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ECE 451: Ansys HFSS Tutorial

Simulate and Analyze an Example of Microstrip Line

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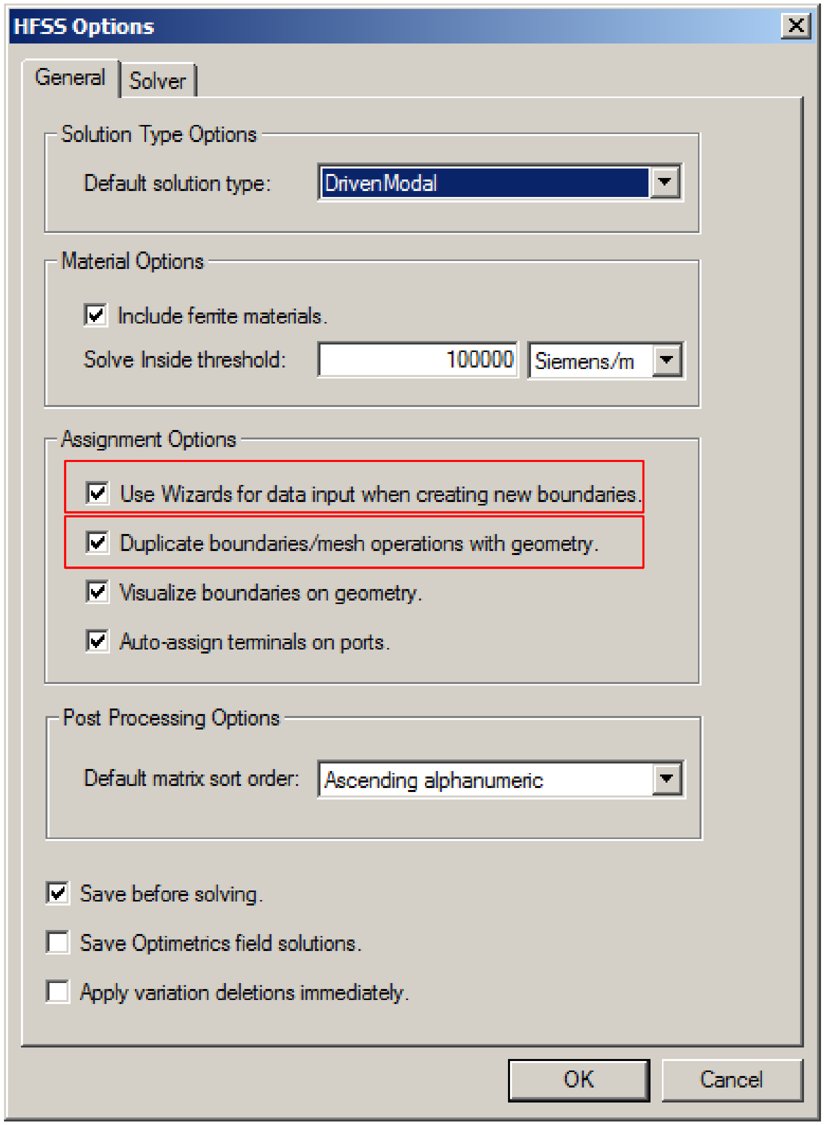
Introduction

- ANSYS HFSS is an industry standard tool for simulating 3-D full-wave electromagnetic fields.
- Students registered in ECE451 can get free access to ANSYS HF package from the University of Illinois Software Webstore.
- Follow the installation guide* to install the software on your PC.

*Note: You will need to e-mail your computer name and a copy of the purchase receipt to webstore@illinois.edu. Allow 1-2 business days for your computer to be added to the license pool.

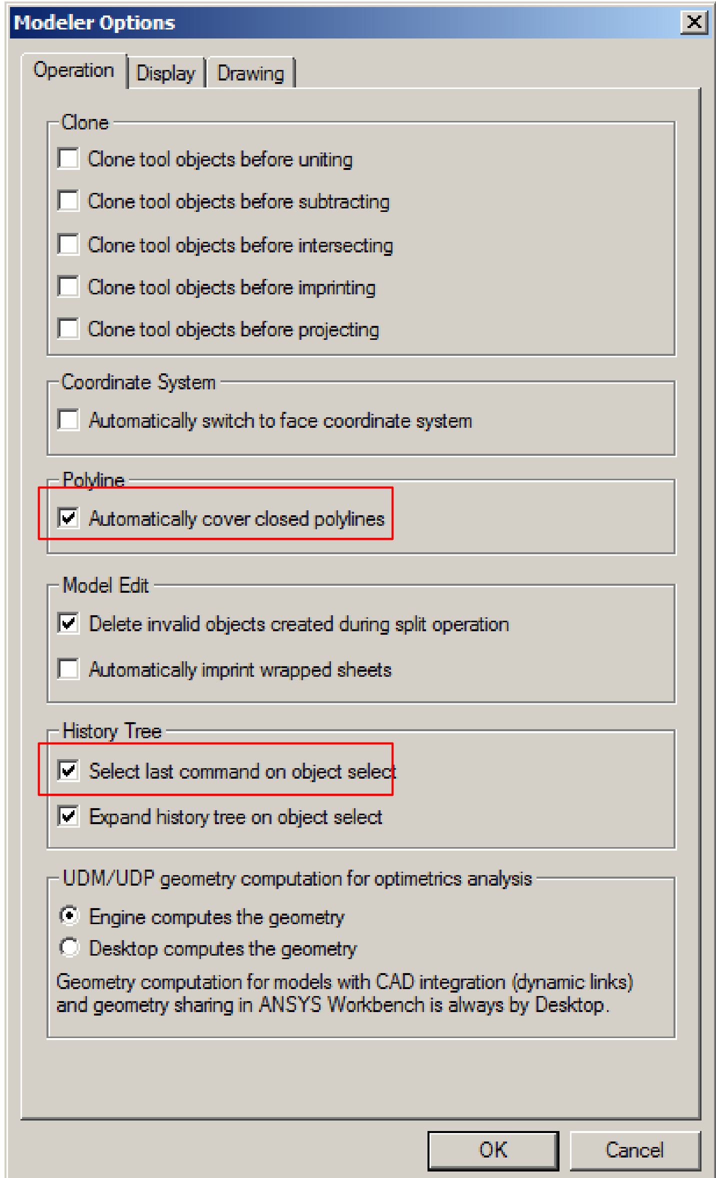
Getting Started

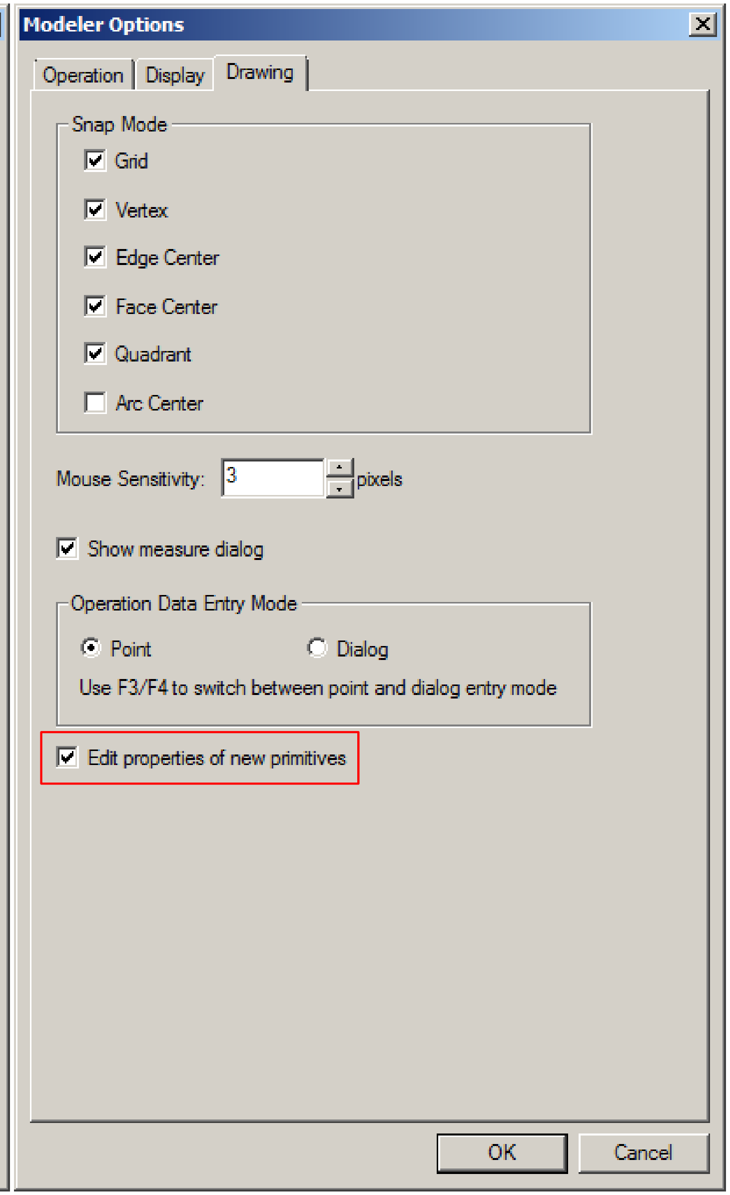
- **Launch HFSS:**
  - **Start→All Programs→ANSYS Electromagnetics→HFSS 15.0→Windows 64-bit (or 32-bit)→HFSS 15.0**
- **Set HFSS options:**
  - **Tools→Options→HFSS Options→General Tab**
    - **Check ✓Use Wizards for data input when creating new boundaries**
    - **Check ✓Duplicate boundaries/mesh operations with geometry**
    - **Click OK**



Getting Started

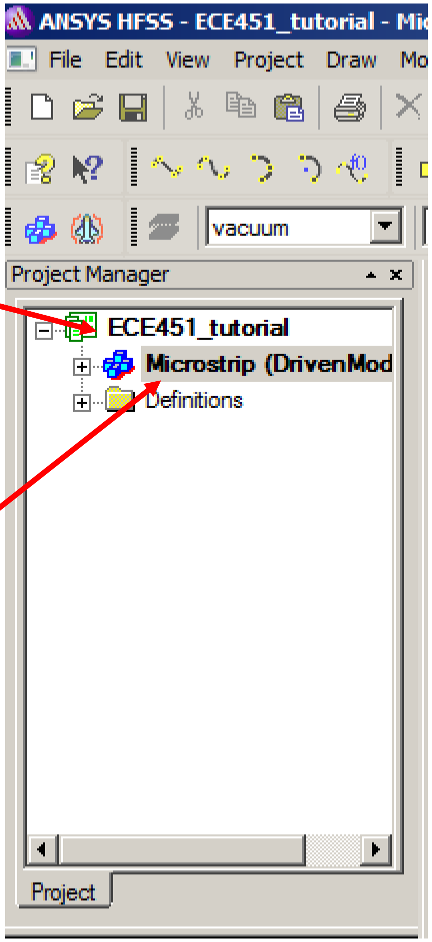
- **Set Modeler options:**
  - Tools→Options →Modeler Options
  - Operation Tab
    - Check ✓Automatically cover closed polylines
    - Check ✓Select last command on object select
  - Drawing Tab
    - Check ✓Edit properties of new primitives
  - Click OK





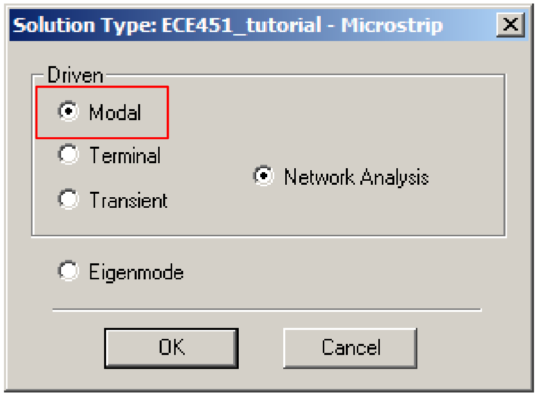
Getting Started

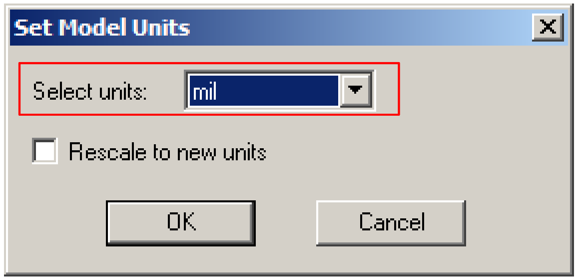
- **Name Project**
  - **Project 1 is already created by default**
  - **Right click on Project 1→Rename**
  - **Type a name of your choosing (helloHFSS, ECE451, tutorial, etc.)**
- **New HFSS**
  - **Right click on your project→Insert→Insert HFSS Design**
  - **Rename the HFSS Design as *microstrip***



Getting Started

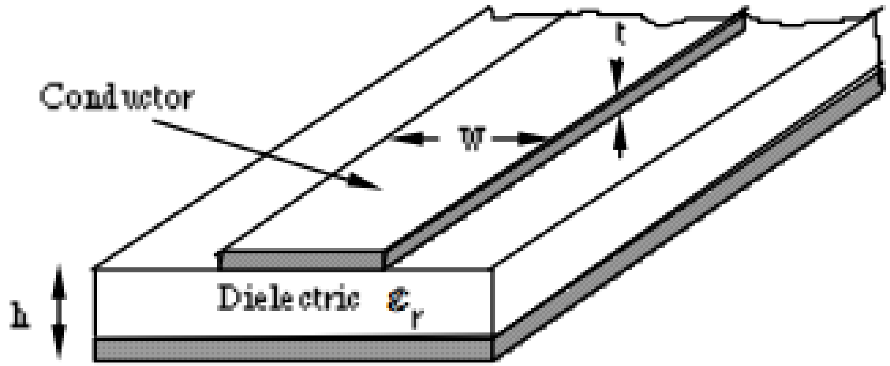
- **Set the solution type:**
  - **Click on HFSS→Solution Type**
  - **Select Modal**
  - **Click OK**
- **Set Model Unit:**
  - **Click on Modeler→Units**
  - **Select <u>mil</u> from the drop down menu**
  - **Click OK**





Creating the Microstrip

We are going to make the substrate (a.k.a dielectric layer), ground plane, and copper trace (conductor) for a microstrip line.



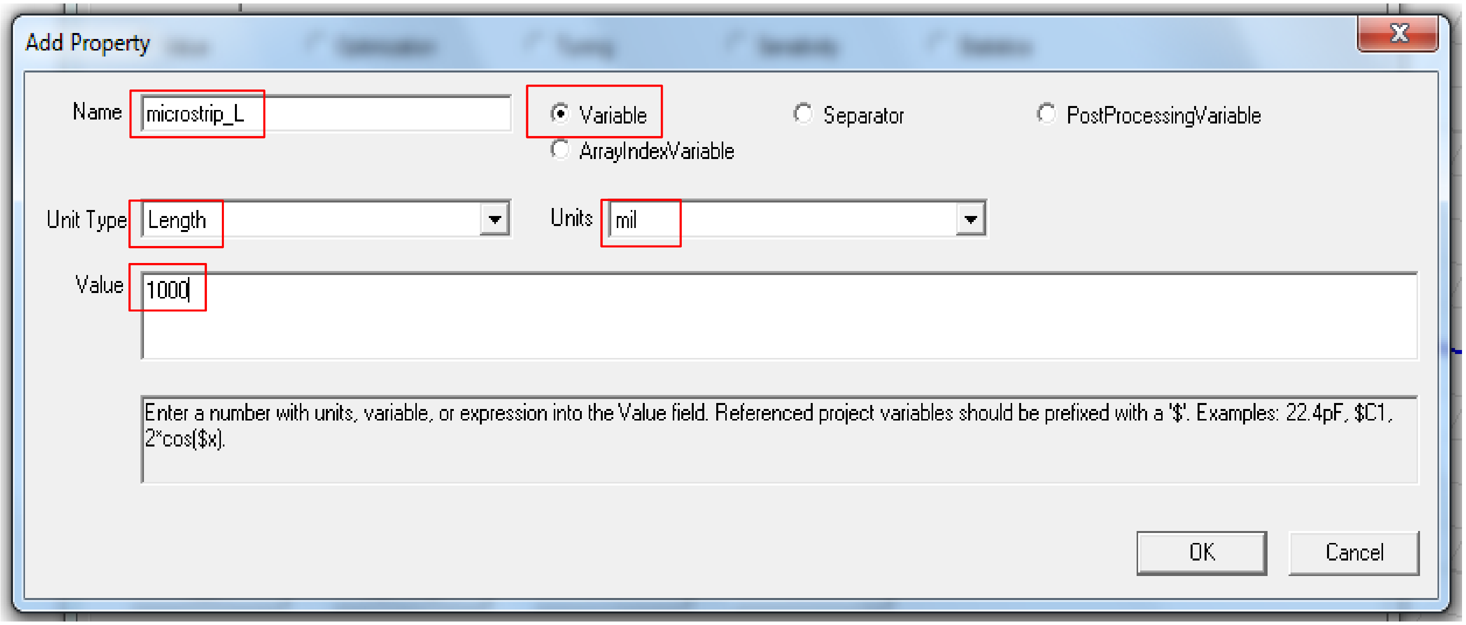
http://emlab.uiuc.edu/ece451/appnotes/planar_structures.pdf

To do this, we will make three "boxes" in HFSS, and then designate the appropriate dimensions and material for each box.

Creating the Microstrip

First we are going to define several variables for the dimensions of our substrate, ground plane, and copper trace

- **Select HFSS→Design Properties→Add**
- **Fill in the properties as shown below**



- **Click OK**

Creating the Microstrip

Repeat the previous steps to create 7 more variables with the following values:

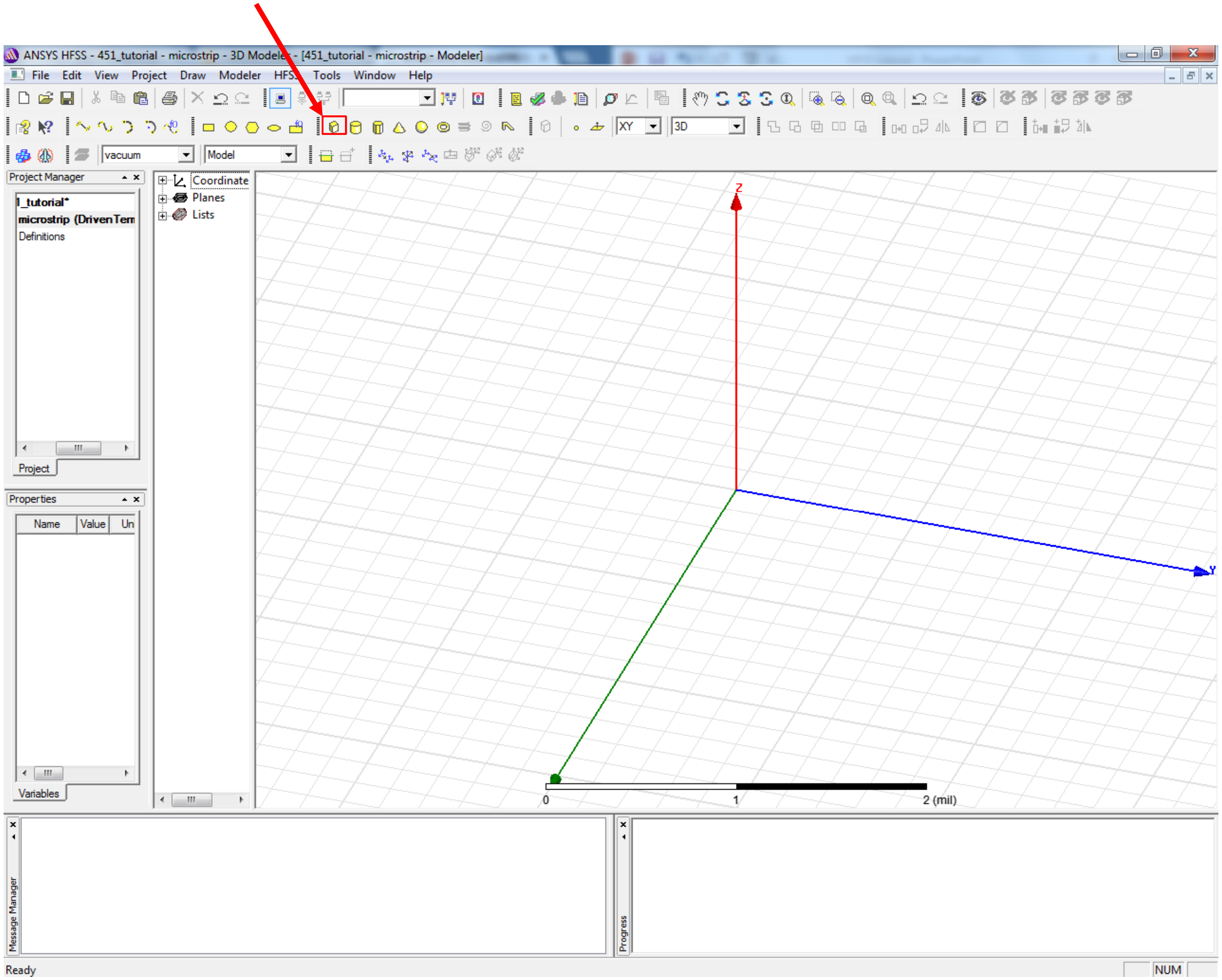
- **Substrate_W – 1000 mil**
- **Substrate_H – 60 mil**
- **Gnd_H – 4 mil**
- **Trace_W – 114.7mil**
- **Trace_H – 4 mil**
- **Waveport_W – 419 mil**
- **Waveport_H – 115 mil**

Using these variables, we will define a 1.00”x1.00” board with a 60 mil thick substrate, 4 mil thick ground plane and trace, and 107.4 mil wide trace

**Recall: 1 inch =1000 mil = 25.4mm

Creating the Microstrip (1): Substrate

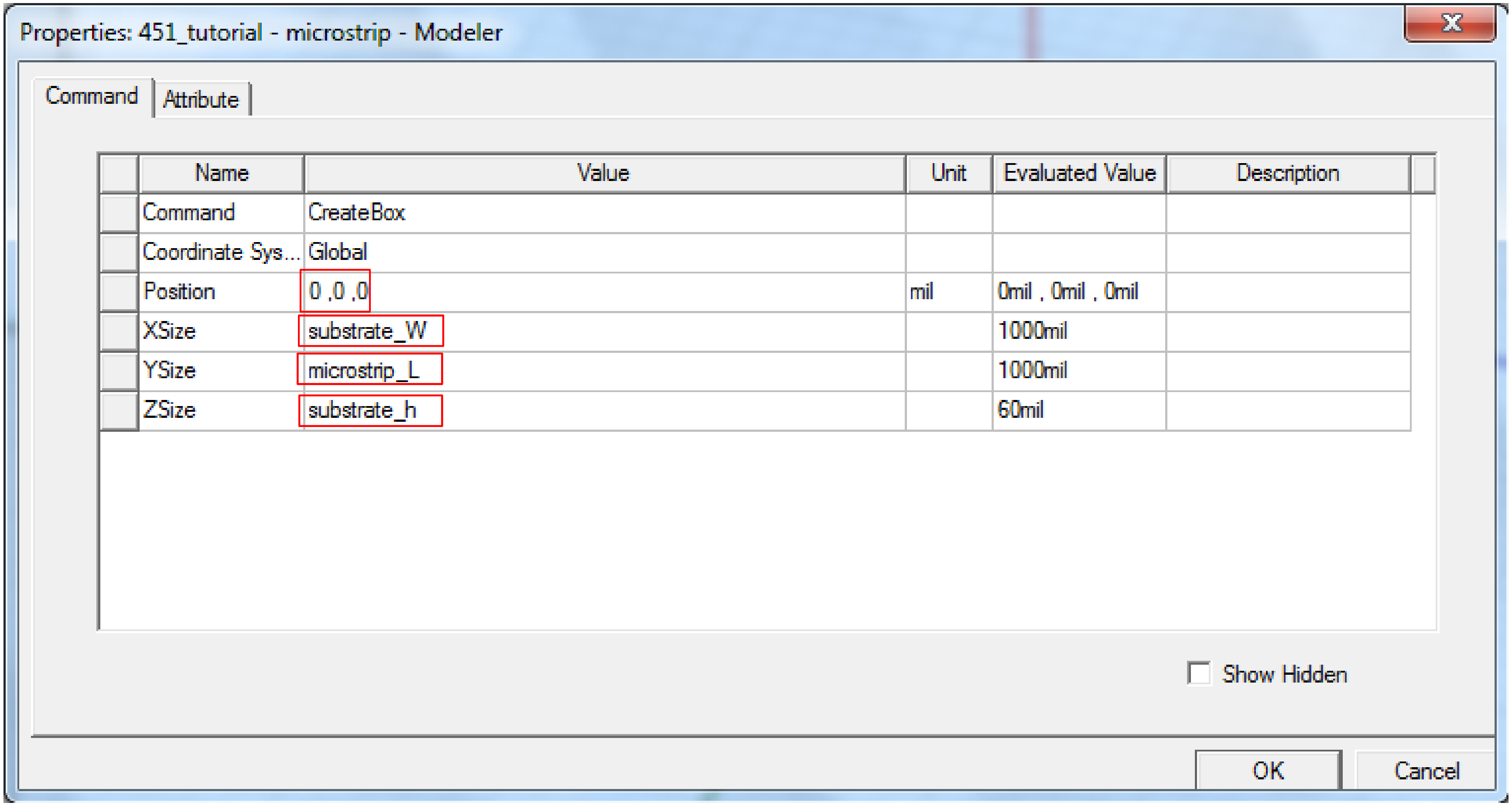
Select the Draw Box button



Creating the Microstrip (1): Substrate

- **Once you have selected the draw box, move your cursor into the window the 3D axis shown**
  - **Click anywhere, move your mouse in the XY plane, click again, move your mouse in the Z direction, and click a third time**
- **You have now created an arbitrary sized box**
- **A window will pop up in which you can define the dimensions and location of the box**
  - **Fill in the location and dimension as shown below**

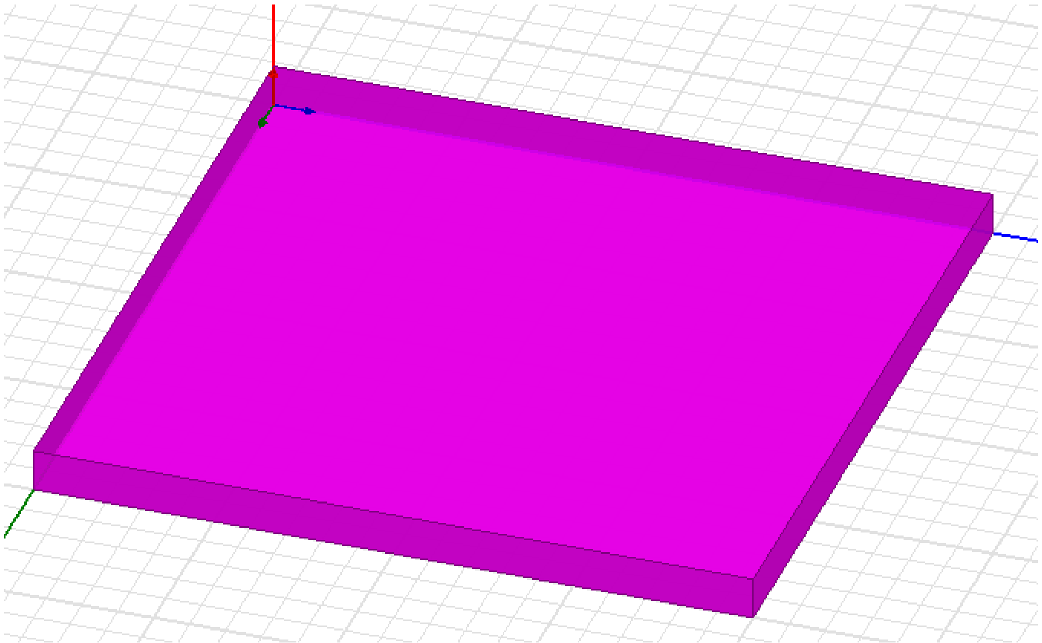
Creating the Microstrip (1): Substrate



- **Click OK**
- **You may need to zoom out in order to see your box (scroll down with your mouse to zoom out)**

Creating the Microstrip (1): Substrate

You should have a box that looks like this

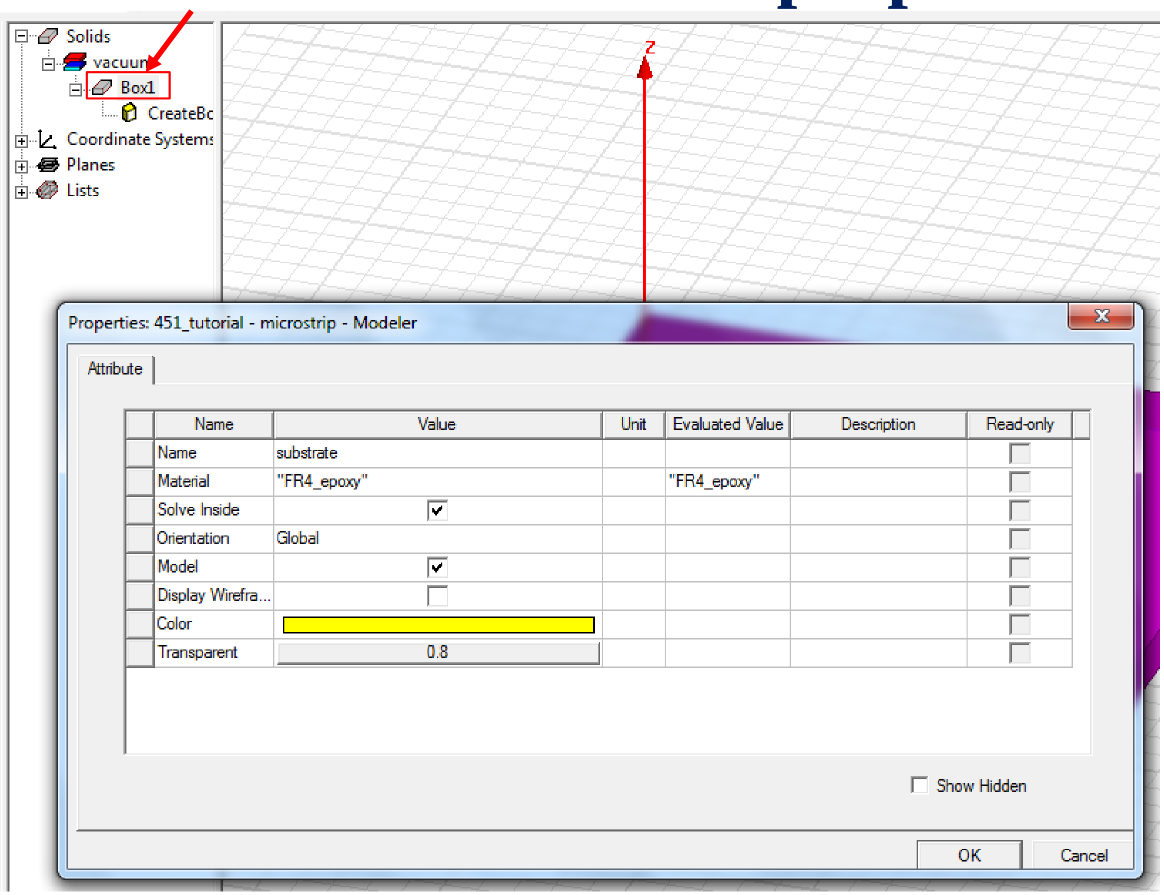


- **To change your view in 2D, hold <u>Shift + left click and drag</u>**
- **To change your view in 3D, hold <u>Alt + left click and drag</u>**
- **To fit the view in the 3D modeler window: <u>Ctrl+D</u>**

Creating the Microstrip (1): Substrate

This box now has the dimensions that we want for our substrate. The next step is to define the material of our substrate.

- **Double click on "Box1" and fill in the properties as shown below**
- **Details on next slide**



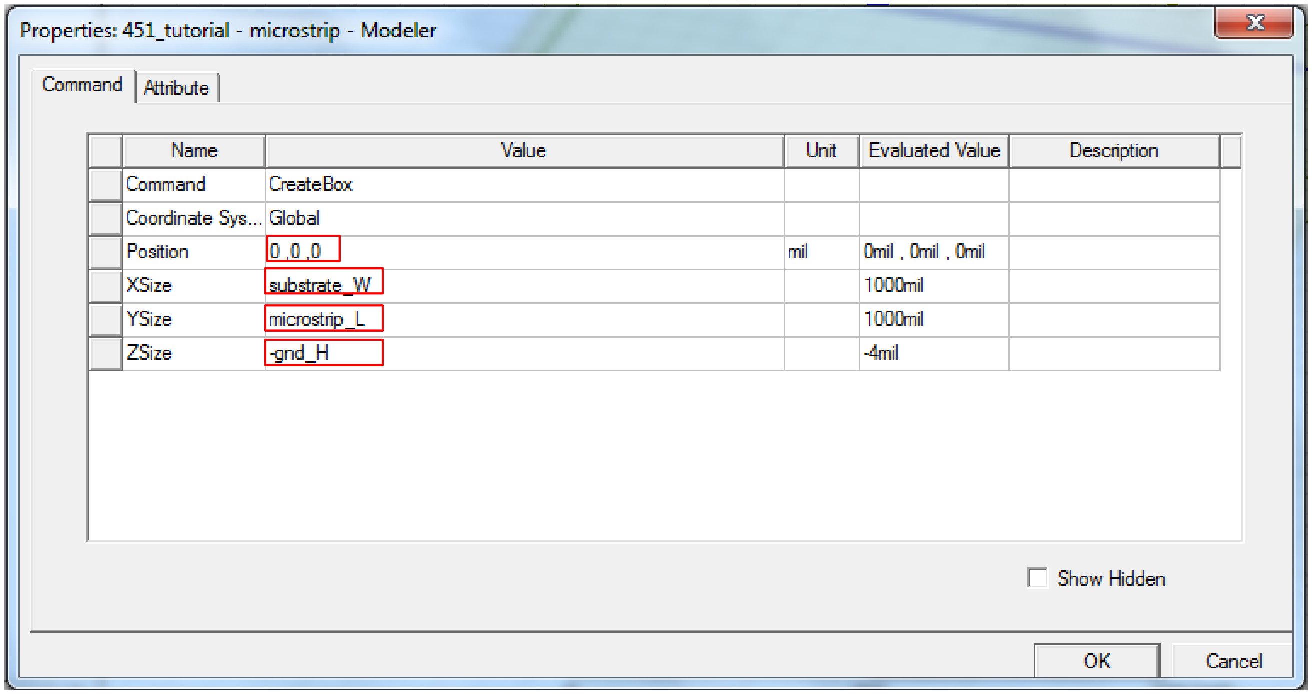
Creating the Microstrip (1): Substrate

- Change the name from Box1 to substrate
- Change the material from vacuum to FR4_epoxy
  - Select Edit from the material drop down menu
  - In the Search by Name box, type in fr
    - FR4_epoxy should be highlighted
  - Click OK
- Change the color to whatever you want
- Change the transparency to 0.8

Creating the Microstrip (2): Gnd Plane

Now we are going to make the ground plane

– **Draw another arbitrary sized box and fill in the location and dimension as shown below**



Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	0 ,0 ,0	mil	0mil , 0mil , 0mil	
XSize	substrate_W		1000mil	
YSize	microstrip_L		1000mil	
ZSize	-gnd_H		-4mil	

– **Make sure the ground height is negative**

- **Alternatively, you could make the position 0,0,-gnd_H and keep the ZSize positive**

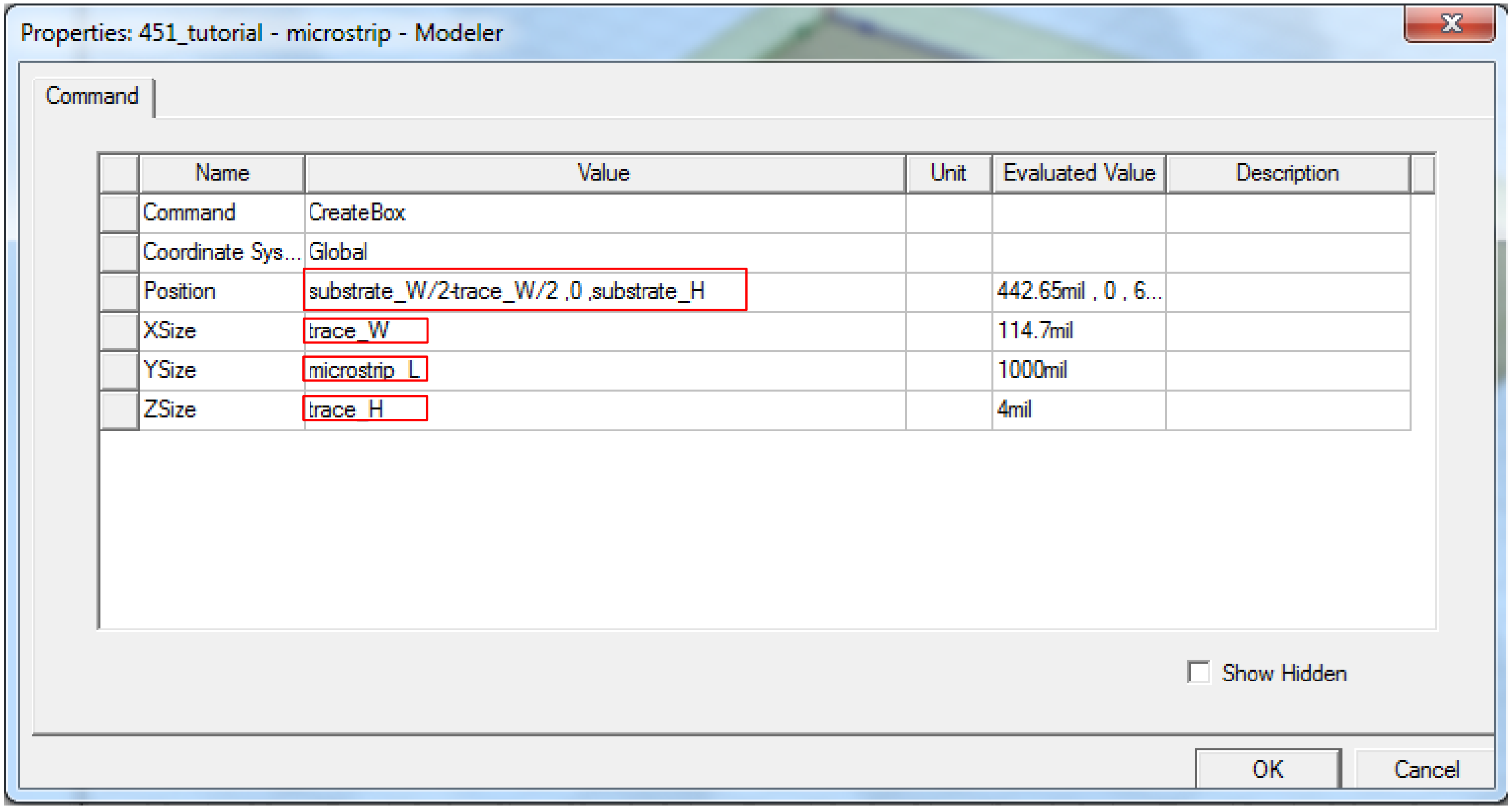
Creating the Microstrip (2): Gnd Plane

Now we have our ground plane with the correct dimensions and location, but still need to change the material.

- **Double click on Box1**
- **Change the name to gnd_plane**
- **Change the material to copper**
- **Change the color**
- **Make the transparency 0.8**

Creating the Microstrip (3): Trace

The last part of building our microstrip line is to add the microstrip trace. To do this, create another box and fill in the location and dimensions as shown below.



Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	substrate_W/2-trace_W/2 ,0 ,substrate_H		442.65mil , 0 , 6...	
XSize	trace_W		114.7mil	
YSize	microstrip_L		1000mil	
ZSize	trace_H		4mil	

Creating the Microstrip (3): Trace

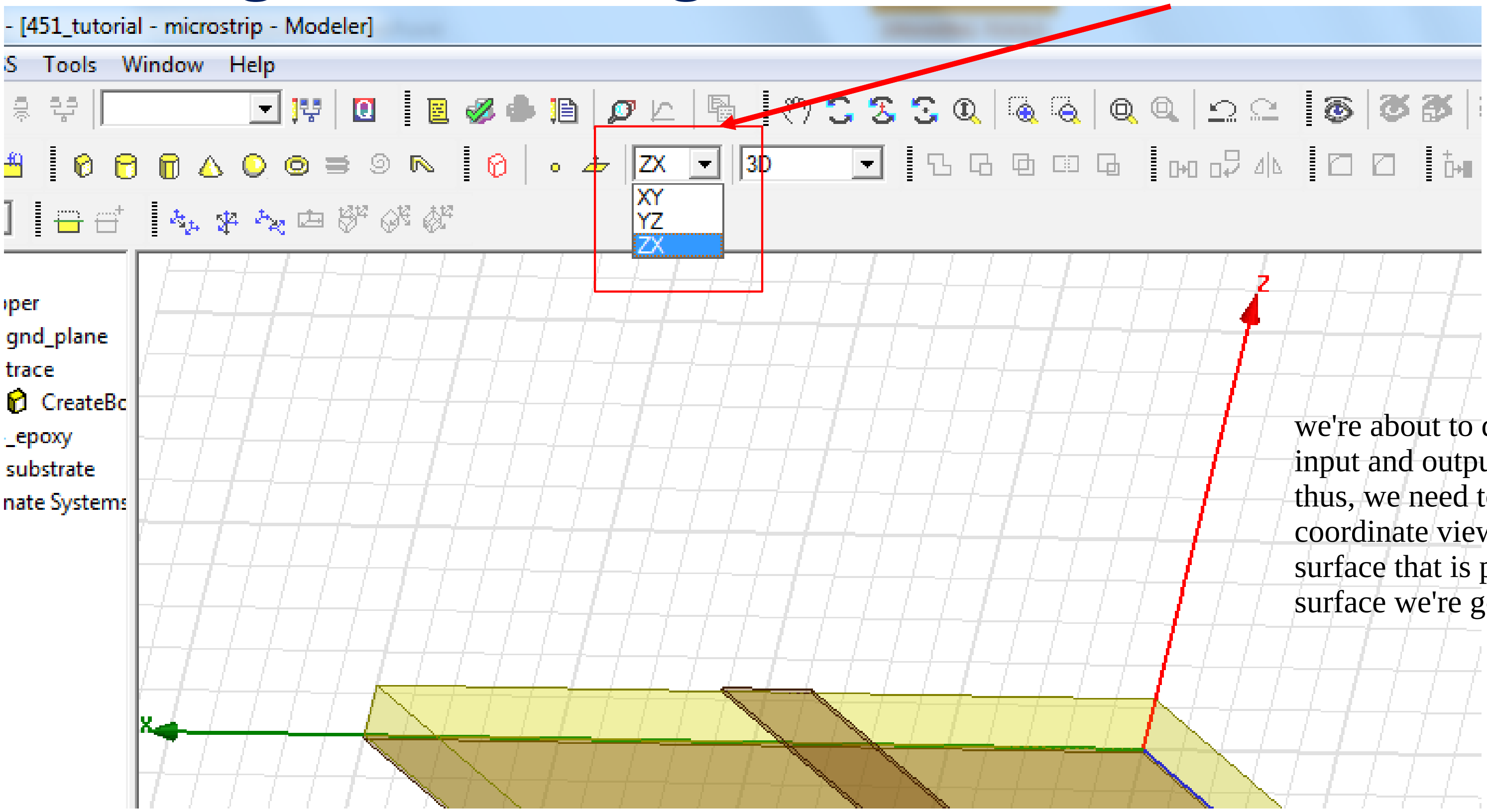
Again we need to change the material

- Double click on Box1
- Change the name to trace
- Change the material to copper
- Change the color
- Make the transparency 0.8

Creating the Excitation

Our model for our microstrip line is almost complete and ready to simulate. We still need to define the excitation for our model.

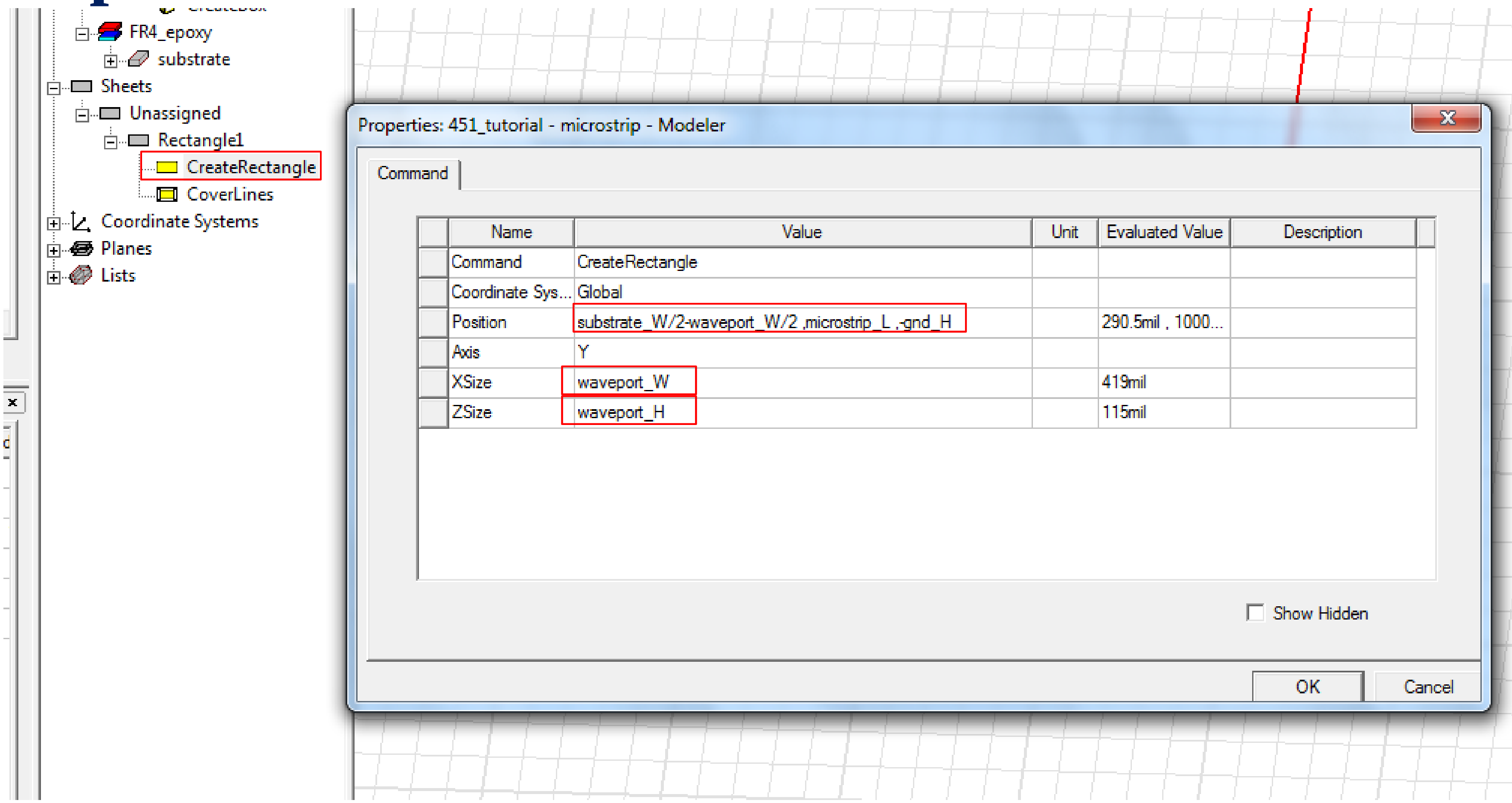
- **Change the Drawing Plane from XY to ZX**



we're about to draw 2 surfaces as input and output (as seen below), thus, we need to move the coordinate view into the principal surface that is parallel to the surface we're going to draw.

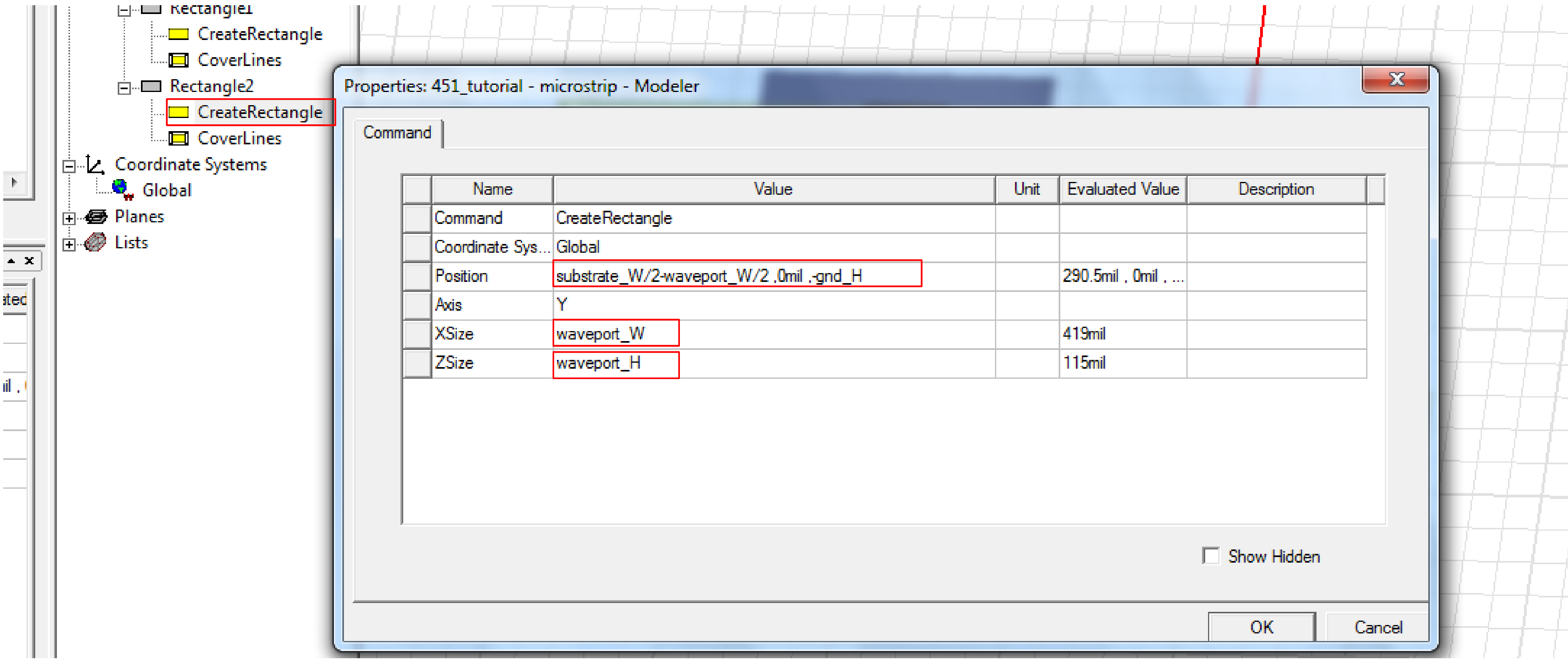
Creating the Excitation

- **Draw a rectangle (not a box)**
- **Double click on create rectangle and fill in the position and dimensions as shown below**



Creating the Excitation

- **Draw a second rectangle**
- **Double click on create rectangle and fill in the position and dimensions as shown below**



Creating the Excitation

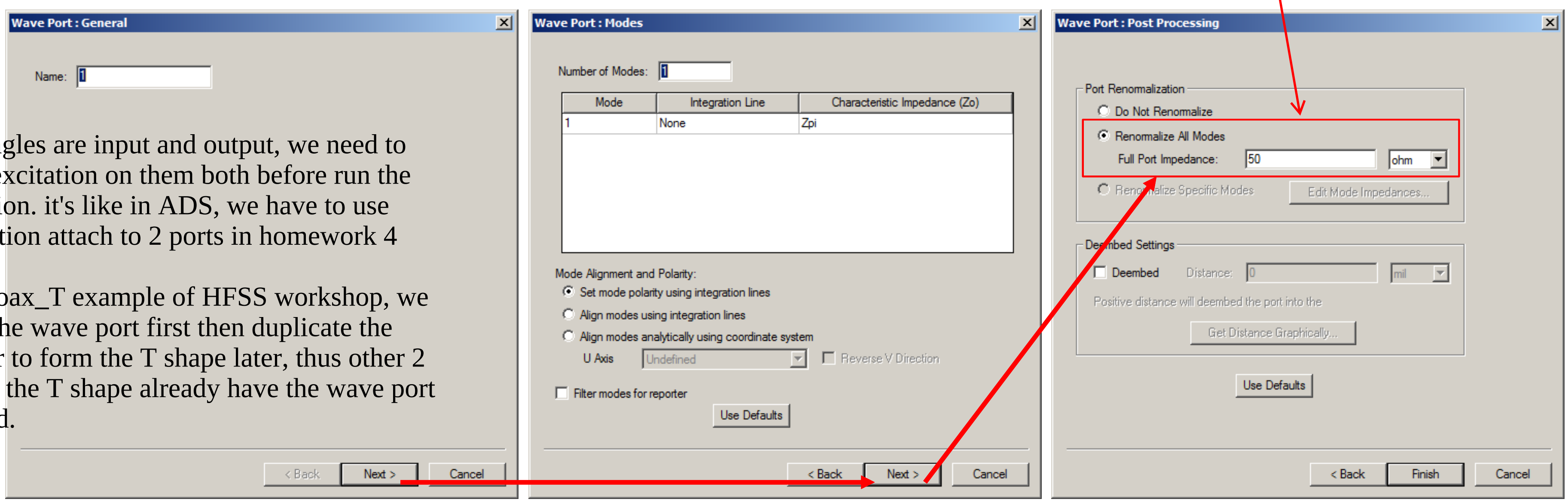
– Right click rectangle 2→Assign Excitation→Wave Port

- Wave Port: General – leave the port number 1 and click Next
- Wave Port: Modes – leave default settings and click Next
- Wave Port: Post Processing – select Renormalize All Modes and leave the Full Port Impedance as 50 Ohms
- Click Finish

if we dont this step, we still have another chance to do it when export the data to touchstone file. There will be an option says "Override Solution Renormalization" with the option 50Ohms as default.

2 rectangles are input and output, we need to assign excitation on them both before run the simulation. it's like in ADS, we have to use termination attach to 2 ports in homework 4

in the coax_T example of HFSS workshop, we assign the wave port first then duplicate the cylinder to form the T shape later, thus other 2 ports of the T shape already have the wave port assigned.

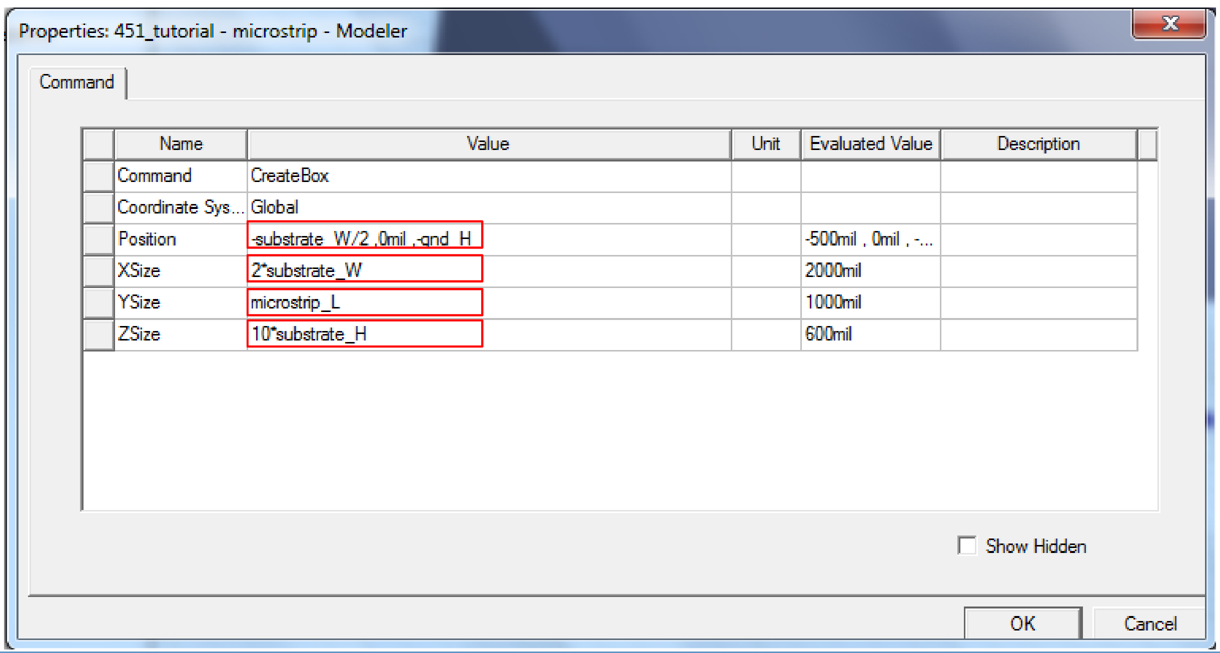


– Repeat the steps above to make rectangle 1 Wave Port 2

Creating the Air Box

HFSS treats the space around your design that hasn't been designated as a specific material as PEC. Because of this, we need to define an airbox around our design.

- **Change the Drawing Plane back from ZX to XY**
- **Draw a box and fill in the values as shown below**



Properties: 451_tutorial - microstrip - Modeler

Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-substrate_W/2 ,0mil ,-gnd_H		-500mil , 0mil , -...	
XSize	2*substrate_W		2000mil	
YSize	microstrip_L		1000mil	
ZSize	10*substrate_H		600mil	

Show Hidden

OK Cancel

Creating the Air Box

- **Double click on Box1**
  - **Rename it as airbox**
  - **Change the material to air**
  - **Change the color**
  - **Make the transparency 0.8**

Add Solution Setup

Click on HFSS→Analysis Setup→Add Solution Setup

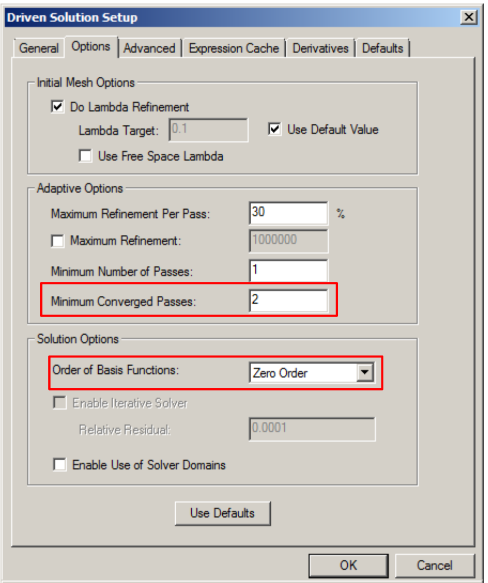
General Tab:

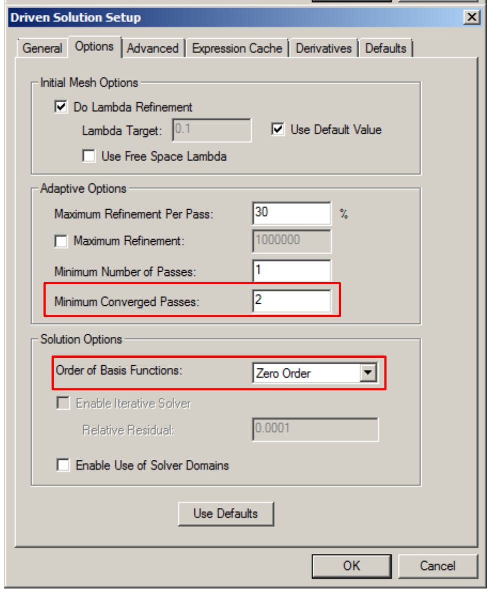
- Solution Frequency: 10 GHz
- Maximum Number of Passes: 20
- Maximum Delta S: 0.02

Options Tab:

- Minimum Converged Passes: 2
- Order of Basis Function: Zero Order

Click OK

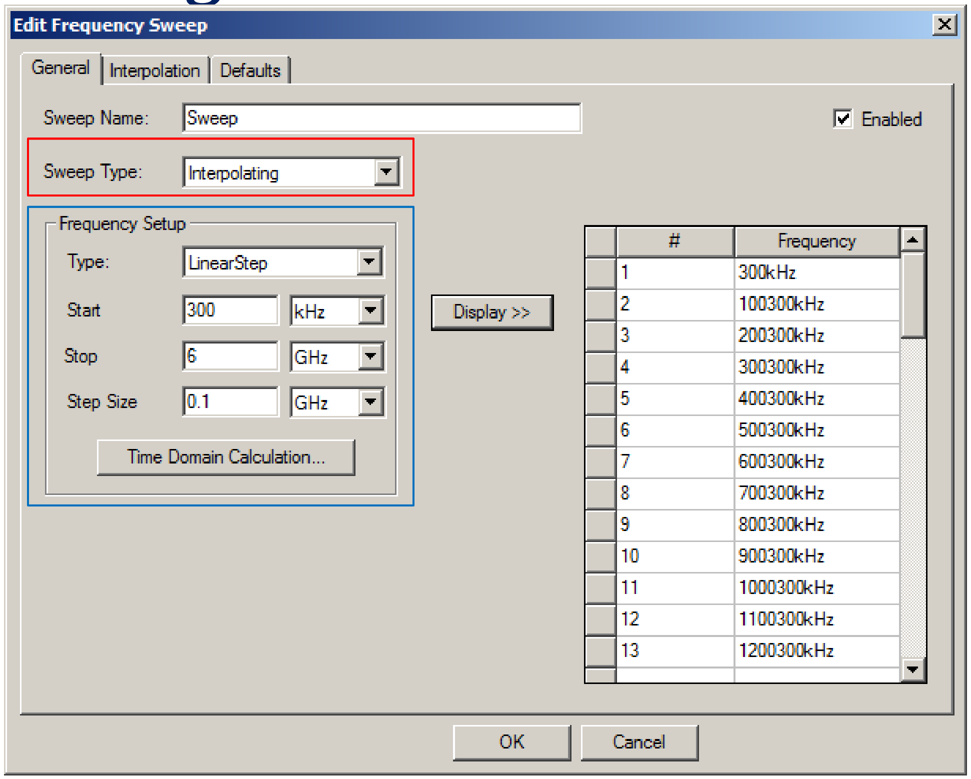




Add Frequency Sweep

Click on HFSS→Analysis Setup→Add Frequency Sweep

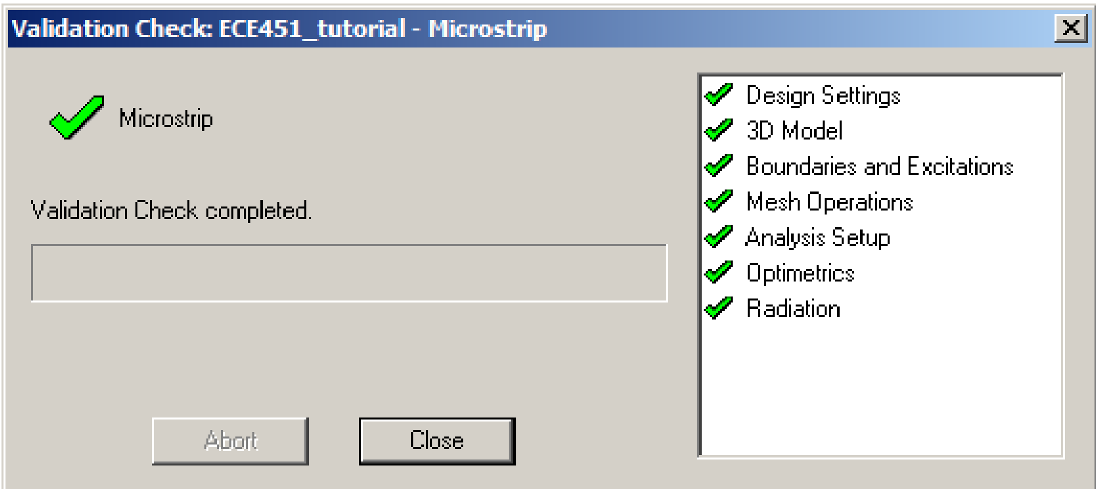
- **Select Setup1 and click OK**
- **General tab:**
  - **Sweep Type: Interpolating**
  - **Frequency Setup**
    - **Type: Linear Step**
    - **Start: 300 kHz**
    - **Stop: 6 GHz**
    - **Step Size: 0.1 GHz**
- **Click OK**

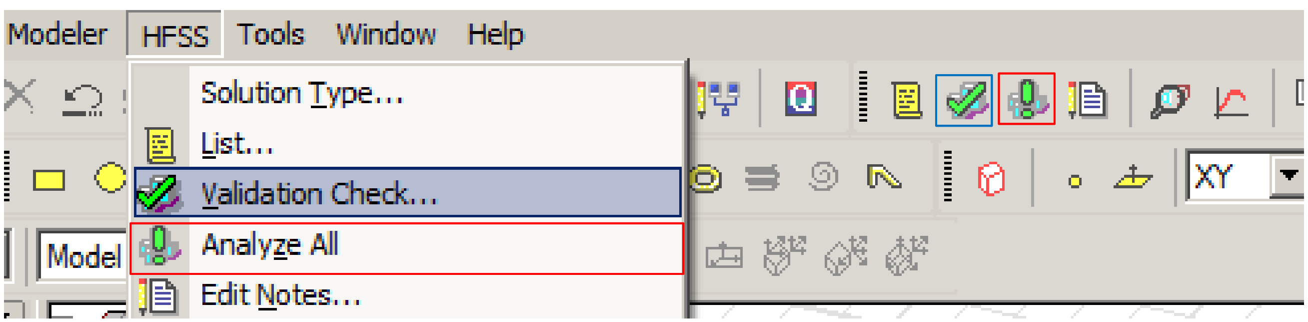


Validation Check and Analyze All

Click on HFSS→Validation Check

- **If everything passes, close the validation check window and you are ready to run your simulation**



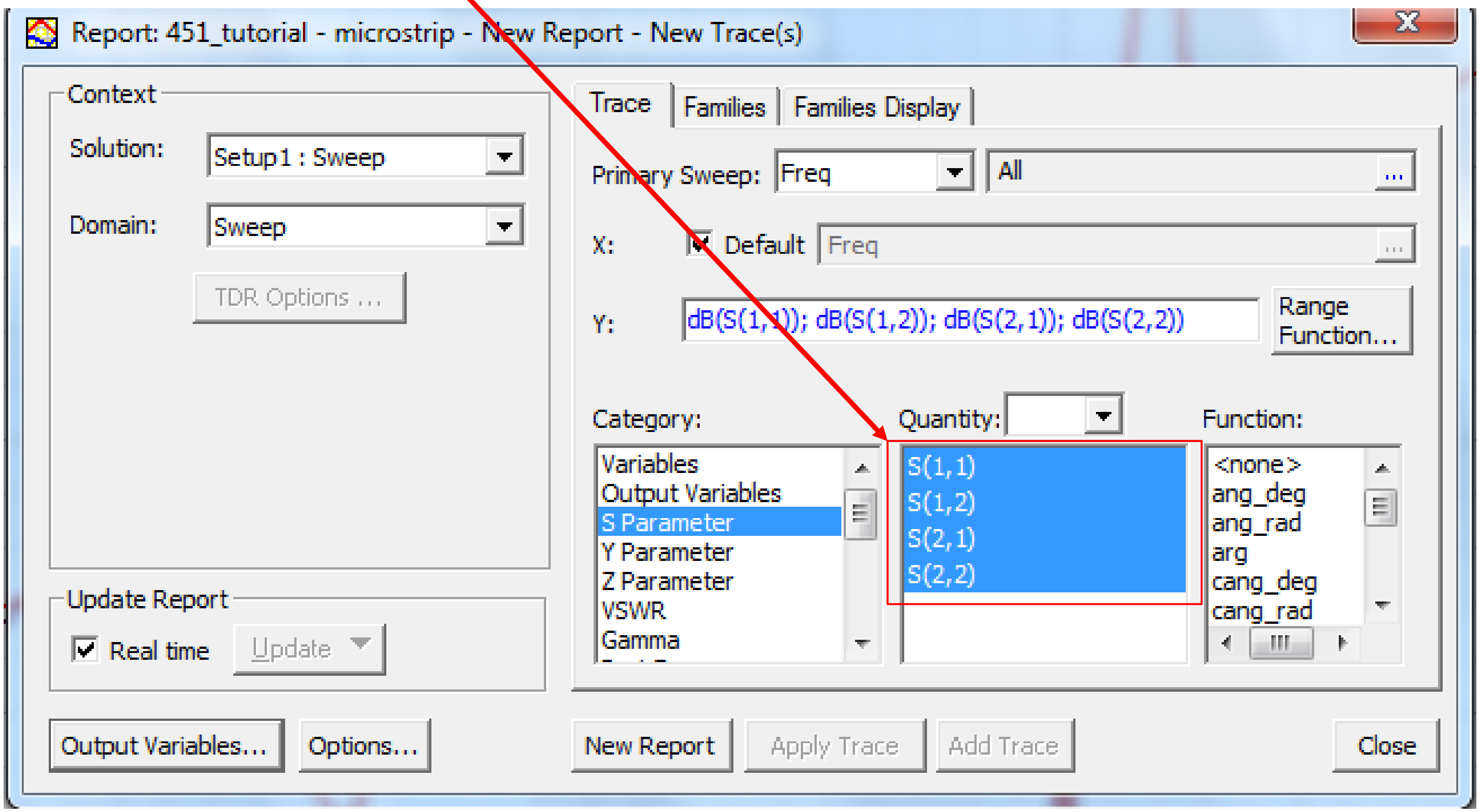


- **HFSS→Analyze All**

Plot S-Parameters

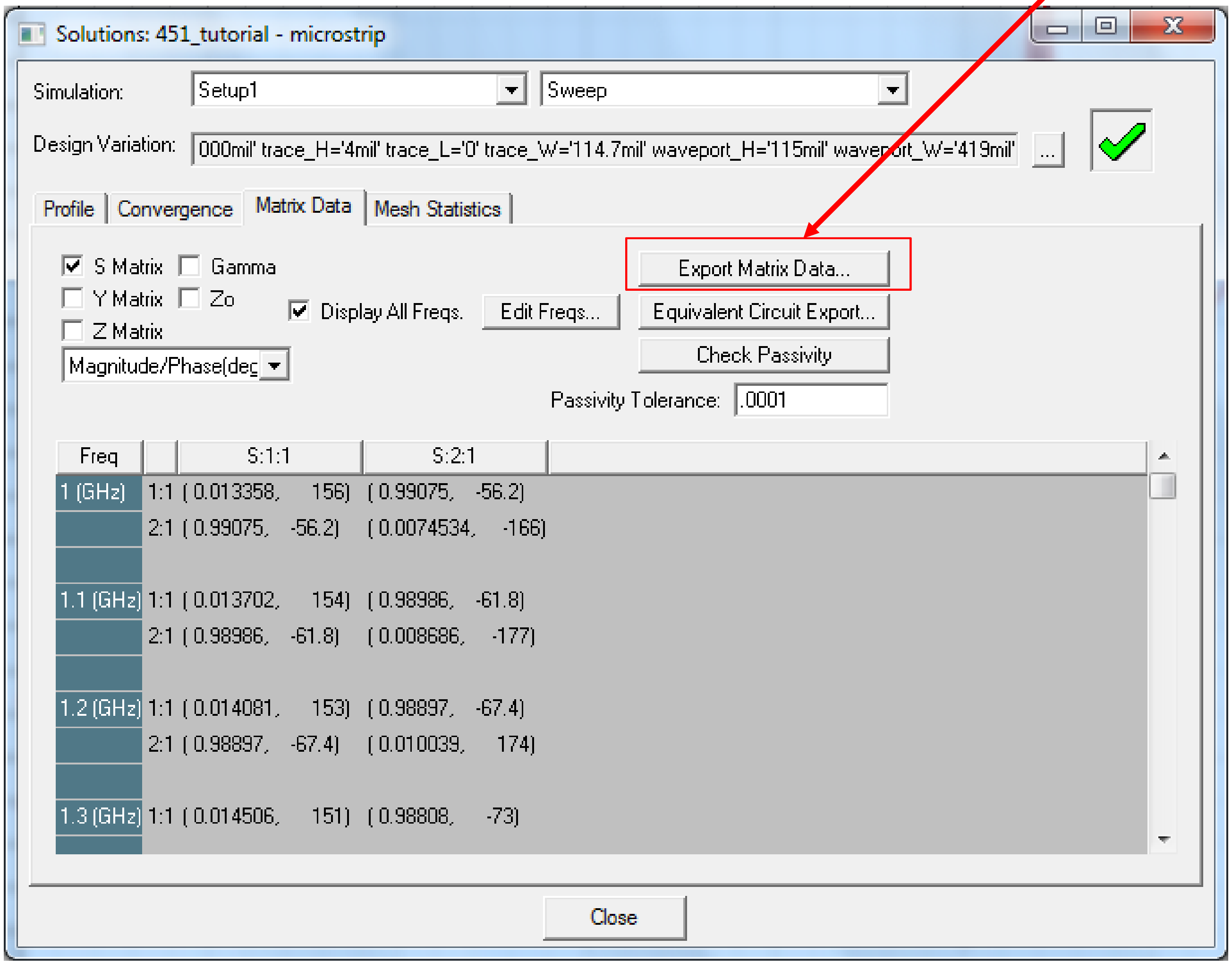
Click on HFSS→Results→Create Modal Solution Data Report→Rectangular Plot

– Select all 4 S-Parameters and click New Report



Exporting S-Parameters

HFSS→Results→Solution Data→Export Matrix Data



Reference:

- ECE 451: Planar Transmission Lines by Professor Jose E. Schutt-Aine
- ECE 546: ANSYS HFSS Tutorial by Tianjian Lu