ECE 451 Automated Microwave Measurements

Homework #5 Due Wednesday, April 14, 2021

Introduction to HFSS

<u>Part 1:</u> Simple microstrip line

(*http://emlab.uiuc.edu/ece451/HFSS_tutorial_451.pdf*)

Go through the HFSS tutorial available from the ECE451 course website. Attach <u>screenshots of your design</u>, as well as your <u>plots with comments/observations</u>. Also, look at the profile of your simulation by going to **HFSS→Results→Solution Data**. In the tab "**Profile**", you should be able to see information about meshing, elapsed time, memory usage, solved frequencies etc. In the tab "**Convergence**", you should be able to see the adaptive passes. Look for the following information in your profile and report it in your hand-in:

1. Look at "**Convergence**" tab, after how many passes did the solution converge? Include a plot of *Max Mag. Delta S* vs *Pass number*.

2. Look at "**Profile**" tab, list out the number of tetrahedra used when meshing the structure and the matrix size in each pass you answered above.

After the converged pass, HFSS started to solve the problem at multiple frequencies, how many frequencies at which the problem was solved? For each solved frequency, what was the matrix size?

You should see that the solved frequencies are grouped. After a group of frequencies are solved, HFSS calculated and report "**S Matrix Error**". Report the "**S Matrix Error**" evolution (you should see "**S Matrix Error**" getting smaller as more frequencies are solved)

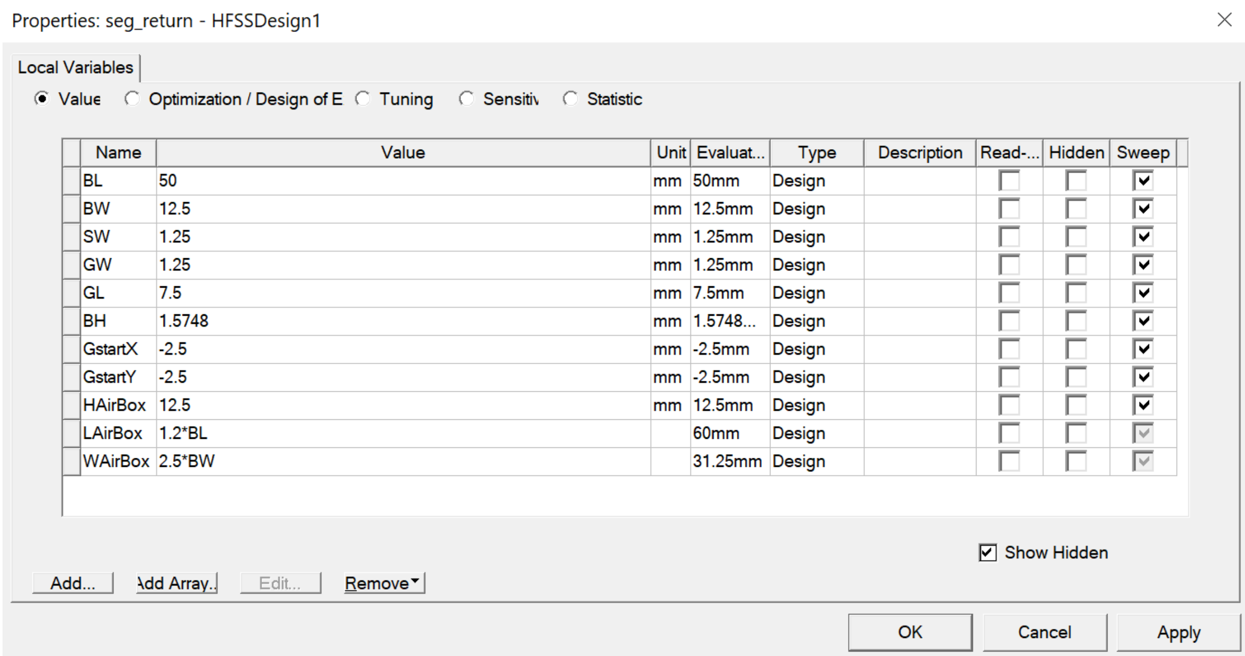
Questions:

1. What is HFSS? Describe the benefits, features, applications of HFSS and why it is used so much in industry today?
2. What are the non-idealities of the interconnect at high frequencies, and how can they be modeled accurately?
3. Look at your simulated S-Parameter matrices from the HFSS tutorial
   a. Is this two-port reciprocal? Why or why not?
   b. Is this two-port lossless? Why or why not?

<u>Part 2:</u> A microstrip line with discontinuity in return path

In this section, you will learn the importance of the return path current to signal integrity. The simple microstrip line will be used again. This time, a cut-out in the ground plane will be made and we will study the effect of the cut-out to S-parameter of the line.

Open Ansys Electronics Desktop, insert a new HFSS project, save the file as "**seg_return.aedt**". Define variables as follows


Properties: seg_return - HFSSDesign1

Local Variables

Value | Optimization / Design of E | Tuning | Sensitiv | Statistic

Name	Value	Unit	Evaluat...	Type	Description	Read-...	Hidden	Sweep
BL	50	mm	50mm	Design		[ ]	[ ]	[x]
BW	12.5	mm	12.5mm	Design		[ ]	[ ]	[x]
SW	1.25	mm	1.25mm	Design		[ ]	[ ]	[x]
GW	1.25	mm	1.25mm	Design		[ ]	[ ]	[x]
GL	7.5	mm	7.5mm	Design		[ ]	[ ]	[x]
BH	1.5748	mm	1.5748...	Design		[ ]	[ ]	[x]
GstartX	-2.5	mm	-2.5mm	Design		[ ]	[ ]	[x]
GstartY	-2.5	mm	-2.5mm	Design		[ ]	[ ]	[x]
HAirBox	12.5	mm	12.5mm	Design		[ ]	[ ]	[x]
LAirBox	1.2*BL		60mm	Design		[ ]	[ ]	[x]
WAirBox	2.5*BW		31.25mm	Design		[ ]	[ ]	[x]

Show Hidden

Add... | Add Array... | Edit... | Remove

OK | Cancel | Apply

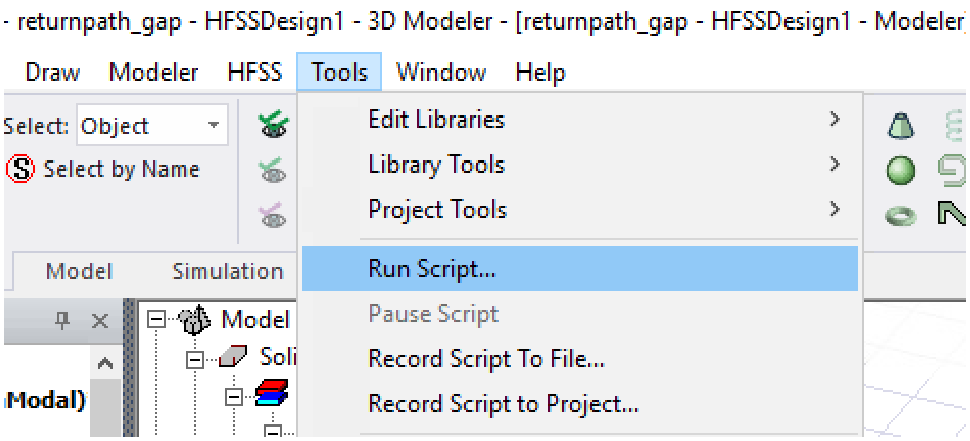
We will now create the mentioned microstrip line with a gap in the ground plane using a macro. The macro will draw the model for you:

+ create the substrate.
+ draw the ground plane.
+ draw the signal trace.
+ create a cut-out in the ground plane.
+ create a **lump port** at one end of the line, representing the excitation.
+ create a **termination** at the other end of the line as a 50Ω resistor.
+ create an air-box surrounding the structure and assign a radiation boundary on it.

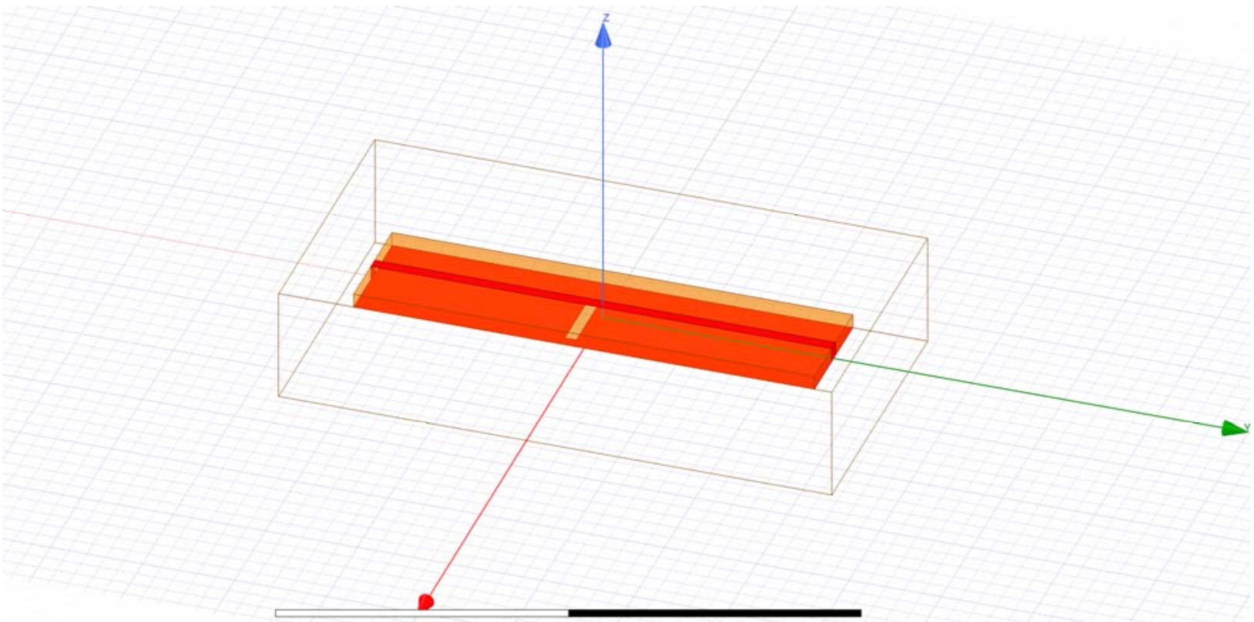
To run a script from HFSS, go to **Tools > Run Script**, then browse to the *.py source code and select it.

Download the script here: *http://emlab.uiuc.edu/ece451/hw/seg_return_py*

(copy the text over and name it 'seg_return.py')



After the code is executed, you should have the model similar with this



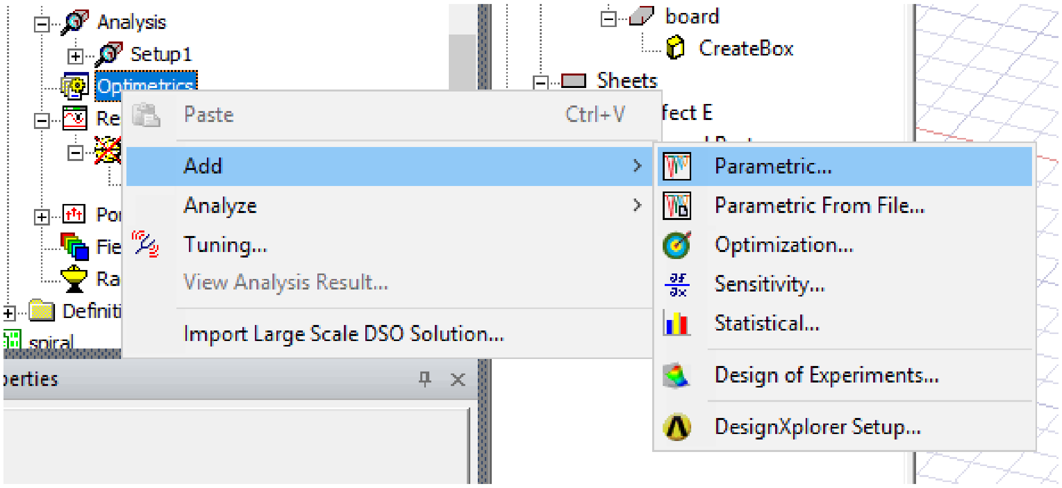
Set solution frequency to 10GHz, add a frequency sweep from 10MHz to 10GHz with 401 points. Before studying the gap effect, let's first center the gap by setting:

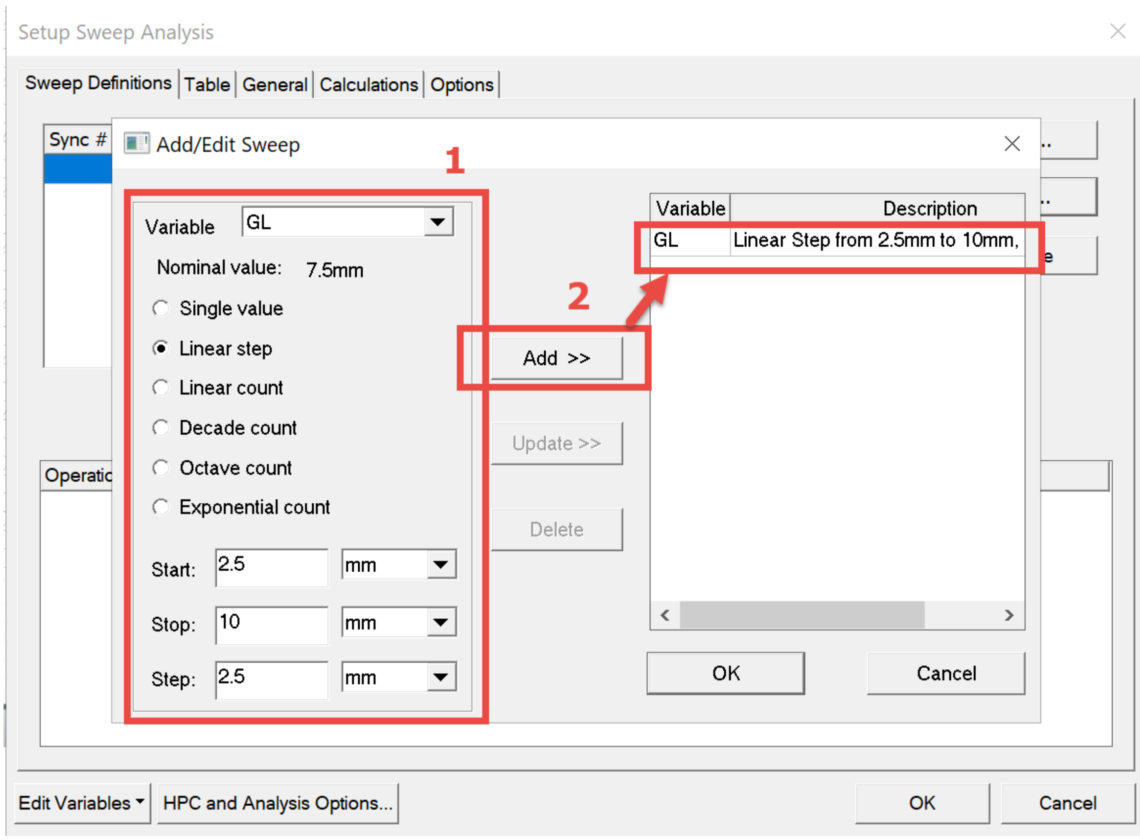
`GstartX = -6.25mm` and `GstartY = -0.625mm`

Take a screenshot of the model at this step for your report before moving on.

a. Gap length effects

You will now run a parametric sweep simulation with different gap length. Setup a parametric sweep using **Optimetrics** feature as follows



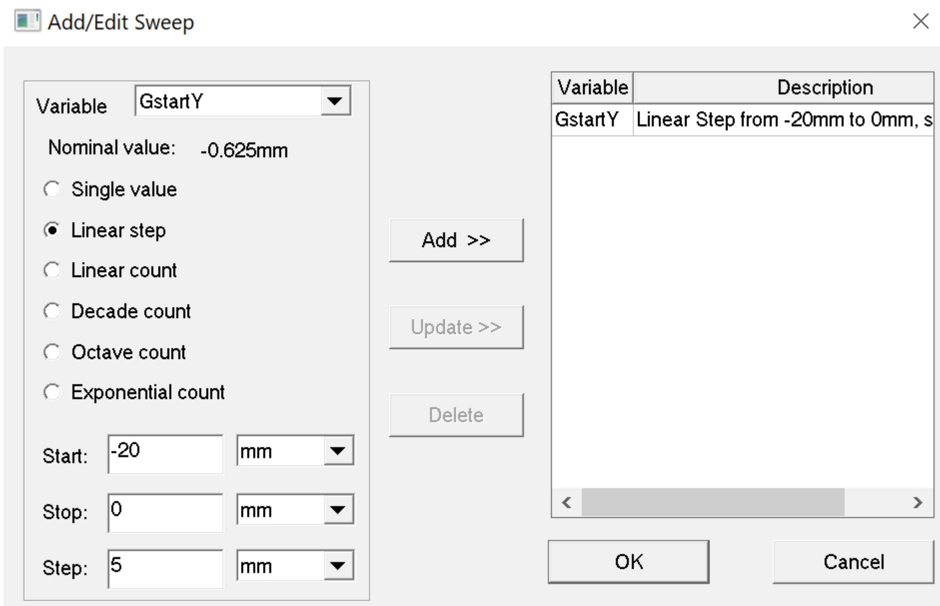


b. Gap location effects

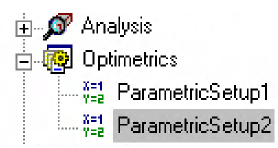
Now we will investigate how the location of gap along signal flow will affect the trace impedance.

Note: If you choose to overwrite ParametricSetup1, data from part 2a will be deleted. Adding another ParametricSetup will keep your previous run data and only run new cases.

Add another parametric sweep from **Optimetrics** option to vary location of the gap.



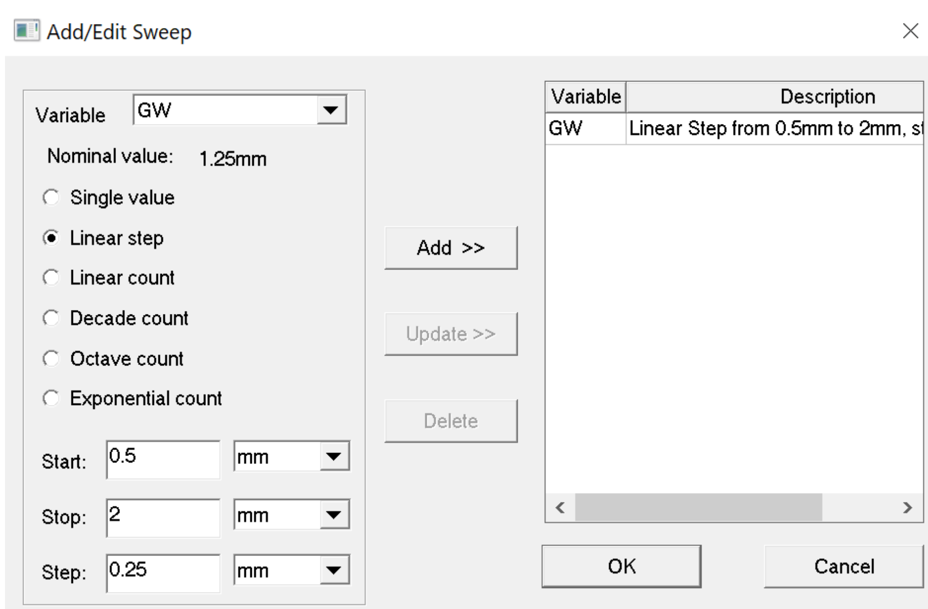
Now you should have 2 parametric setups. **ParametricSetup1** is sweeping `GL` as above, while **ParametricSetup2** is sweeping `GstartY` we just added (you can rename them to make them distinguishable). You can disable 1 and run the other.



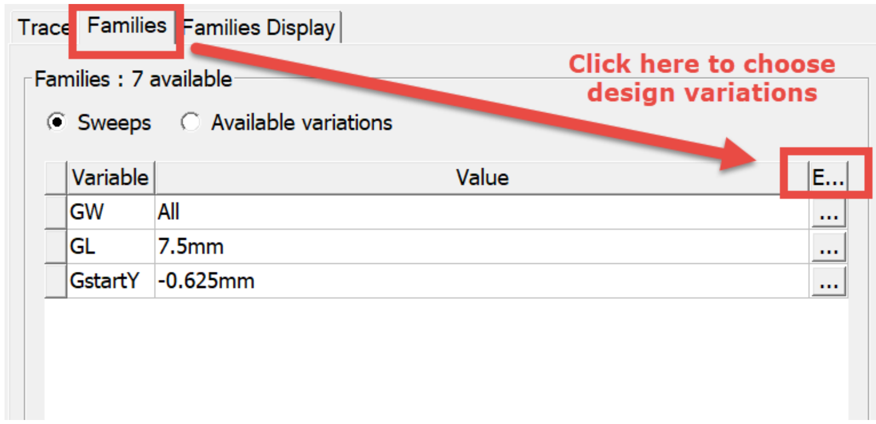
When **ParametricSetup1** is disabled, `GL` would be the nominal value specified in *Design Properties*.

c. Gap width effects

Now that you're familiar with **Optimetrics** simulation in HFSS, continue to investigate how the gap width would affect the trace impedance by sweeping `GW`



Note: When plotting S-parameter, you can use tab "**Families**" to choose which design variations you want



Submit screenshots of the model at a few different design parameters and plots of S-parameters of all above sweeps and comment on the effects of the gap on the ground plane to the trace. Also include plots of the trace impedance (in this case, Z_{11}) to support your comments. You can get the Z parameters in HFSS by two ways:

a. In the "**Matrix Data**" tab of the **Solution** window, you will be able to export Z matrix to touchstone format file along with S and Y parameter, then use another tool to read the file and post-process it.
b. When creating plots in HFSS, you can directly request to plot Z parameter.

Questions:

1. Report the same quantities asked in question 2 of Part 1.
2. Include a final comment about the effect of a discontinuity in the return path current