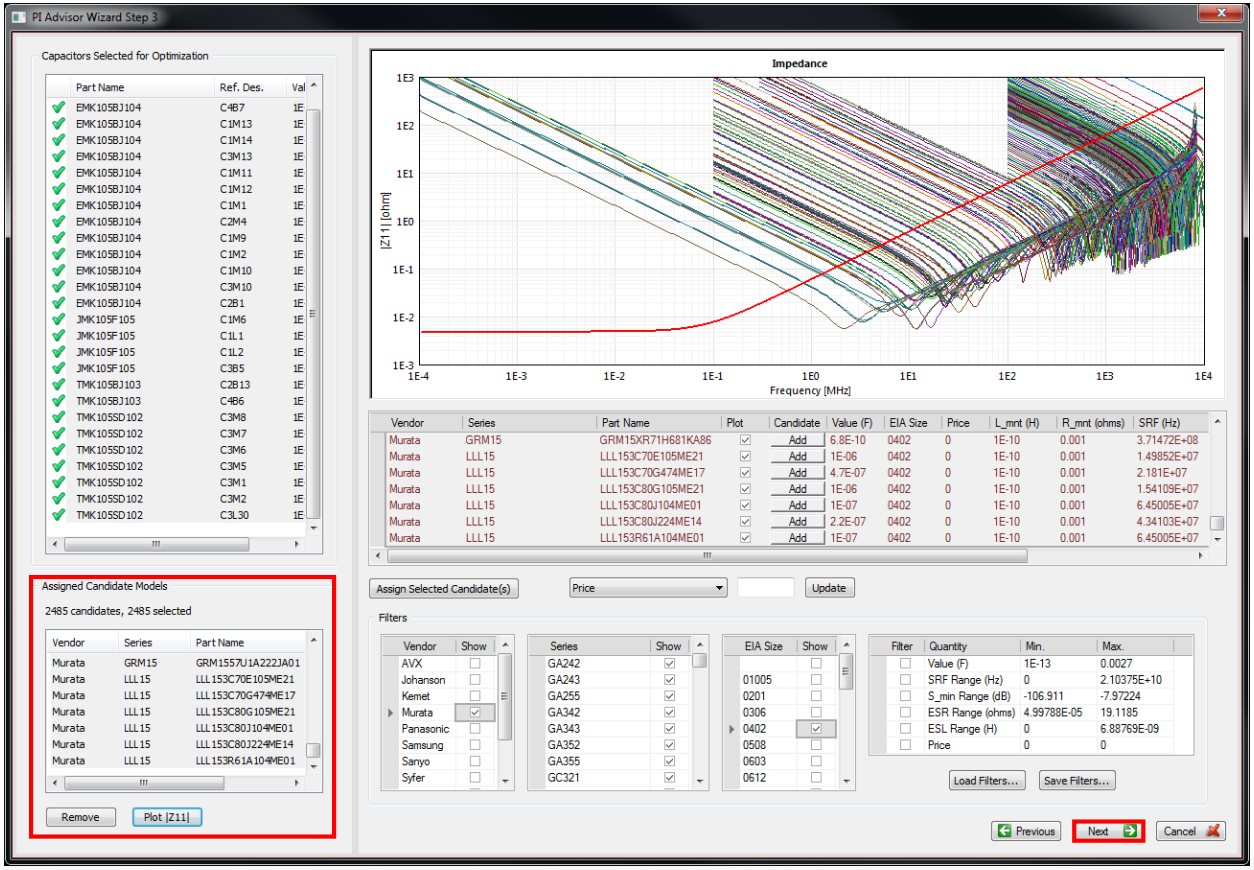
- Click the **Assign Selected Candidates** button with both Capacitor Instances and Selected Candidates to populated the Assigned Candidate Models.

PI Advisor: Step 3, cont.

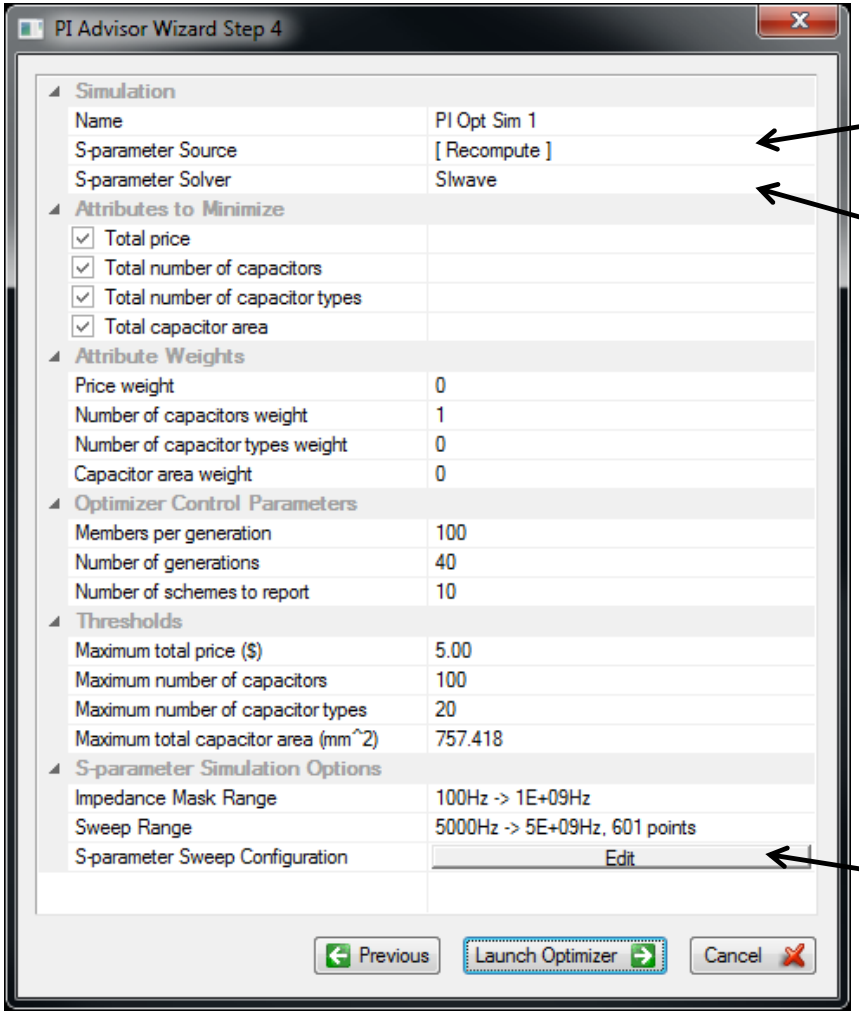
Plot Assigned Candidate Models

- Select all of the Assigned Candidate Models by using **Shift+Click** or **Ctrl+Click**.
- Click the **Plot |Z11|** button to display the candidate model profiles. Your display should now appear similar to the graphic below.

- Click **Next** to proceed to Step 4.



PI Advisor: Step 4



Recompute OR Reuse S-parameters from Previous Simulation

Solver Selection: SIwave or Sentinel-PSI

Genetic Algorithm Inputs

Solver Settings

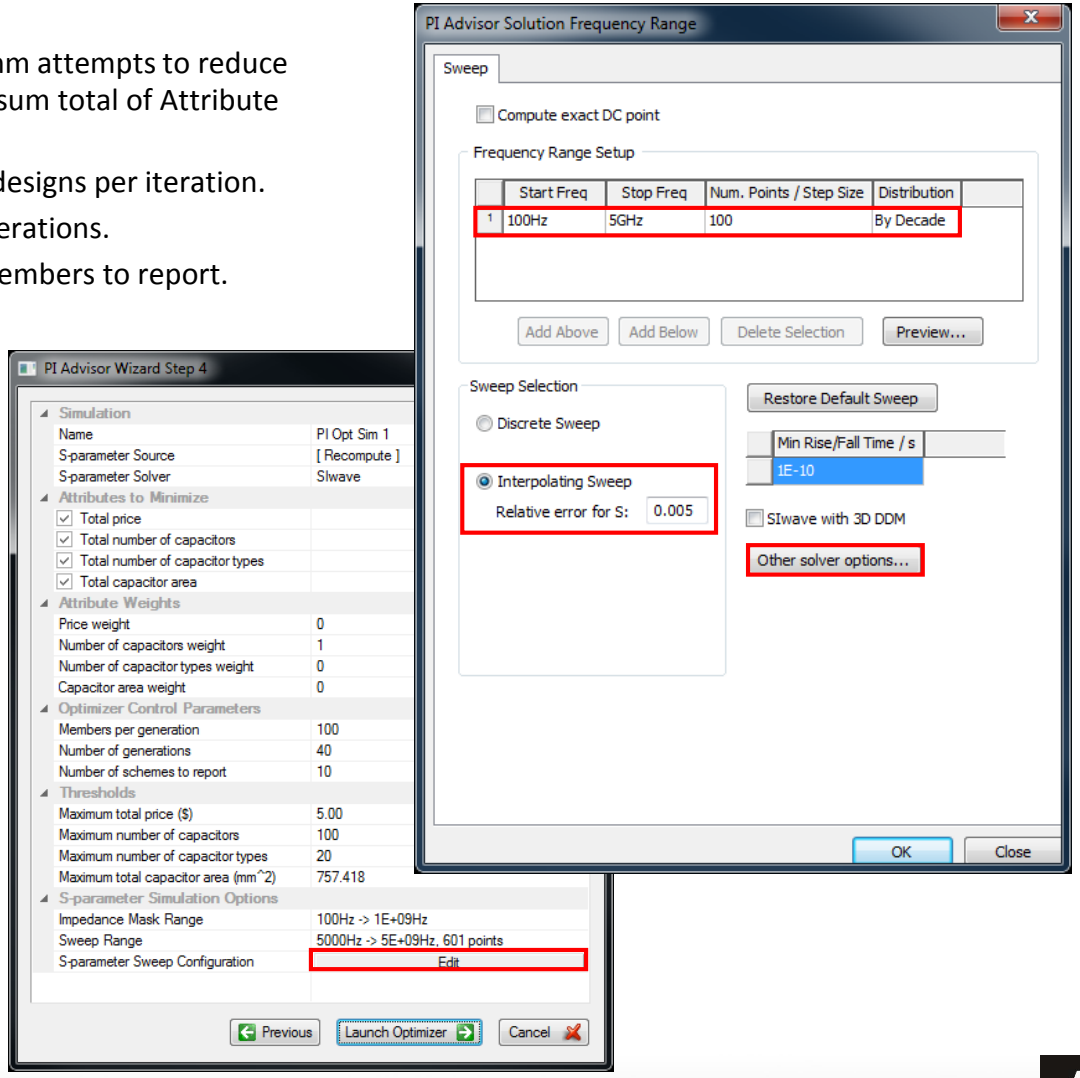
PI Advisor: Step 4, cont.

Genetic Algorithm Settings

- The default settings for the genetic algorithm attempts to reduce the number of capacitors as the goal. The sum total of Attribute Weights should add up to 1.
- Members per generation: Number of trial designs per iteration.
- Number of generations: Total number of iterations.
- Number of schemes to report: Subset of members to report.

SYZ Sweep Settings

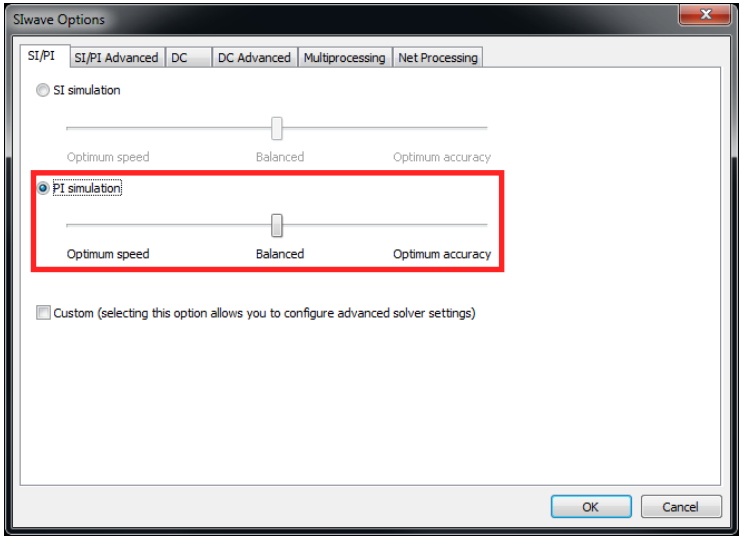
- Click the **Edit** button.
- Set the following Sweep Definition:
  - Start Frequency: **100Hz**
  - Stop Frequency: **5GHz**
  - Num. Points / Step Size: **100**
  - Distribution: **By Decade**
- Set the Sweep Selection to:
  - **Interpolating Sweep**
  - Relative error for S: **0.005**
- Click **Other solver options…**



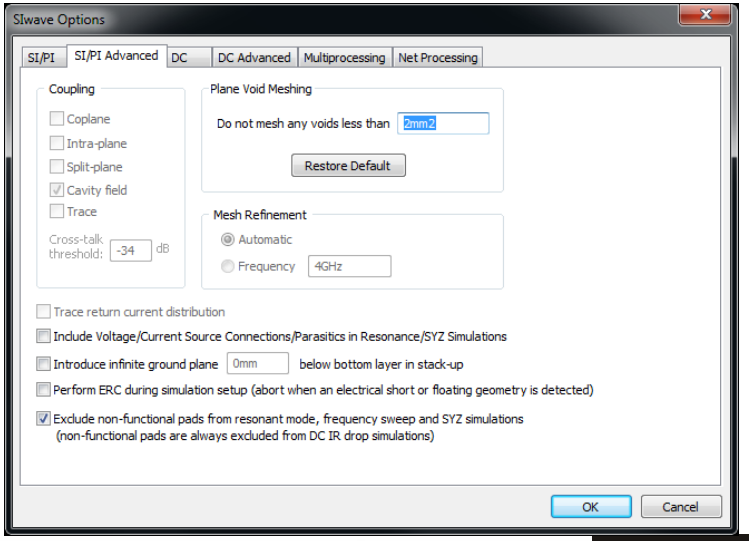
PI Advisor: Step 4, cont.

SIwave Options

- SI/PI tab
  - Choose **Balanced**
  - The slider bar allows you to choose between three predefined settings. To see what settings are changed, move the slider bar to different positions and click on the SI/PI Advanced tab.



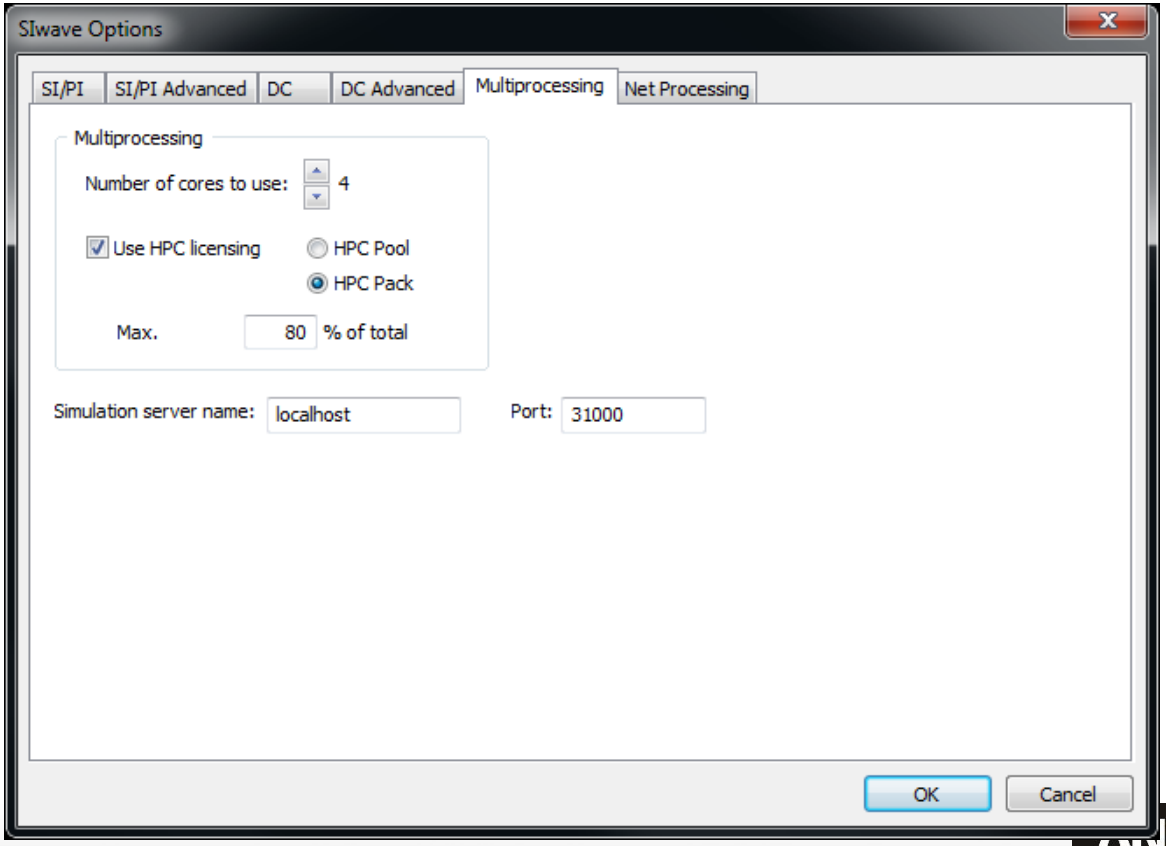
- SI/PI Advanced tab
  - Note that we are only solving for cavity fields for this balanced PI simulation and Automatic Mesh Refinement is turned on.



PI Advisor: Step 4, cont.

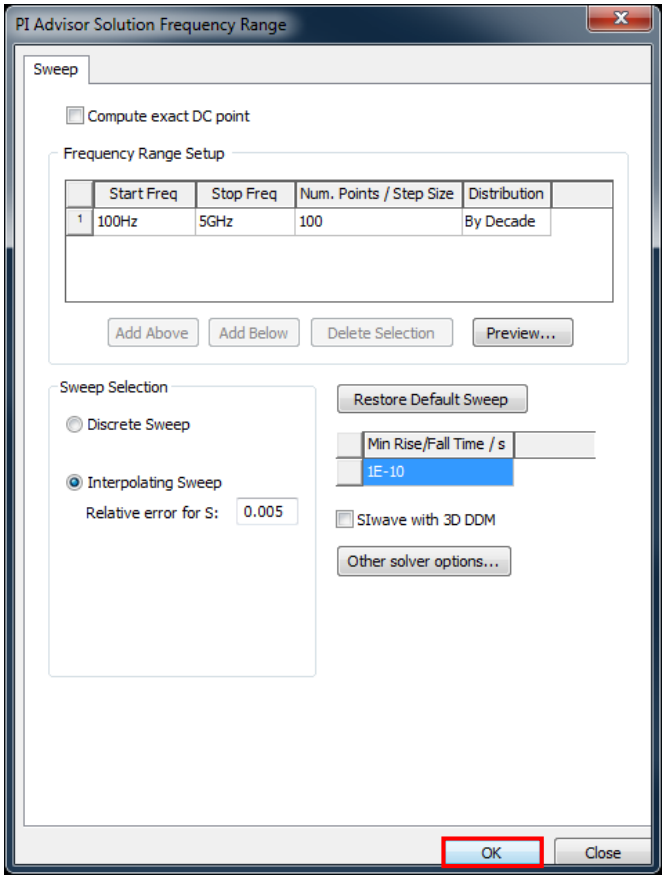
Multiprocessing (High Performance Computing, HPC)

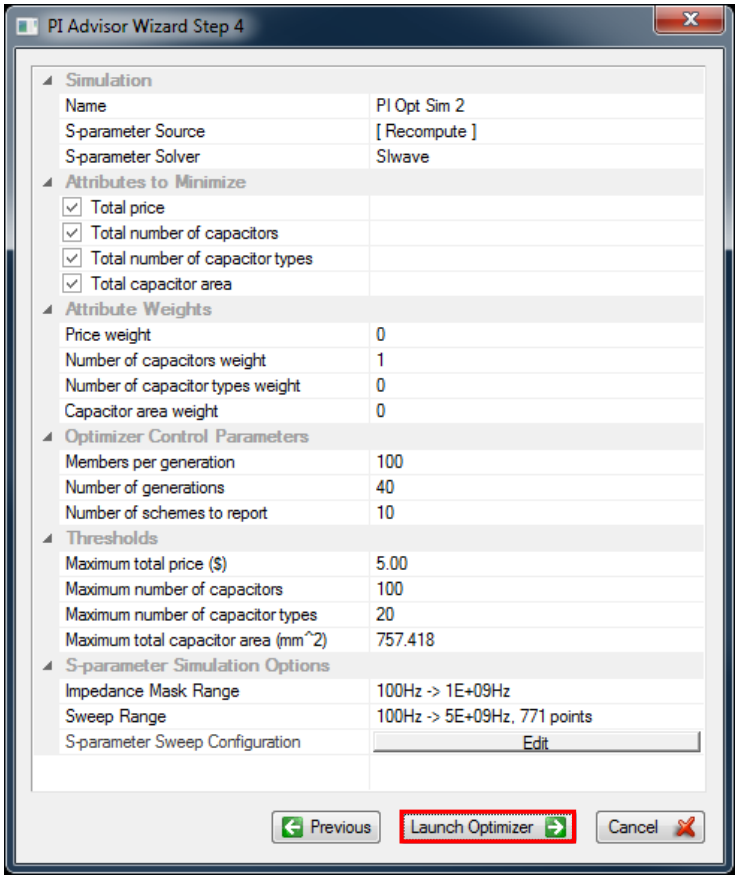
- For a PI simulation, HPC can distribute the solver across multiple cores.
- Click on the **Multiprocessing** tab.
- Ensure the following options are set:
  - Number of cores to use: **Max** (increase until it stops incrementing)
  - Use HPC Licensing: **Enable**
  - HPC Pack: **Selected**
  - Max: 80% of total RAM
- Click **OK** to close this window.



PI Advisor: Step 4, cont.

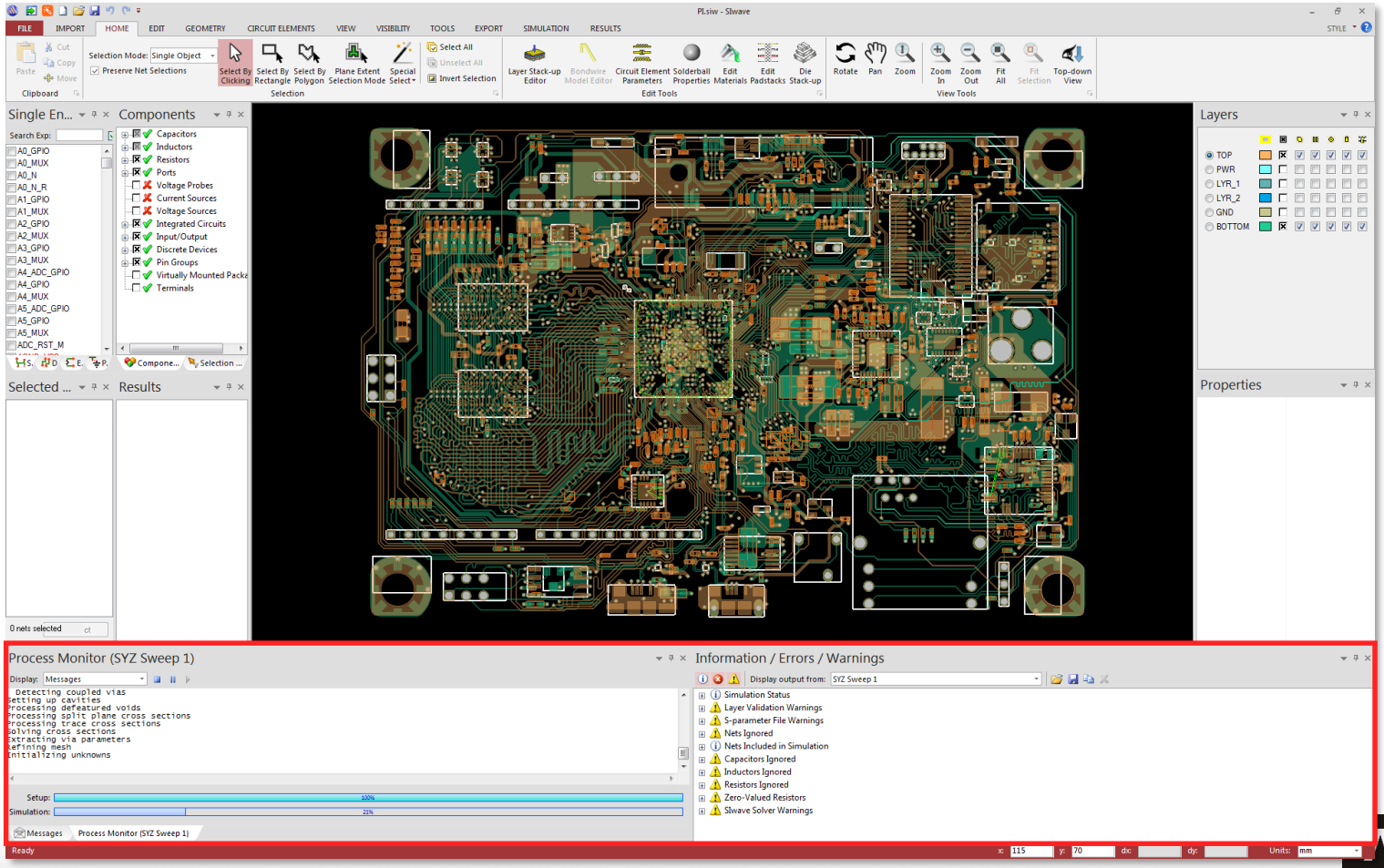
- **Genetic Algorithm and SYZ Sweep Settings, cont.**
  - Click **OK** to apply the S-parameter sweep settings.
  - Click **Launch Optimizer** to begin the PI Advisor simulation.





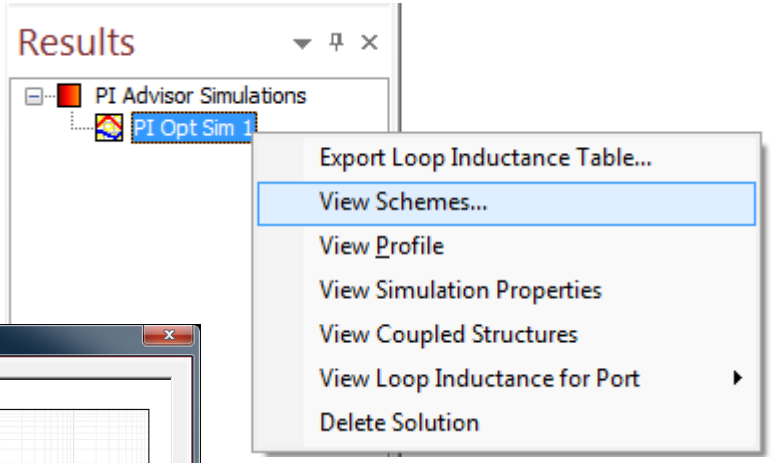
SYZ Sweep and PI Advisor Simulation Status

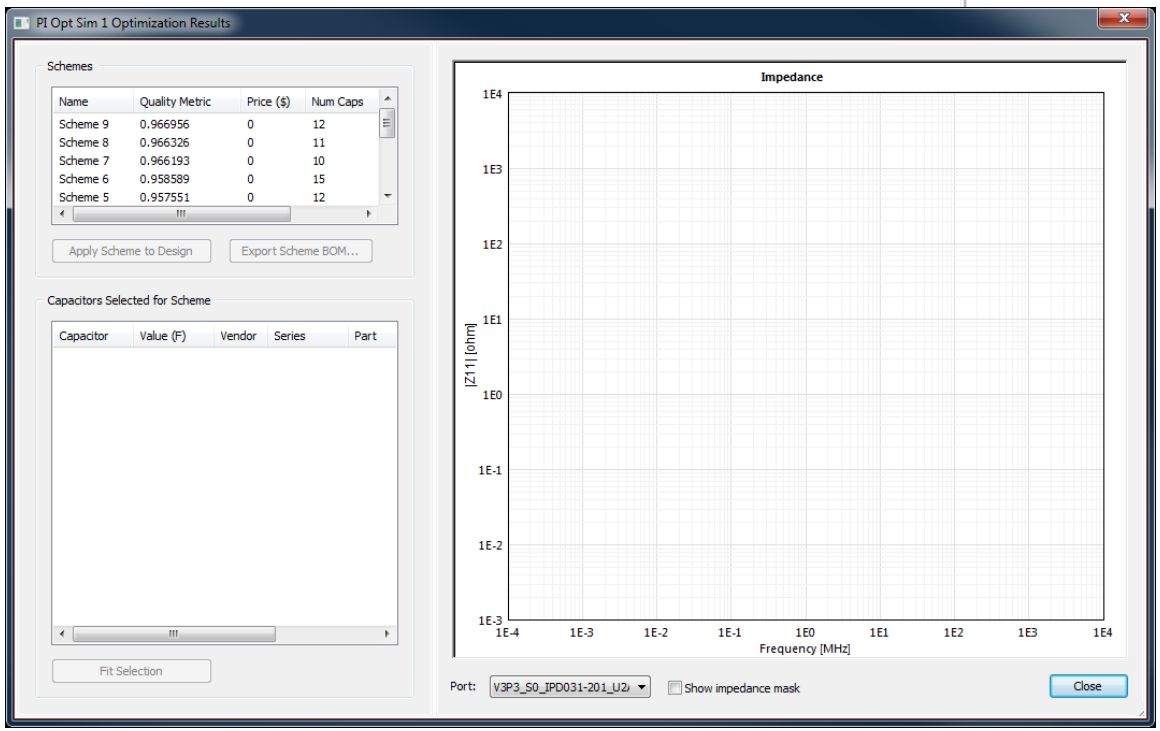
- **Process Monitor and Information / Errors / Warnings**
  - The process monitor shows the simulation status and steps taken by the solver.
  - Information / Errors / Warnings alerts you to any potential issues that may arise during the solution process.



PI Advisor Results

- **View PI Advisor Decoupling Capacitor Schemes**
  - From the Results workspace, **Right-click PI Opt Sim 1 > View Schemes…**
  - This will open the PI Advisor optimization results window.

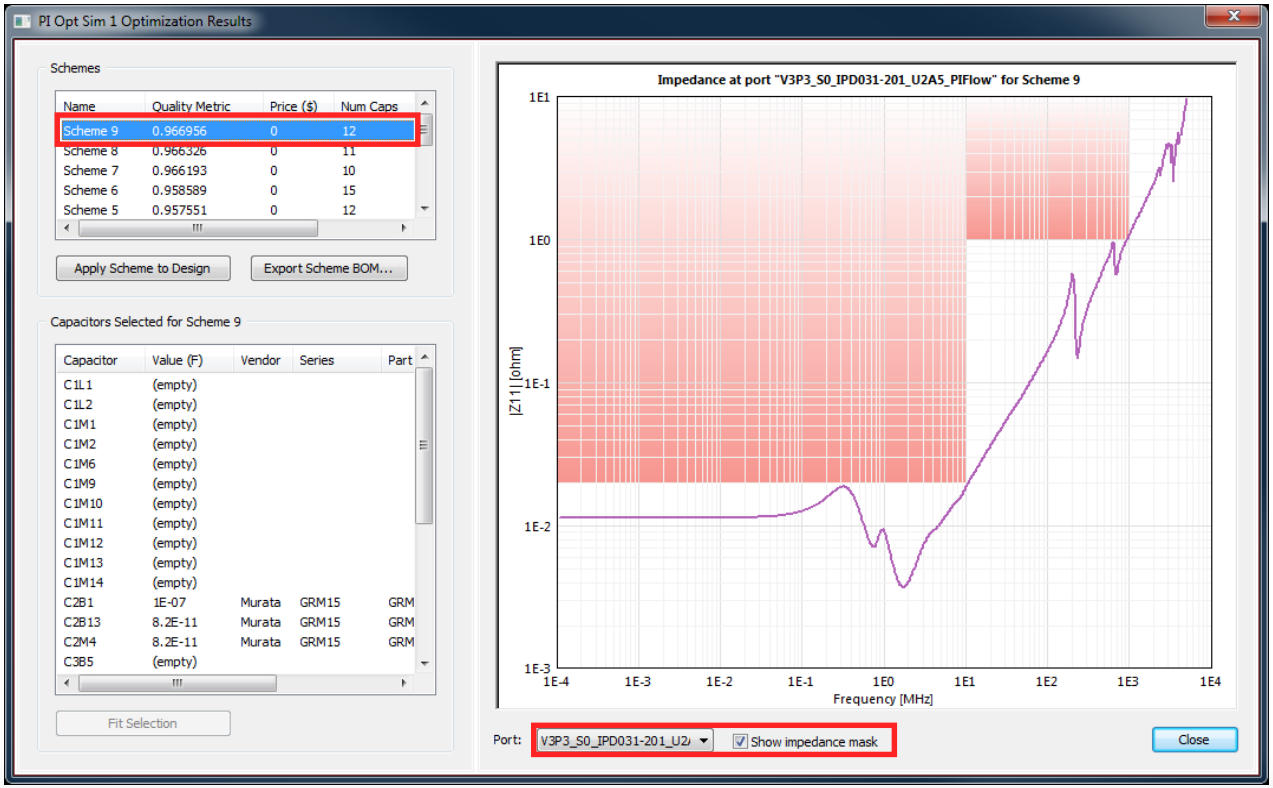




PI Advisor Results

Viewing Results

- The results window displays ten capacitor selections that come the closest to the specified criteria and the corresponding |Z11|.
- Each Scheme is able to be applied back to the project or exported as a Bill of Materials (BOM) change.
- Select **Scheme 9** from the Schemes window.
- Click the **Show impedance mask** check box.
- If multiple Active Devices were specified, the Port field would enable selection of those ports.



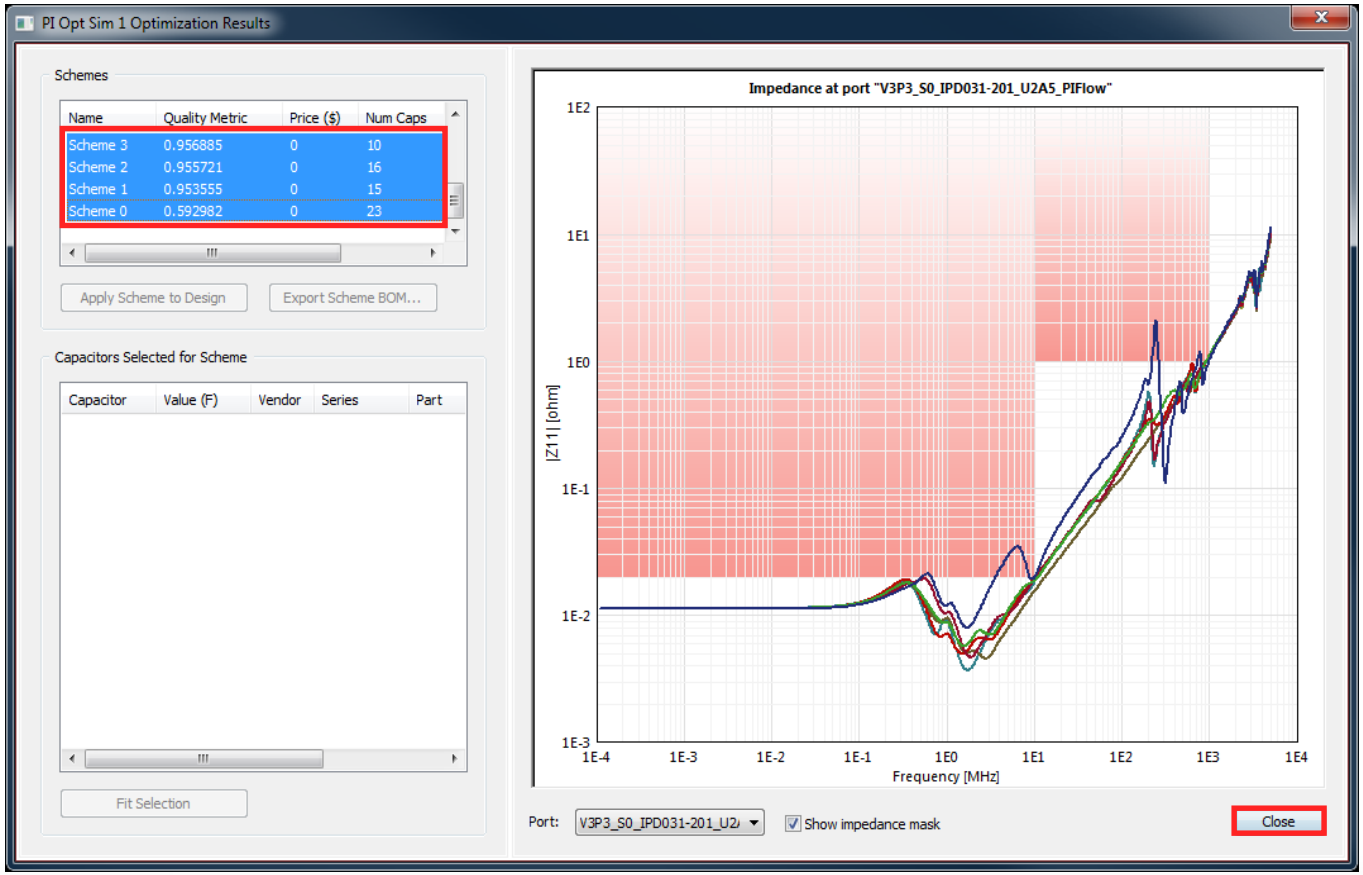
Populated or Depopulated Capacitor Locations

PI Advisor Results, cont.

Viewing Results

- Selecting multiple lines accumulates |Z11| for all available schemes.

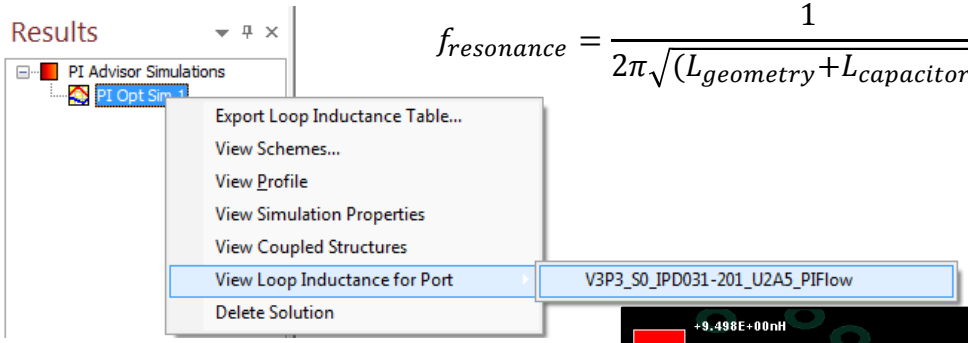
- Click **Close** to close the PI Advisor Results window.



PI Advisor Results

Plotting and Exporting Loop Inductance

- From the Results workspace, **Right-click PI Opt Sim 1 > View Loop Inductance for Port > V3P3_S0_OPD031-201_U2A5_PIFlow**
- This plot shows the loop inductance to each capacitor as seen from the selected active device. The inverse relationship of this loop inductance shows that lower values can contribute to higher frequency resonances. This inductance value is the geometry portion of the loop inductance not inclusive of ESL from a placed capacitor ($L_{geometry}$).
- A text file of these loop inductances can be exported from the results option **Export Loop Inductance Table**.



$$f_{resonance} = \frac{1}{2\pi\sqrt{(L_{geometry}+L_{capacitor})C}}$$