Using Sonnet Project Components to Aid MMIC Design

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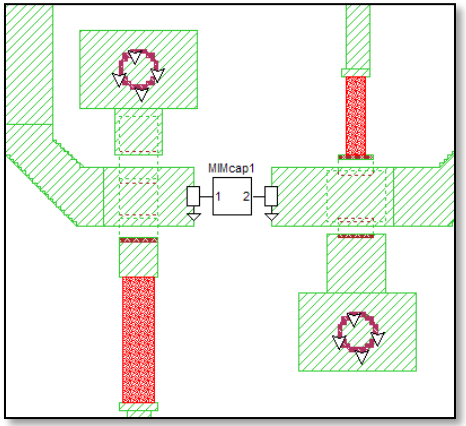
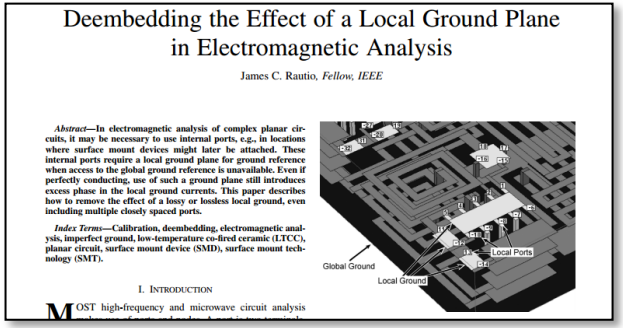
Project Components for MMIC Design

- Sonnet's Project Components allow you to add one or more Sonnet subprojects to your main project
- Subprojects may be geometry or netlist projects
- All geometry sub-projects are electromagnetically analyzed, and then connected to the main project using circuit theory
- Project Components use Sonnet's Co-calibrated Port technology, providing fully calibrated internal ports
- All ports within a Component are calibrated together in "groups" to remove cross-coupling between closely spaced ports
- Co-calibrated Port theory is published





Deembedding the Effect of a Local Ground Plane in Electromagnetic Analysis

James C. Rautio, *Fellow, IEEE*

***Abstract*—In electromagnetic analysis of complex planar circuits, it may be necessary to use internal ports, e.g., in locations where surface mount devices might later be attached. These internal ports require a local ground plane for ground reference when access to the global ground reference is unavailable. Even if perfectly conducting, use of such a ground plane still introduces excess phase in the local ground currents. This paper describes how to remove the effect of a lossy or lossless local ground, even including multiple closely spaced ports.**

***Index Terms*—Calibration, deembedding, electromagnetic analysis, imperfect ground, low-temperature co-fired ceramic (LTCC), planar circuit, surface mount device (SMD), surface mount technology (SMT).**

I. Introduction

MOST high-frequency and microwave circuit analysis

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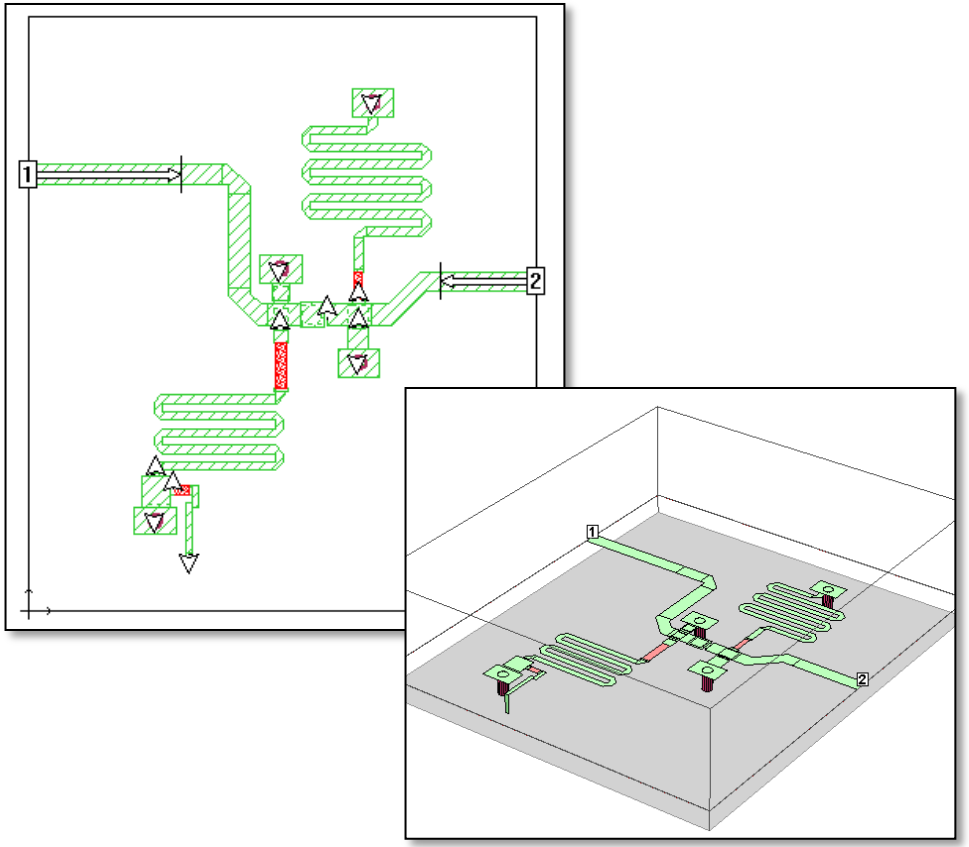
Project Component Applications

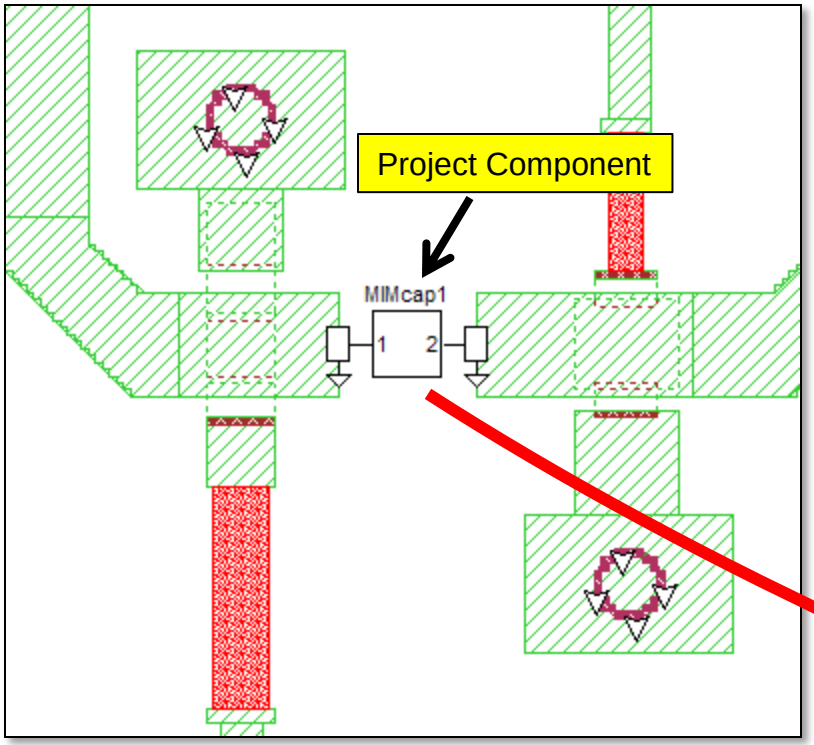
Application	Solution
When one part of your circuit does not couple to another part	Create a subproject of one part of your circuit and use a Project Component in your main project to point to the subproject. Two small circuits run faster than one large circuit.
When your design uses an element multiple times	Create a subproject of the element, and use multiple Project Components in the main project, all pointing to the same subproject
When certain parts of your circuit require a different cell size	Turn those portions into a separate project and use a Project Component to refer to it
When you want to include a network of ideal elements in your circuit	Create a netlist project representing the network of ideal elements. Then create a Project Component which points to this netlist project.
When you want to optimize or sweep the dimensions of just a small portion of your circuit	Create a subproject of the small portion and use a Project Component in your main project to point to the subproject. Then optimize or parameter sweep the variables in the Project Component so only the subproject needs to be reanalyzed.

MMIC Design Example

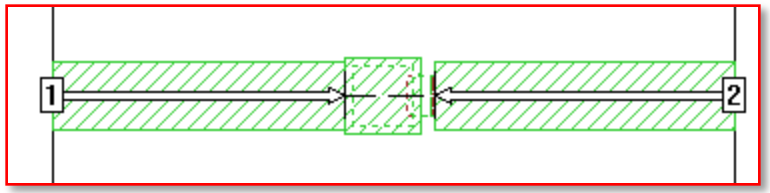
- Example: Interstage matching network for 100 um thick GaAs MMIC with gold traces
- We will show how a Project Component can be used to partition this design



Partitioning the Design



- We will remove the MIM capacitor from the design and analyze it separately
- This can be useful if you want to:
  - Analyze the capacitor with a smaller cell size; or
  - Try several iterations of cap values or layouts
- In the main design, remove the capacitor and replace it with a Project Component
- Project Components use Sonnet's exclusive Co-calibrated Port technology to provide fully calibrated internal ports
- The Project Component refers to a separate project which is the MIM capacitor



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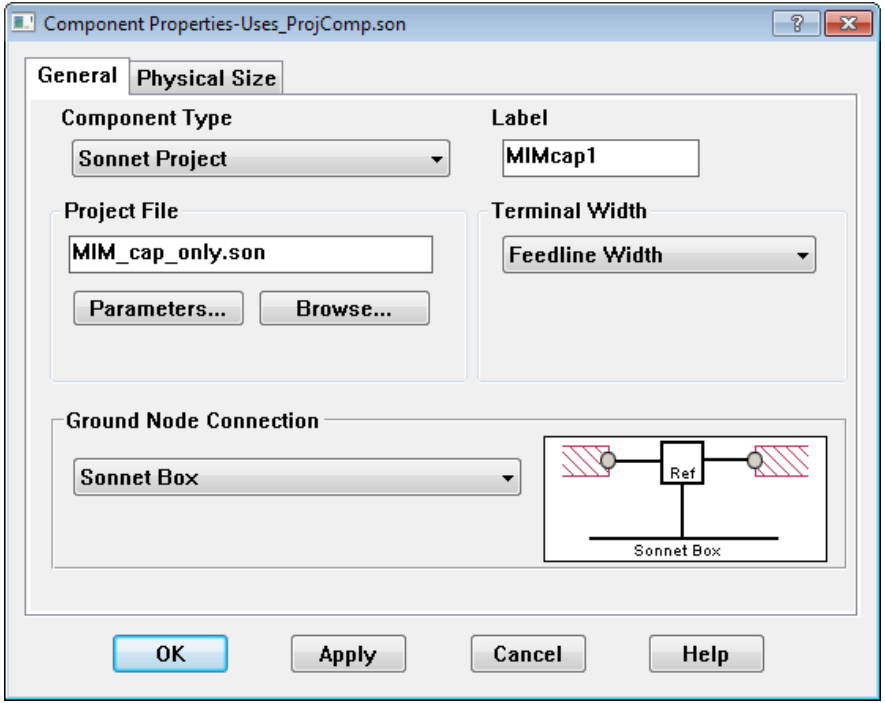
Component Settings

Ground Node Connection:

- Set to “Sonnet Box” because the capacitor subproject has ports that are referenced to the Sonnet box.

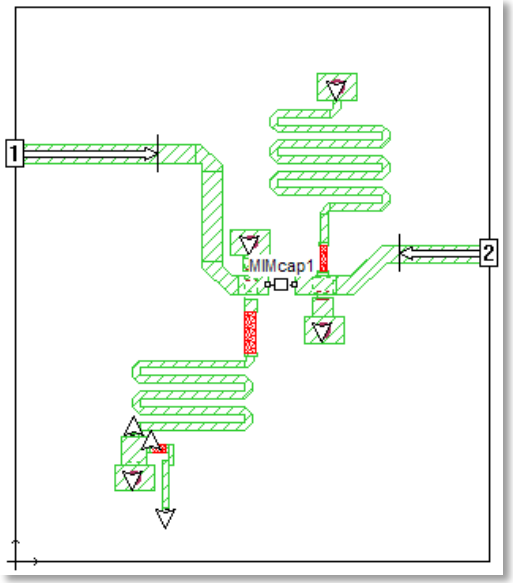
Terminal Width:

- Set to “Feedline Width” because the width of ports of the capacitor subproject is the same as the width of the feed lines connected to the Project Component



If it works correctly…

Circuit with Project Component



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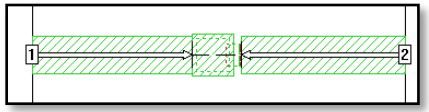
MIM Cap



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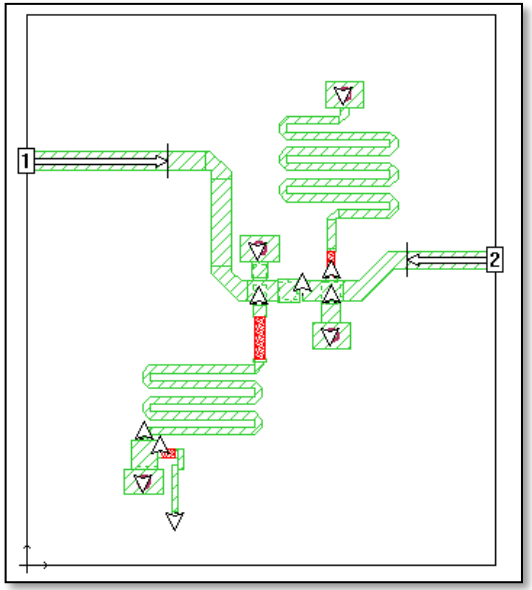
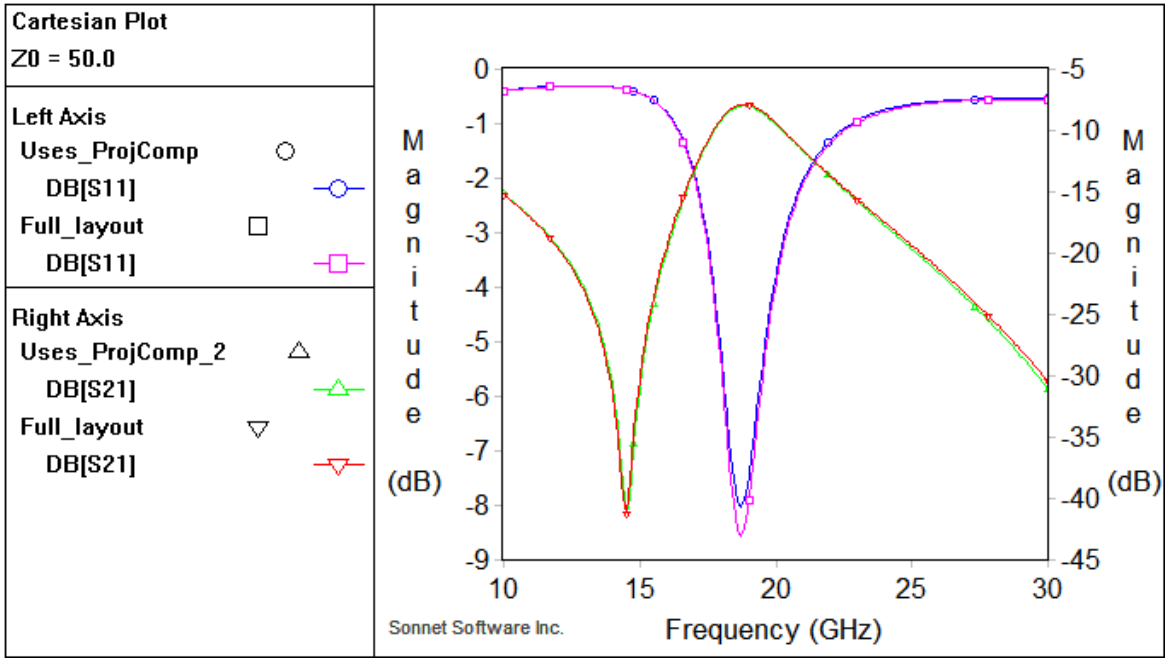
Full Layout



If the Project Component is de-embedded accurately, and if there is no coupling between the capacitor and the rest of the circuit, the project with the Project Component should give the same results as the full layout.

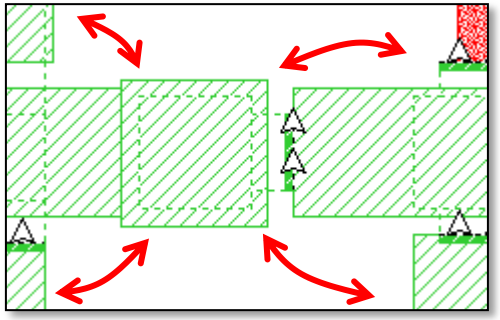
Results

- Shown here is a comparison of the full layout vs using a project component
- Very good agreement is found for both magnitude and phase data. Only magnitudes shown here.
- There is a small difference in dB[S11] at ~18.7 GHz
- We will next investigate a potential cause for this difference

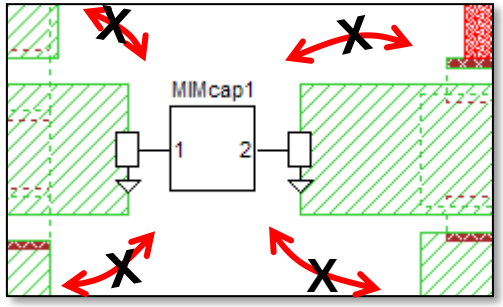


Coupling

Full Layout



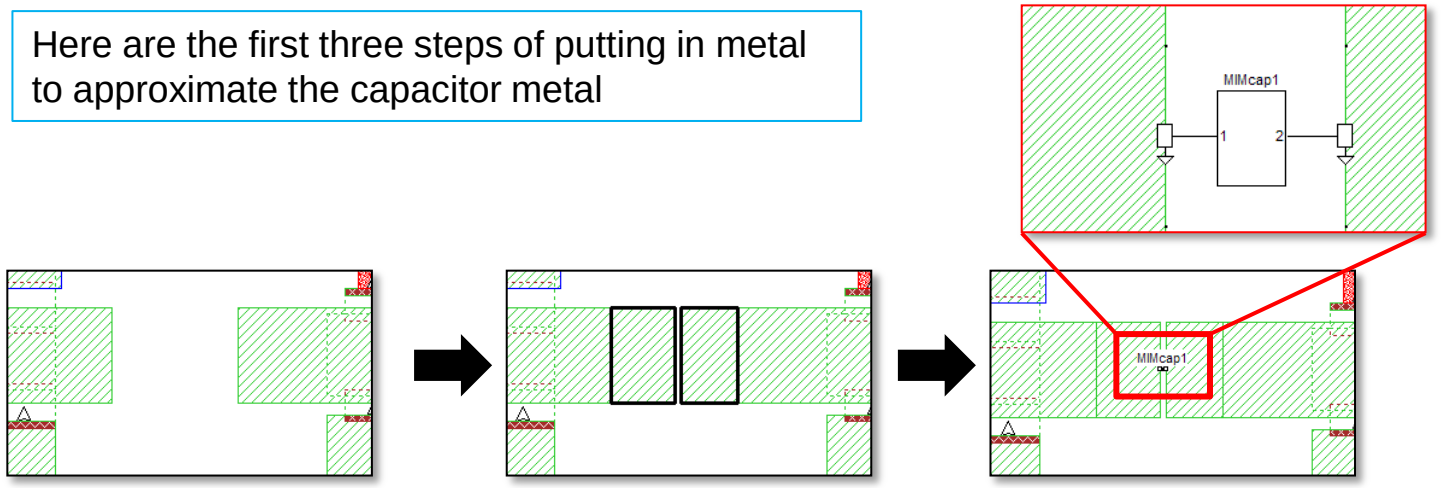
Using Project Component



- The coupling between the MIM cap and the rest of the circuit is modeled with the full layout but is not modeled when using the project component
- This is because when using the Project Component, the capacitor metal was removed
- Since the two cases give almost the same result, this coupling must be quite small
- Adding some metal back in should improve the accuracy of the coupling

Putting Metal back in

Here are the first three steps of putting in metal to approximate the capacitor metal



Step 1: Delete existing Component

Step 2: Add metal to approximate the capacitor metal. Leave one cell gap in the middle for the Component

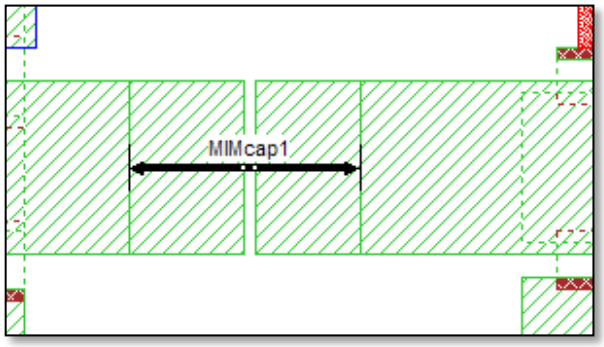
Step 3: Add Project Component

Question: Aren't we including the capacitor metal twice?

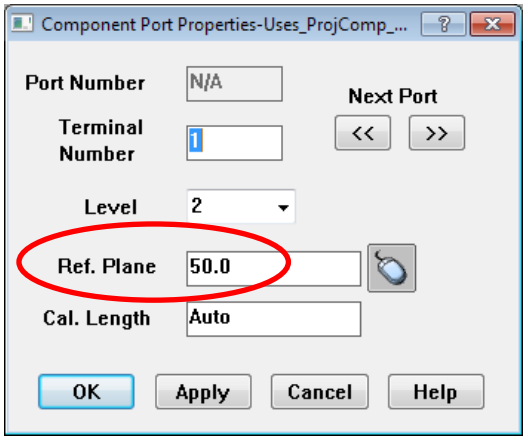
Answer: Yes. The capacitor metal is now modeled in the capacitor subproject and in the main project. This is a problem that needs to be fixed using reference planes...

Use Reference Planes

- Use Modify -> Port Properties to add reference planes
- Click on the “Next Port” button to change both reference planes



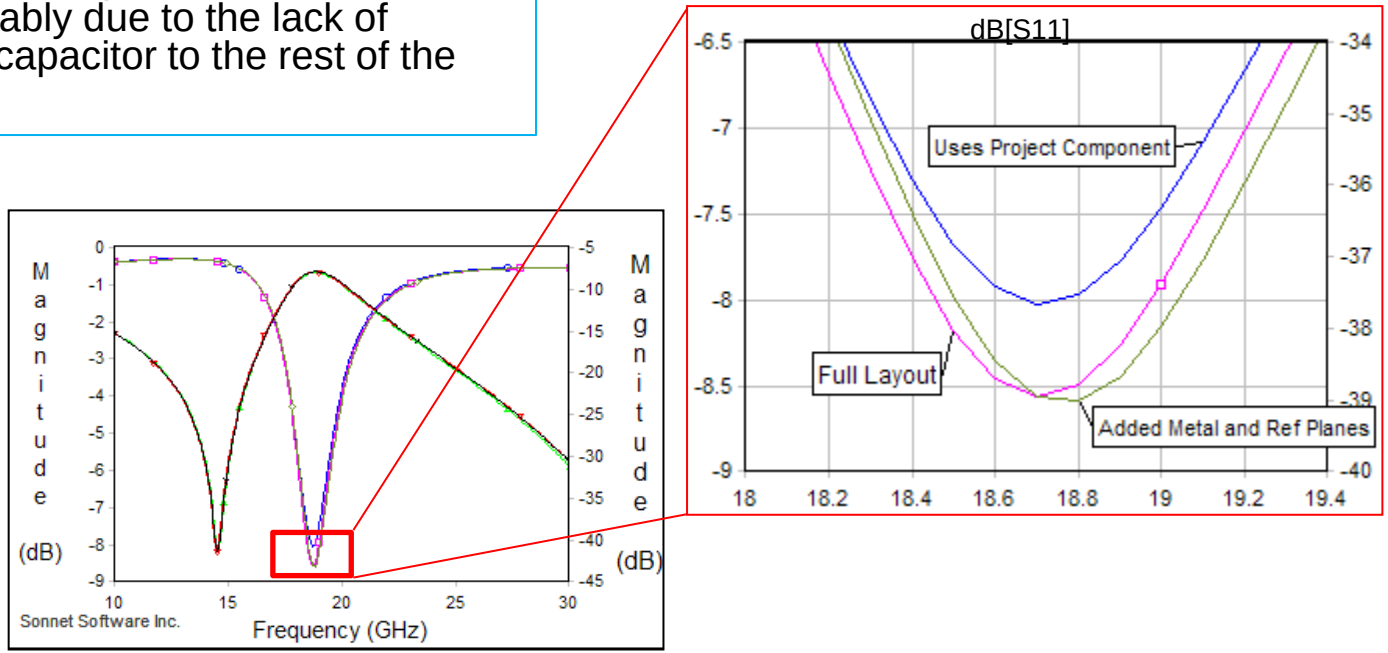
Step 4: Add reference planes



Remember: Reference planes do not remove metal from the project. Instead, they negate the length of transmission line equal to the length of the reference plane

New Results

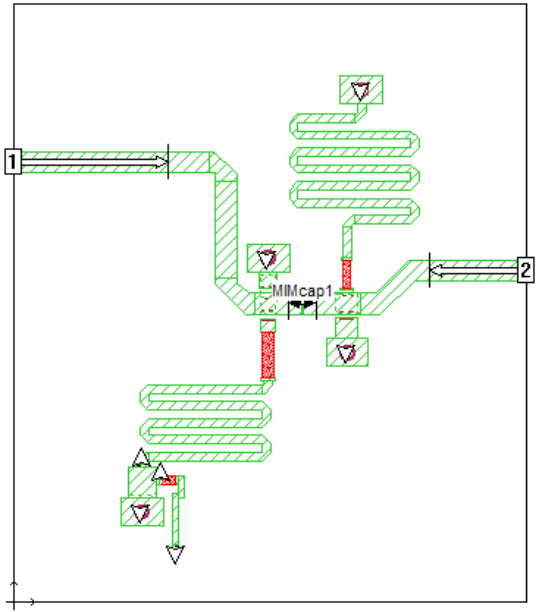
Adding metal and reference planes increased the accuracy. Thus, the previous differences we saw were probably due to the lack of coupling from the capacitor to the rest of the circuit.



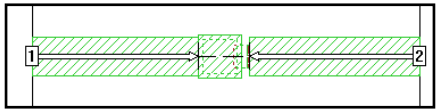
Parameterization

- Let's say you want to sweep the dimensions of the capacitor, with the rest of the circuit unchanged
- You can do this by parameterizing the subproject and setting up a parameter sweep in the main project
- The subproject will be simulated for each parameter combination in the parameter sweep
- The main project only needs to be simulated once

Simulated once



Simulated many times

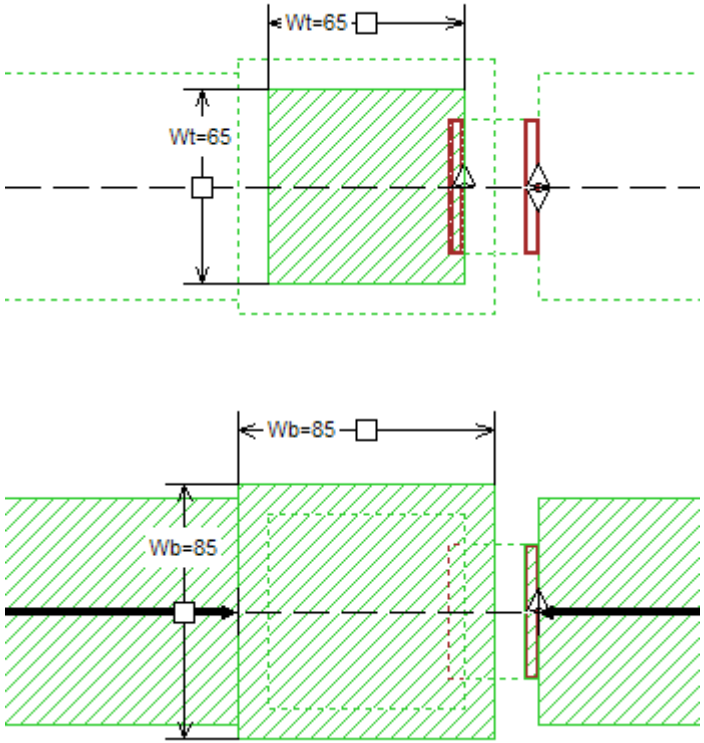


Subproject Parameters

We set up two parameters in the capacitor subproject:

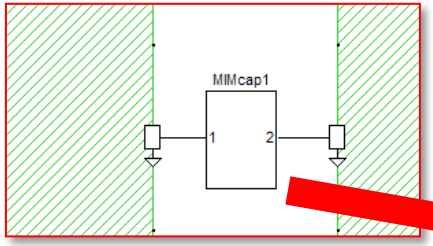
- Wt = width of top plate
- Wb = width of bottom plate

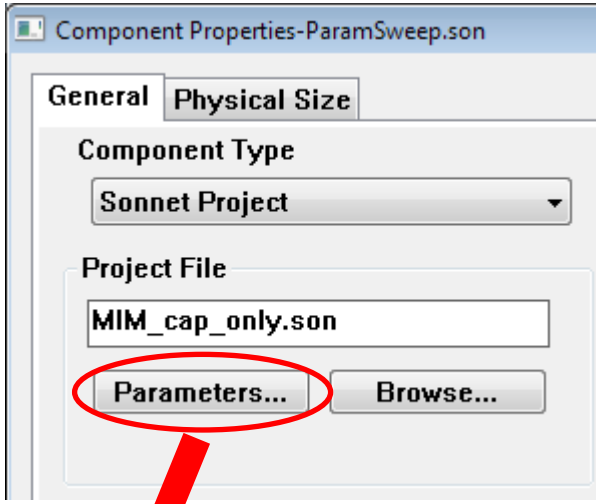
We will want to control these parameters from the main project

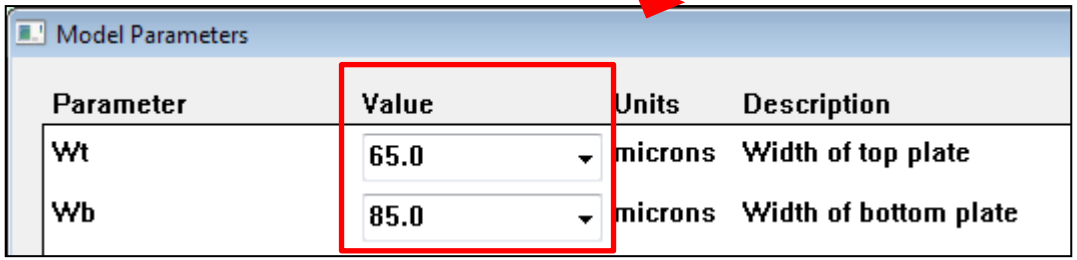


Main Project - Defaults

- By default, the parameters of the Project Component are set to the nominal values in the subproject
- But we want to be able to vary these values

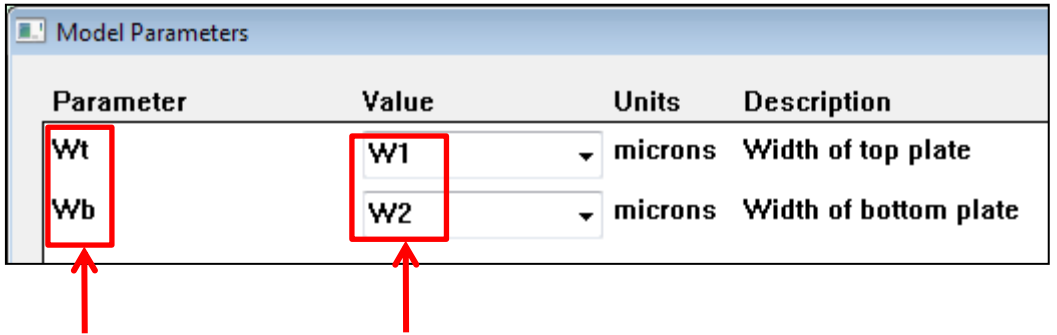






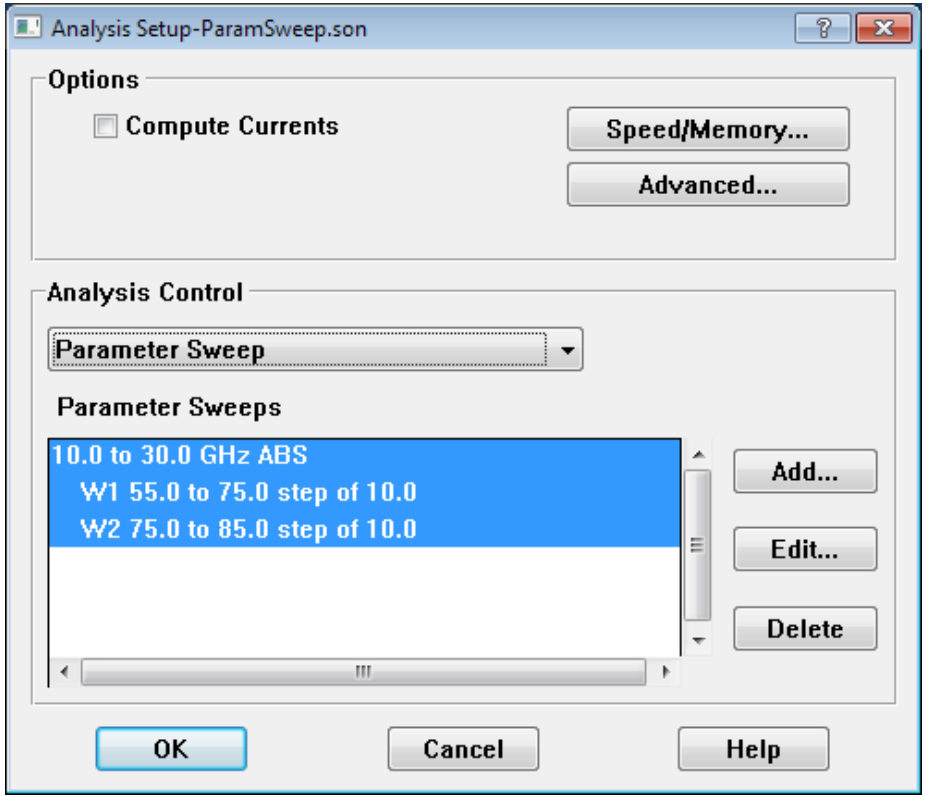
Controlling the Subproject

- We need to set the parameter values to be variables in the main project
- The variables in the main project could be named the same as those in the subproject.
- Instead, we will define new variables W1 and W2 in the main project. This provides greater flexibility, especially when working with multiple Project Components.
- This means that when we change W1 and W2 in the main project, the capacitor's widths will change.



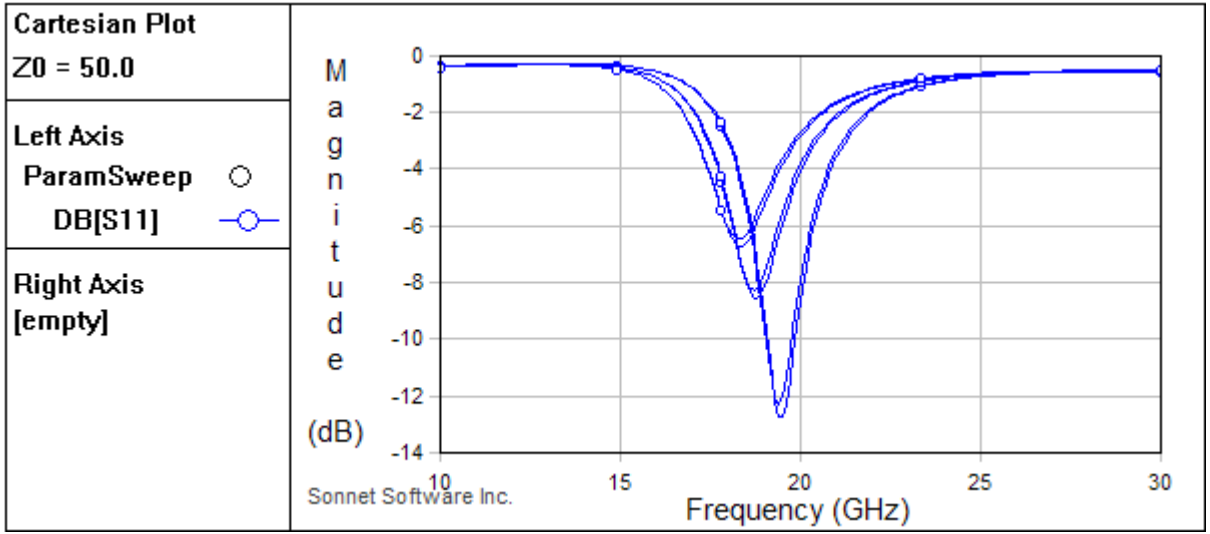
Parameter Sweep Setup

- The main project contains a parameter sweep of W1 and W2
- Six total parameter combinations
- Since W1 and W2 only affect the subproject, the main project will only be analyzed once, but the subproject will be analyzed 6 times
- When finished, the main project will contain results for the six parameter combinations, even though it was simulated only once.



Results of Parameter Sweep

- Shown here is a plot of dB[S11] for the six parameter combinations.
- The curves are in three groups. Changing the bottom plate of the capacitor (Wb) had very little effect on the results, whereas changing the top plate (Wt) did.



Conclusions

- Project Components use Co-calibrated Ports, and provide a method for design partitioning that cannot be found in any other commercial high frequency EM software
- Comparison of the full layout results to the results using a project component were very close to each other, showing that the technique works
- Adding metal that approximates the subproject and using reference planes can improve the accuracy
- Parameters may be passed from the main project to the subproject, opening up a whole range of possible applications

Contact Sonnet Technical Support at:

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