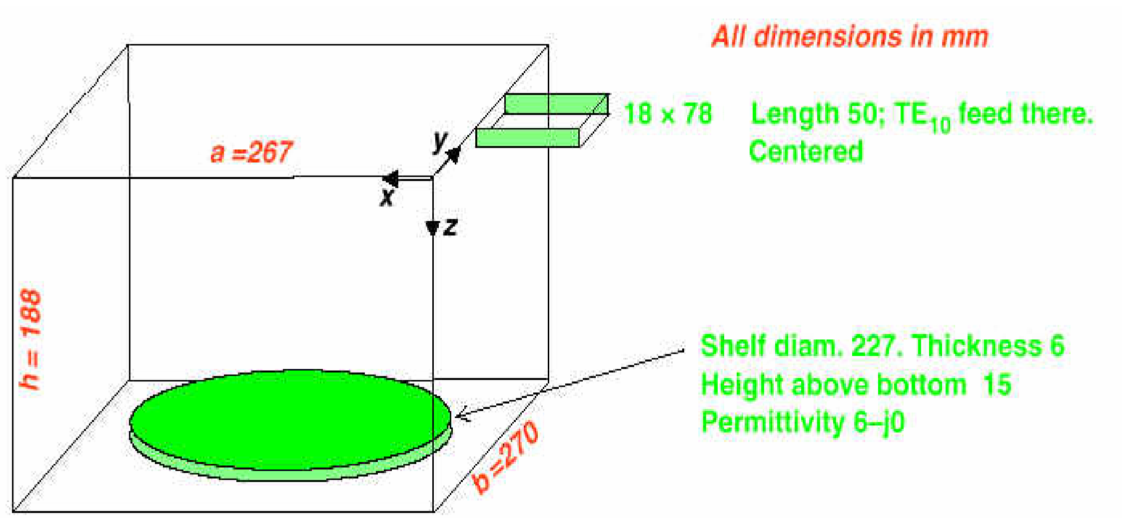
The intent of this tutorial is to simulate a realistic domestic microwave oven using Ansoft's HFSS. This example is available in the website: http://www.qwed.com.pl, where solutions are provided from the commercial software package QuickWave 3-D, which is based on the Finite Difference Time Domain method. The user is invited to compare the results of this tutorial against the results posted on the QuickWave 3-D website.



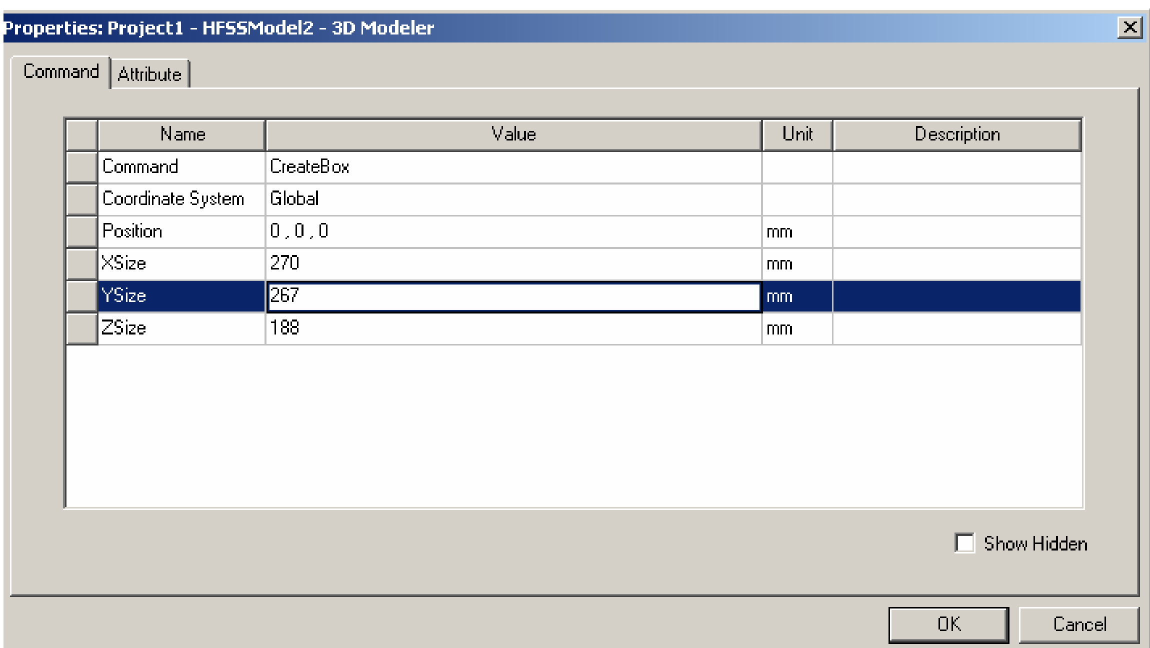
Microwave oven cavity for modeling

Creating the 3-D model

The first step in simulating any design in HFSS is to construct the structure in 3-D. In the case of this design the following procedure should be followed:

Drawing the oven walls:

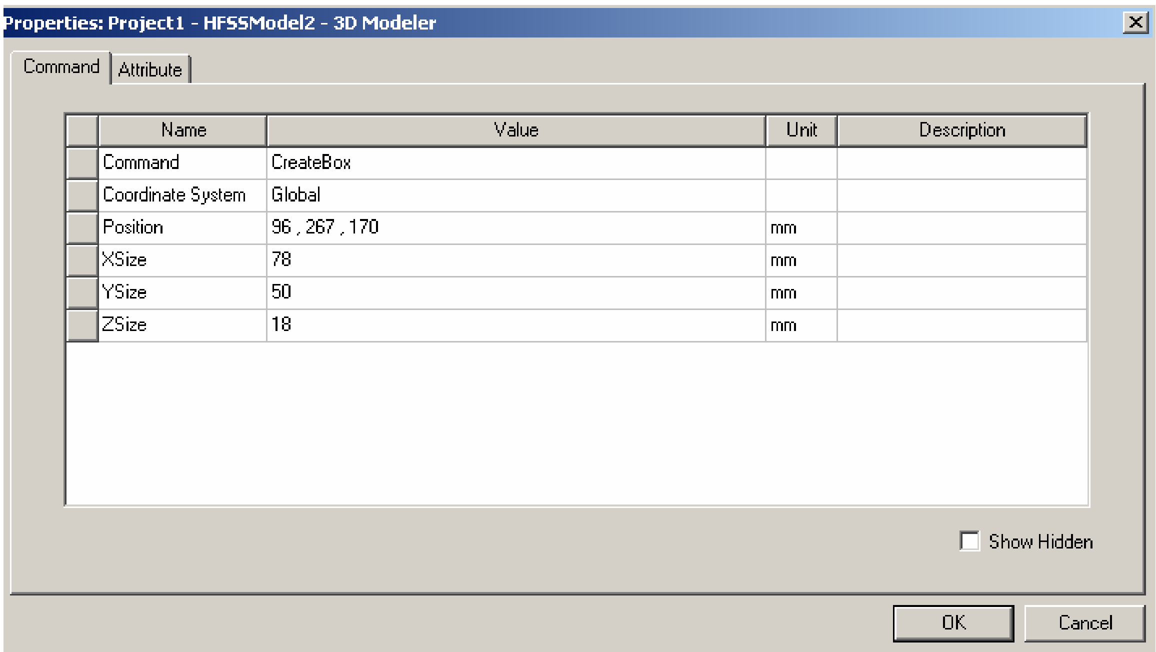
The oven cavity and its walls can be represented by drawing a box. To draw a box, simply choose the  icon from the toolbar, left click in the drawing area until a new window appears. In this window enter the following parameters (these will define the dimensions and position of the box):



Cavity dimensions

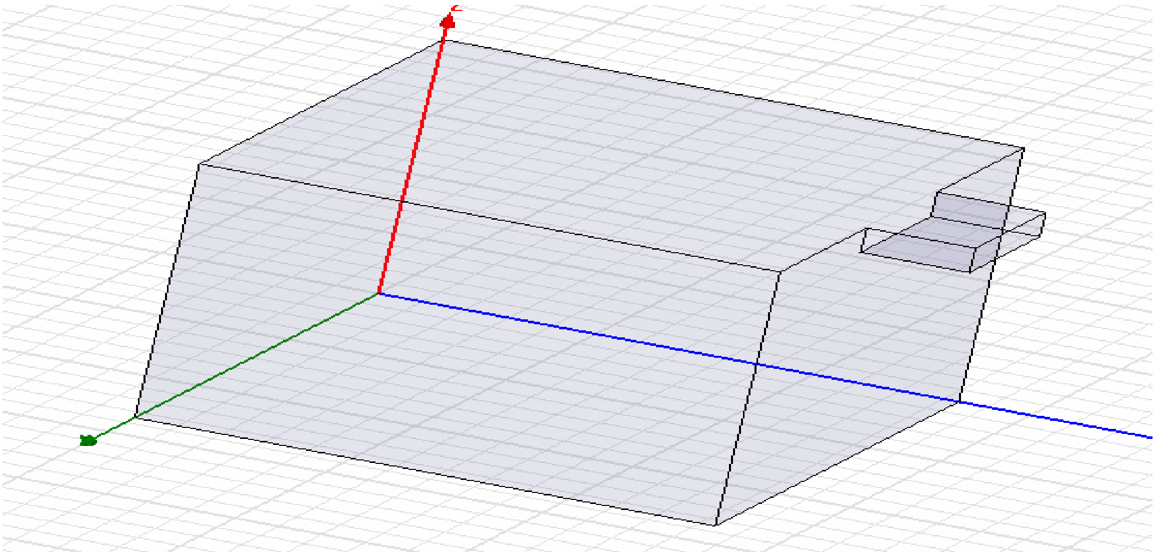
Drawing the waveguide:

The waveguide is created by a box. Repeat the process described previously to draw a box with the following parameters:



Waveguide dimensions

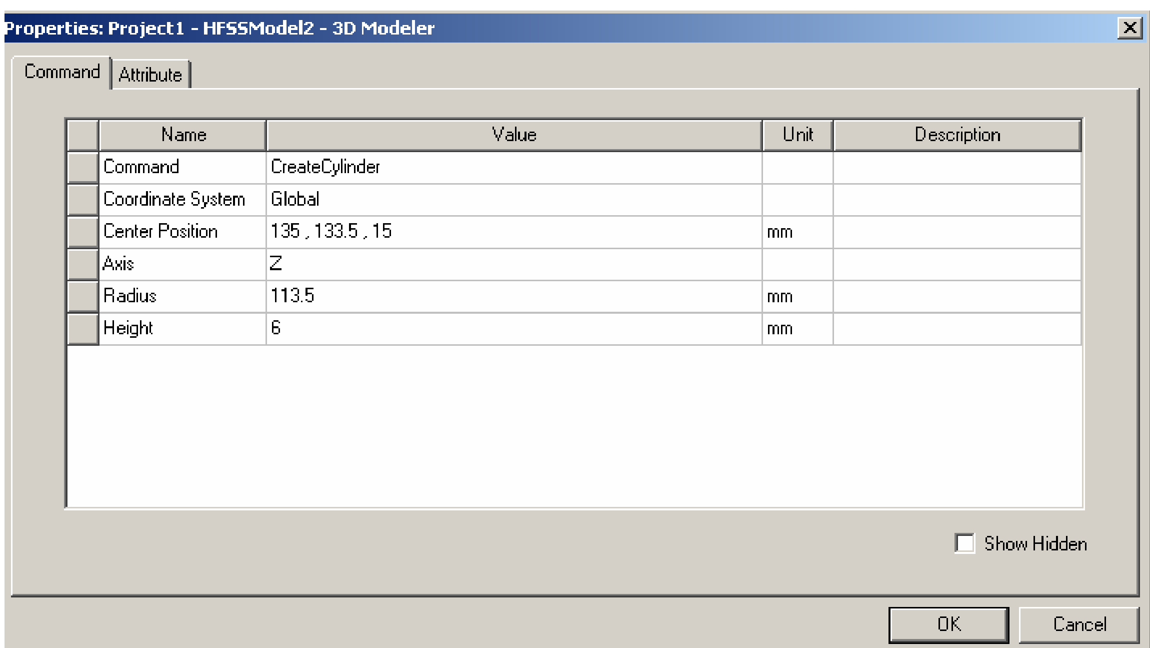
Next, the user will unite the two boxes that were drawn. This is done to eliminate the area of intersection of the two boxes. To unite multiple objects, start by selecting the objects by left clicking on them while pressing down the Ctrl key. The objects chosen will be highlited. Next right click and press **Edit>Boolean>Unite**.



Uniting the cavity and coupling waveguide

Drawing the shelf:

The shelf can be represented by drawing a cylinder. To draw a cylinder, simply choose the  icon from the toolbar, left click in the drawing area until a new window appears. In this window enter the following parameters (these will define the dimensions and position of the cylinder):



Properties: Project1 - HFSSModel2 - 3D Modeler

Command | Attribute

Name	Value	Unit	Description
Command	CreateCylinder		
Coordinate System	Global		
Center Position	135 , 133.5 , 15	mm	
Axis	Z		
Radius	113.5	mm	
Height	6	mm	

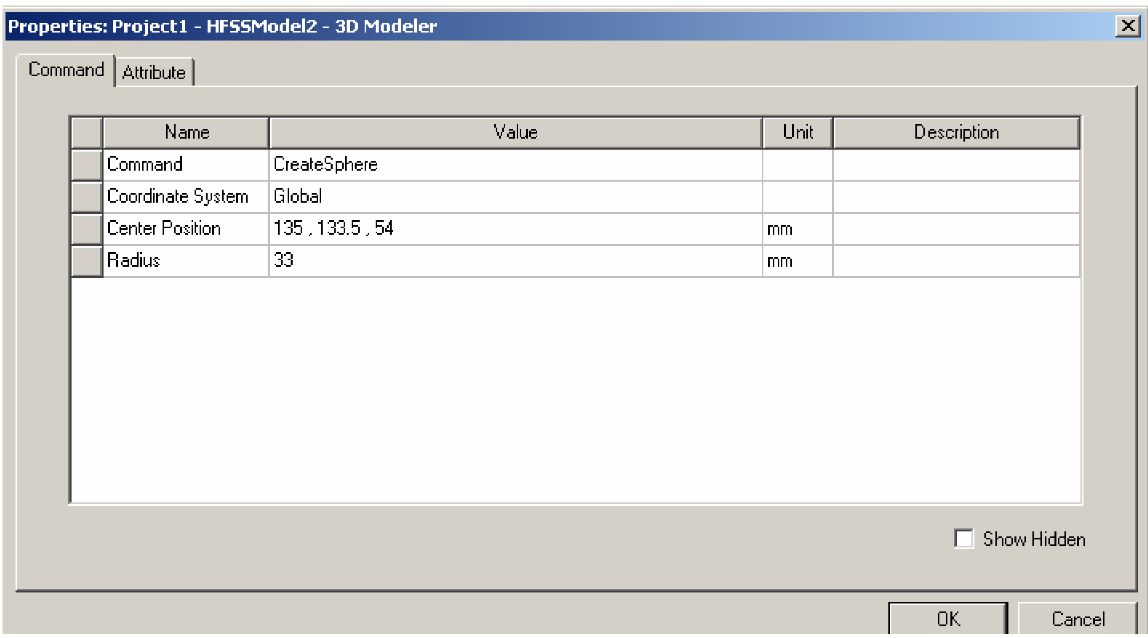
Show Hidden

OK | Cancel

Shelf dimensions

Drawing the potato:

The potato is represented by a sphere. To draw a sphere, simply choose the  icon from the toolbar, left click in the drawing area until a new window appears. In this window enter the following parameters:

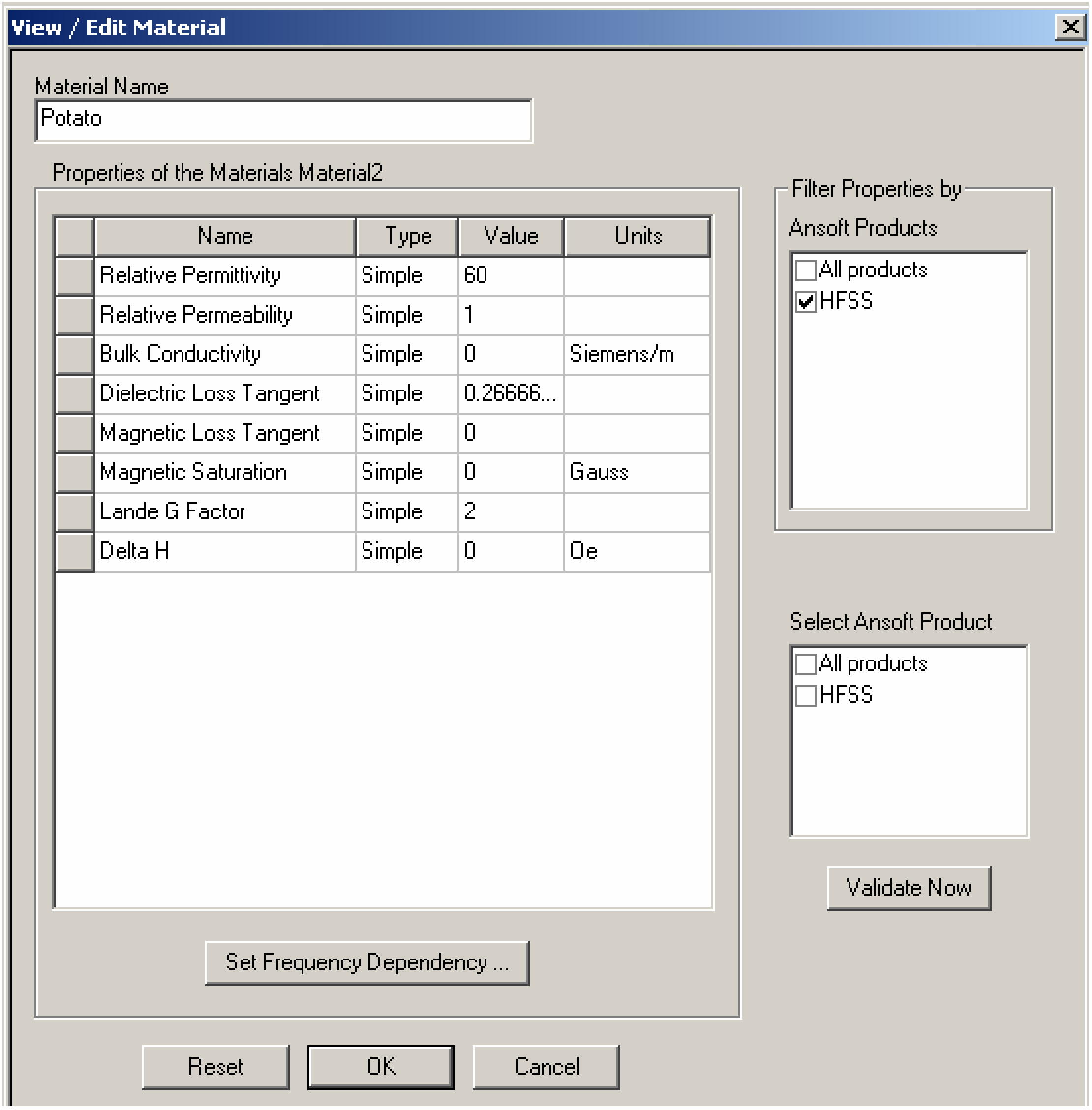


Name	Value	Unit	Description
Command	CreateSphere		
Coordinate System	Global		
Center Position	135 , 133.5 , 54	mm	
Radius	33	mm	

Potato dimensions

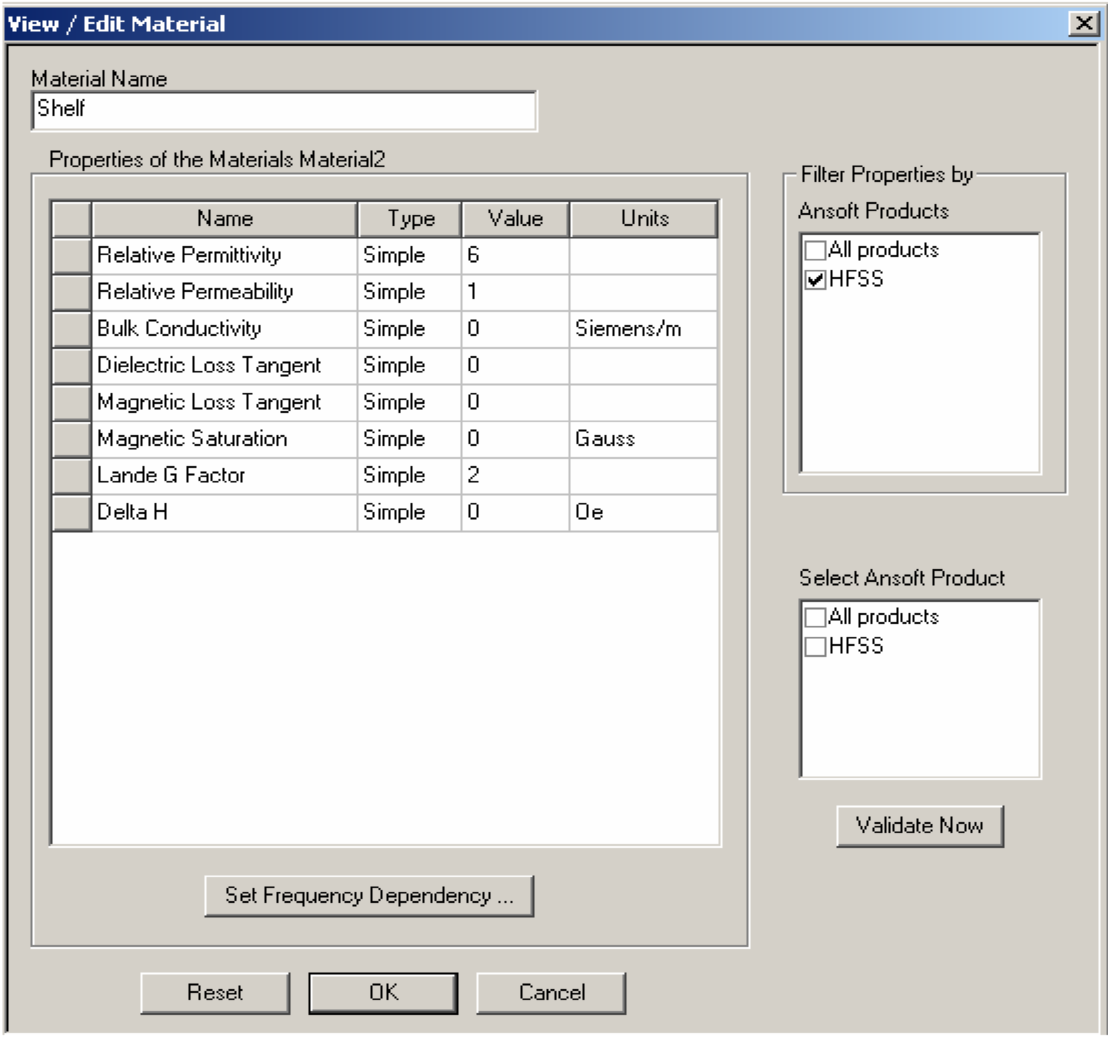
Assigning materials:

Having completed the drawing of the oven and the load, the user will now proceed to assigning material properties to the objects that were created. Start by selecting the sphere that was drawn. Right click and select **Assign material**. A new window will appear, press on **Add material**, a second window will appear. Enter the following parameters in this window then press **OK**.



Material assignment for the load

By doing this, the user has assigned the "potato material" properties to the sphere. Next, the user will assign the shelf material properties to the cylinder. Repeat the same steps as before (starting by selecting the cylinder instead of the sphere), and enter the following parameters in the second window:

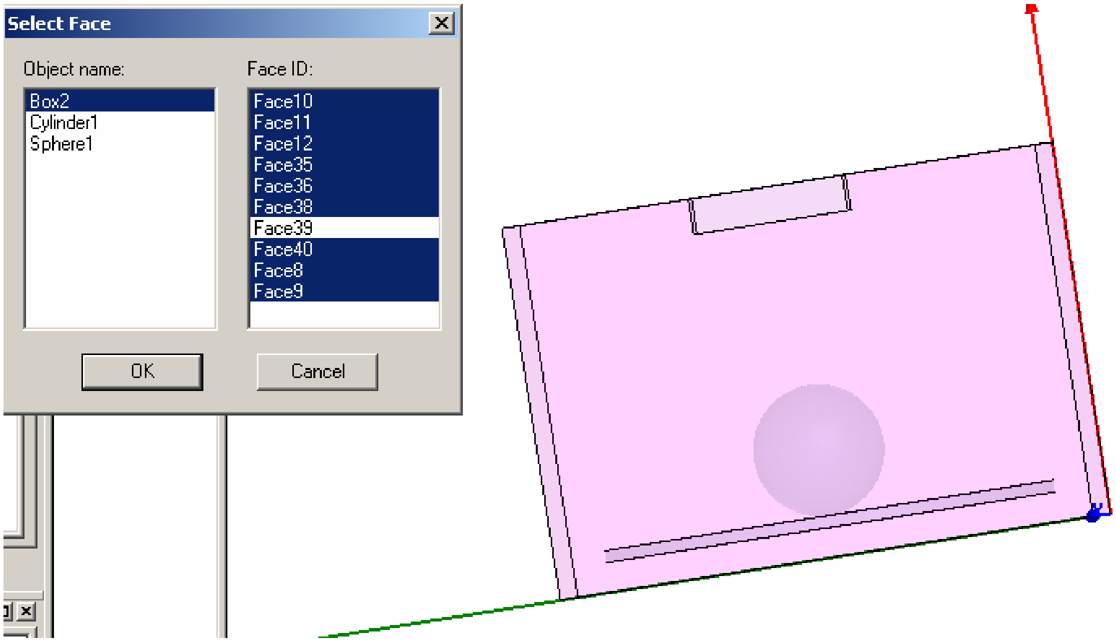


Material assignment for the shelf

Boundary assignment:

Next, the user will define the properties of the cavity walls. Start by pressing the  icon (make sure that **Face** is selected in the selection edit window), a new window will appear, left click on the box object. The names of the faces corresponding to this object will appear in the right column. While pressing down on the **Ctrl** key, select all the faces of the box (left click on their names one by one) except the one correponding to the front side of the waveguide and then press **OK**. Now right click and press **Assign**

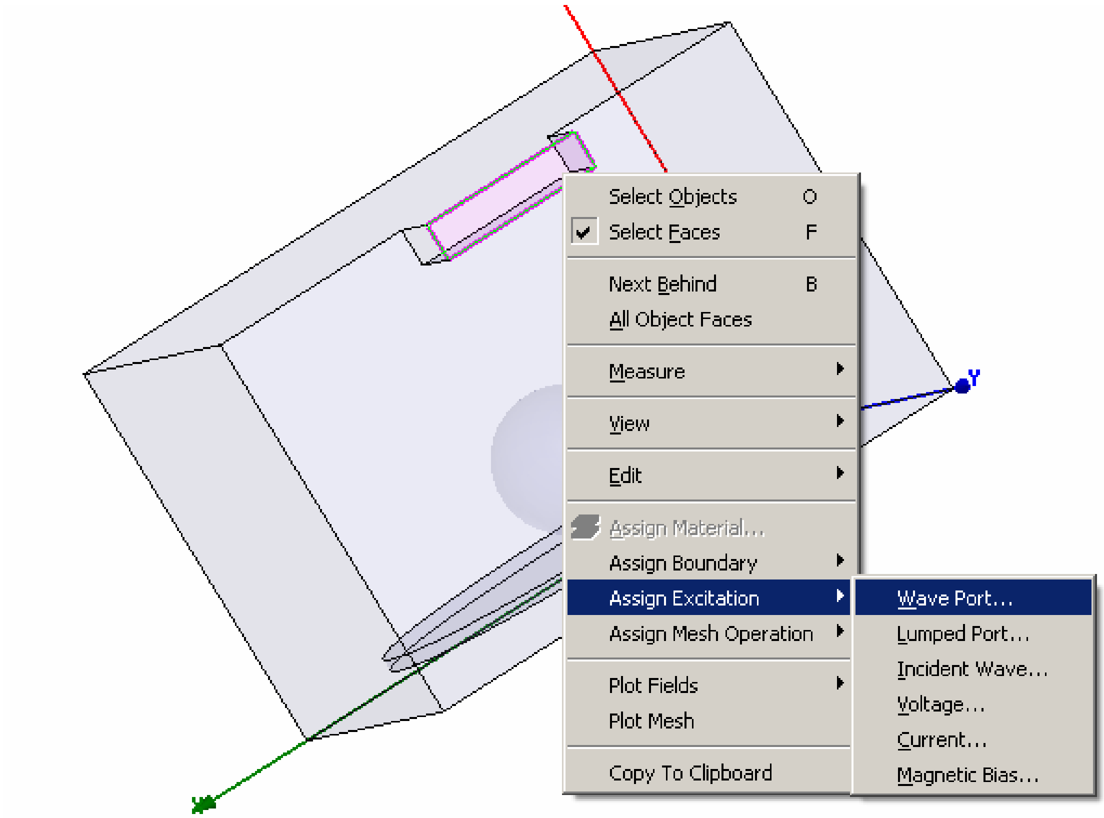
boundary>Perfect E. Do not change anything in the windows that appear, press **Next** and **Finish.**



Face selection for boundary assignment

Excitation assignment:

For the source assignment select the frontmost side of the waveguide, (the only side that was not selected before), right click and choose **Assign excitation>Wave Port**, a window will appear where nothing needs to be changed, just press **Next**.



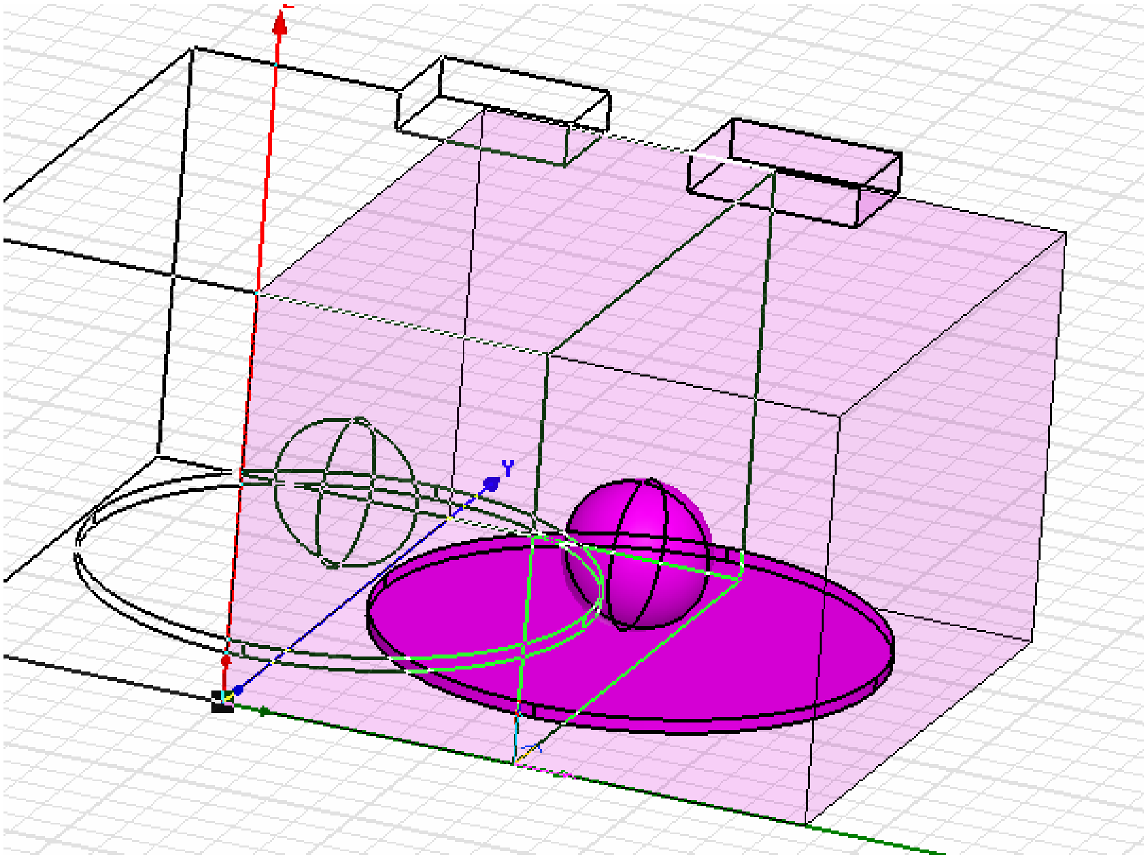
Face selection for excitation assignment

Symmetry:

Since our model is symmetrical with respect to the x = 135 plane, we can reduce the computational time and memory requirements by only simulating half of our model. This is done in three steps:

- **Move**

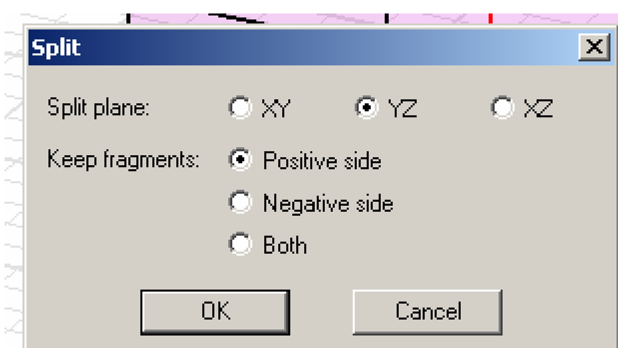
  This step is used to center the model at the yz plane. First select all three objects, next right click and press **Edit>Arrange>Move**. Finally choose the move vector, as shown below, from the center of the lowest side (parallel to the x axis) to the origin.



Centering the model at the yz plane

- **Separate**

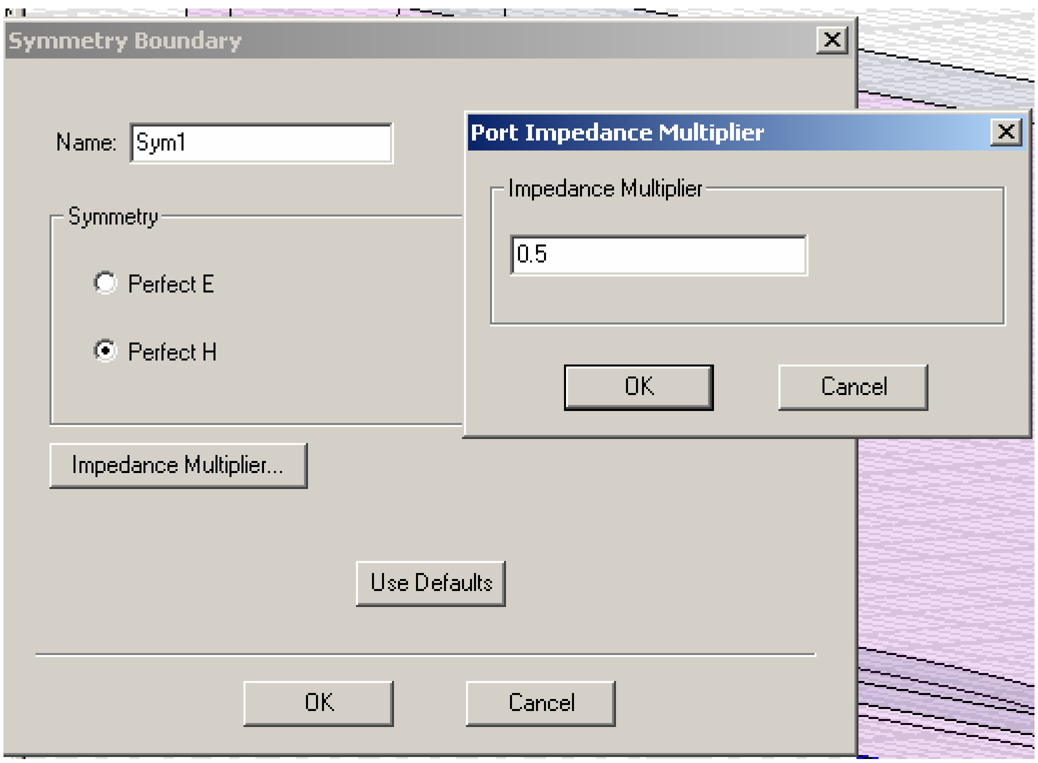
In this step, we will delete half of the model. With all three objects selected, right click and press **Edit>Boolean>Separate** and set the following parameters in the window that appears.



Split parameters

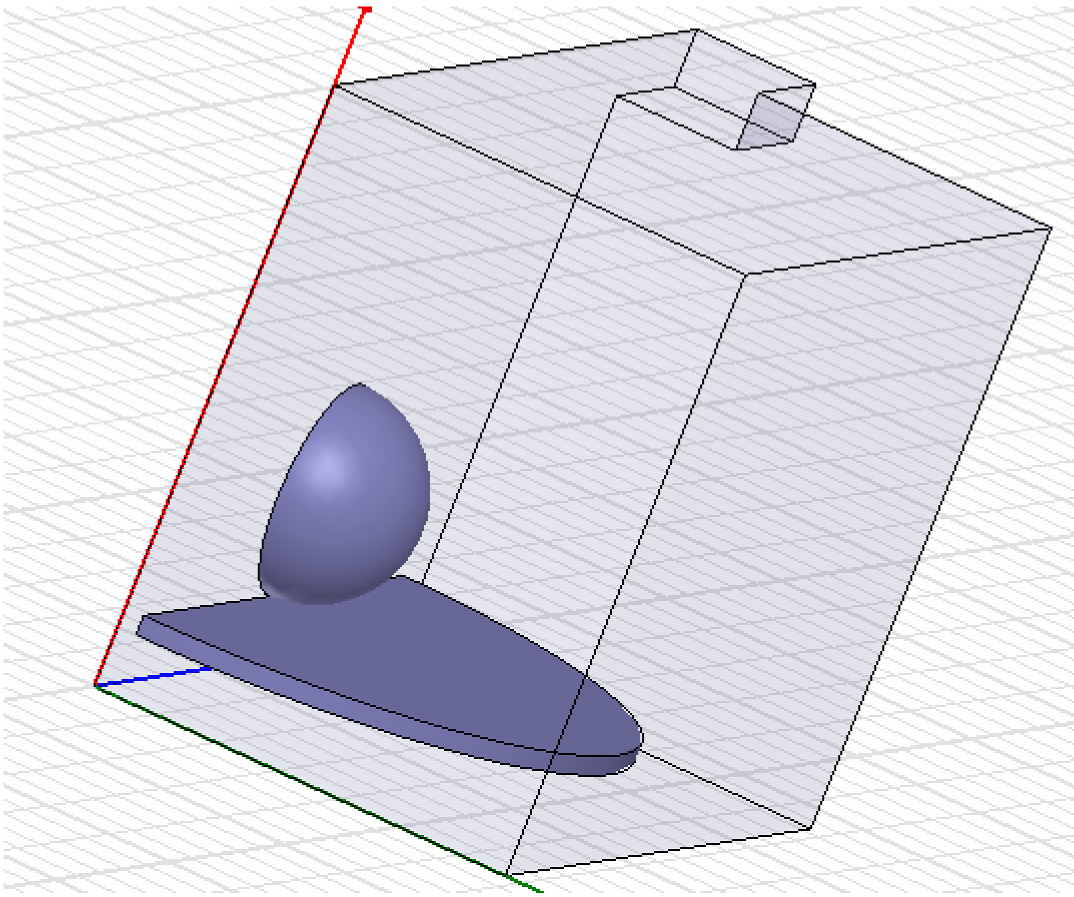
- **Assign symmerty**

  Select the face that was created after the previous step, the one contained in the yz plane, right click and press **Assign Boundary>Symmetry** and set the following parameters in the window that appears.



Symmetry boundary parameters

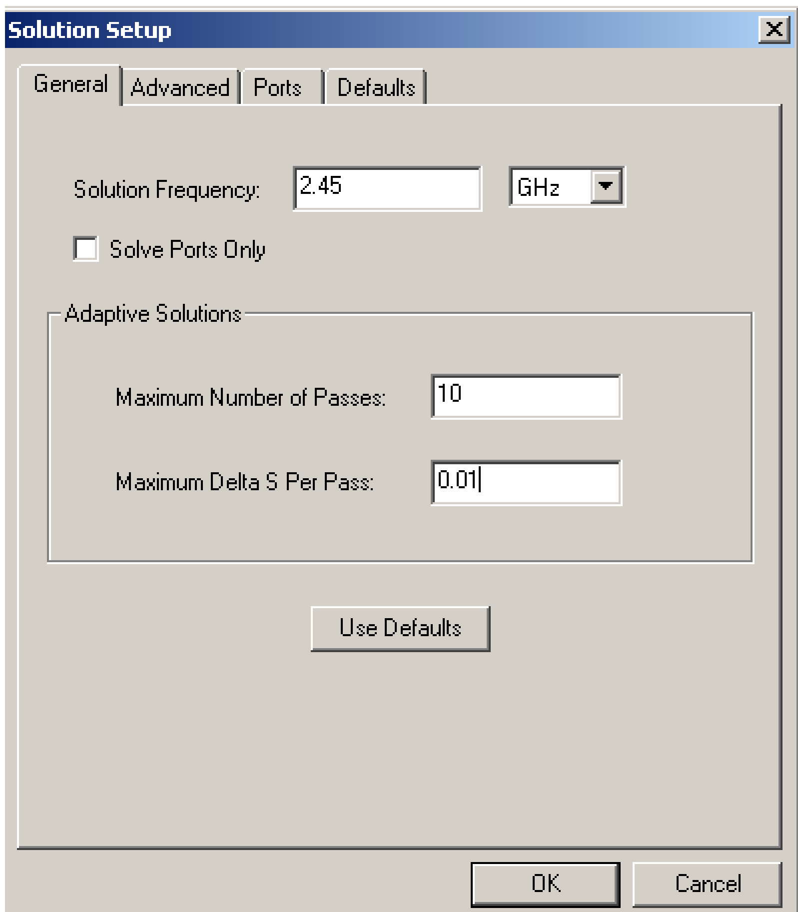
At the end of these steps the user should get a model similar to the one shown below:



Final model

Solution Setup:

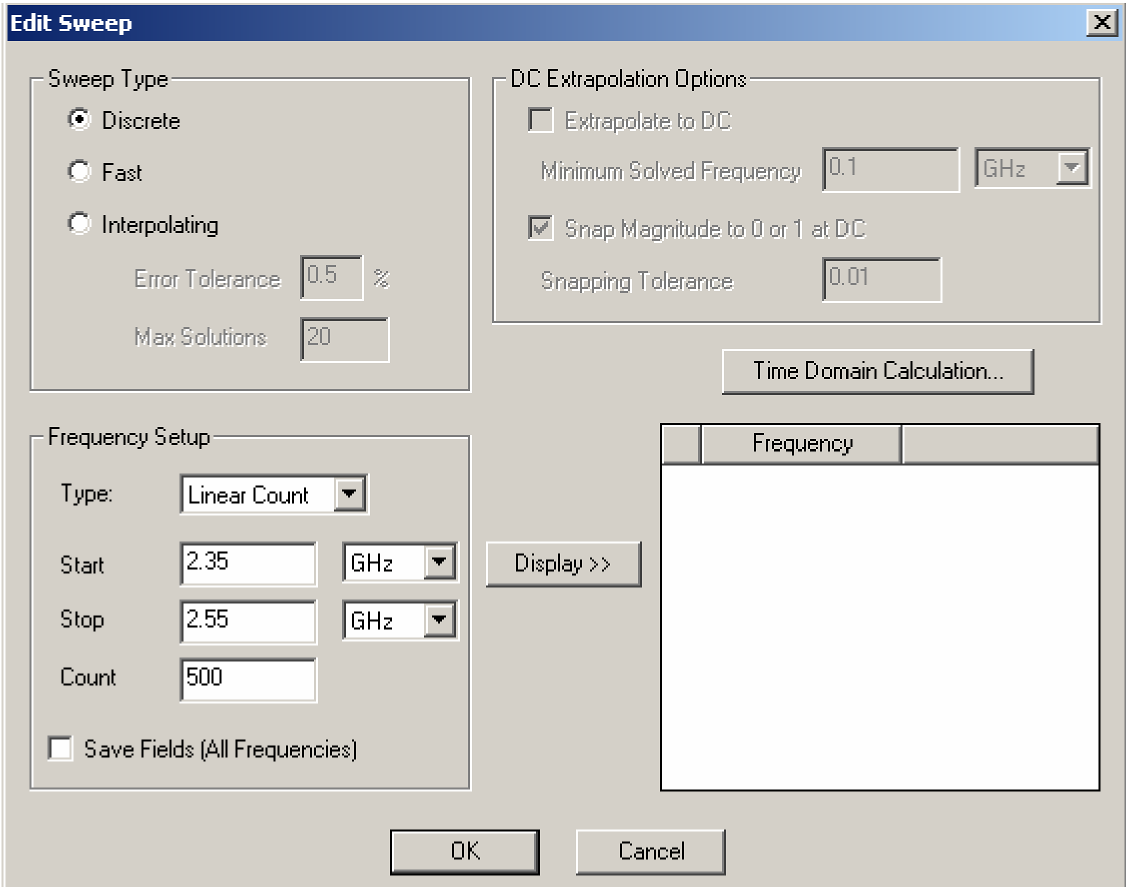
With the model created, the user is now requiered to add a solution setup. This step involves specifying the frequency and the accuracy at which the user wants the design to be simulated at and is done by choosing **HFSS>Analysis>Add Solution Setup**. Enter the following values in the window that appears.



Solution setup parameters

Adding a sweep:

This is done by pressing on **HFSS>Analysis>Add Sweep**. The user will enter the following parameters in the window that appears:

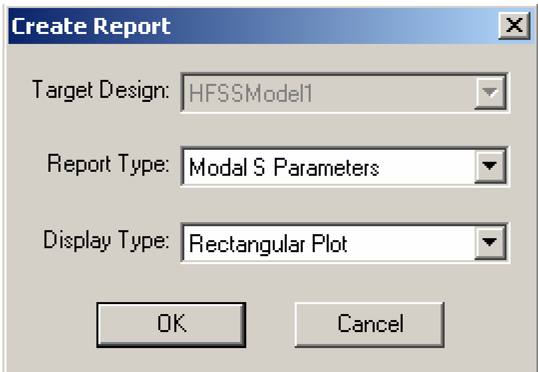


Sweep parameters

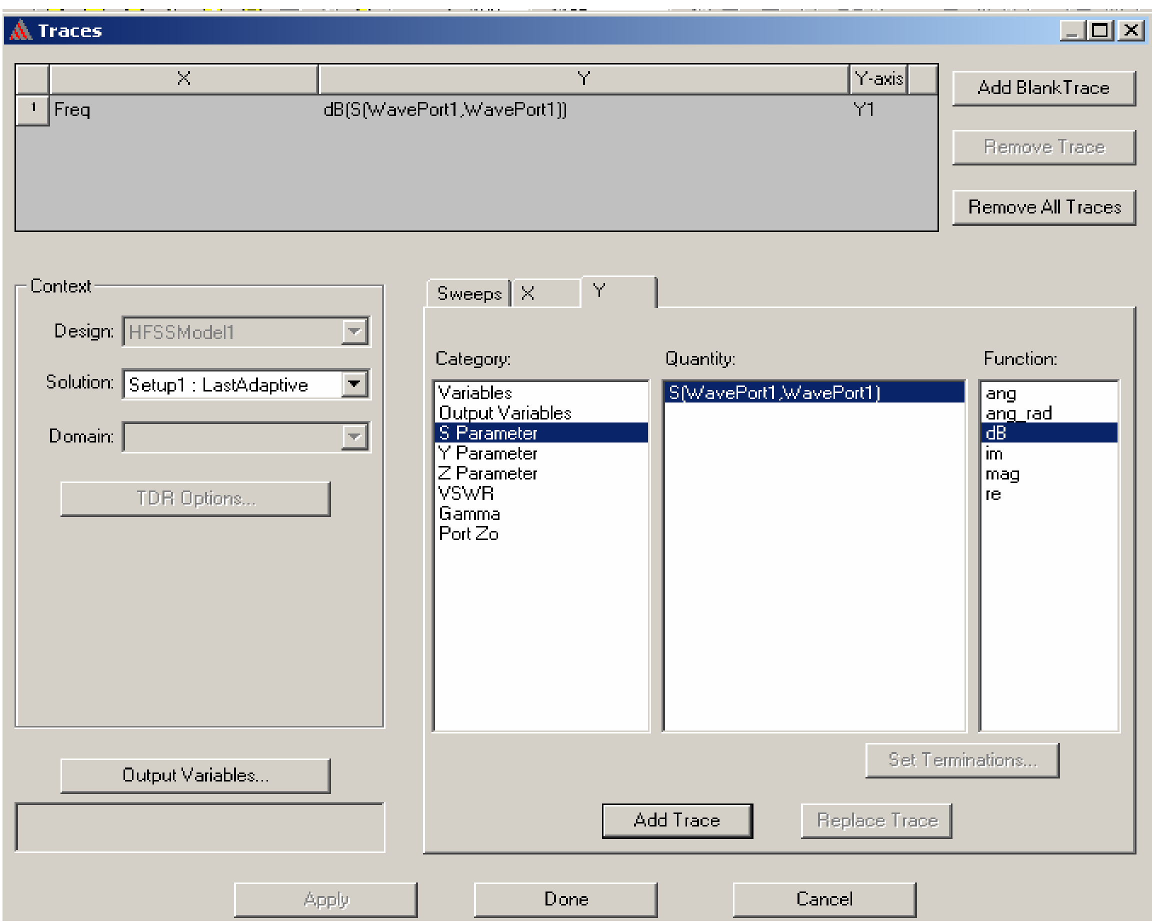
Finally, it is always useful to run the **Validation Checker** before analyzing. This will point out any errors that may have been commited. This is done by pressing on the  icon from the toolbar. If no errors appear then the user can proceed in analyzing his/her design by pressing on the  from the toolbar.

Results:

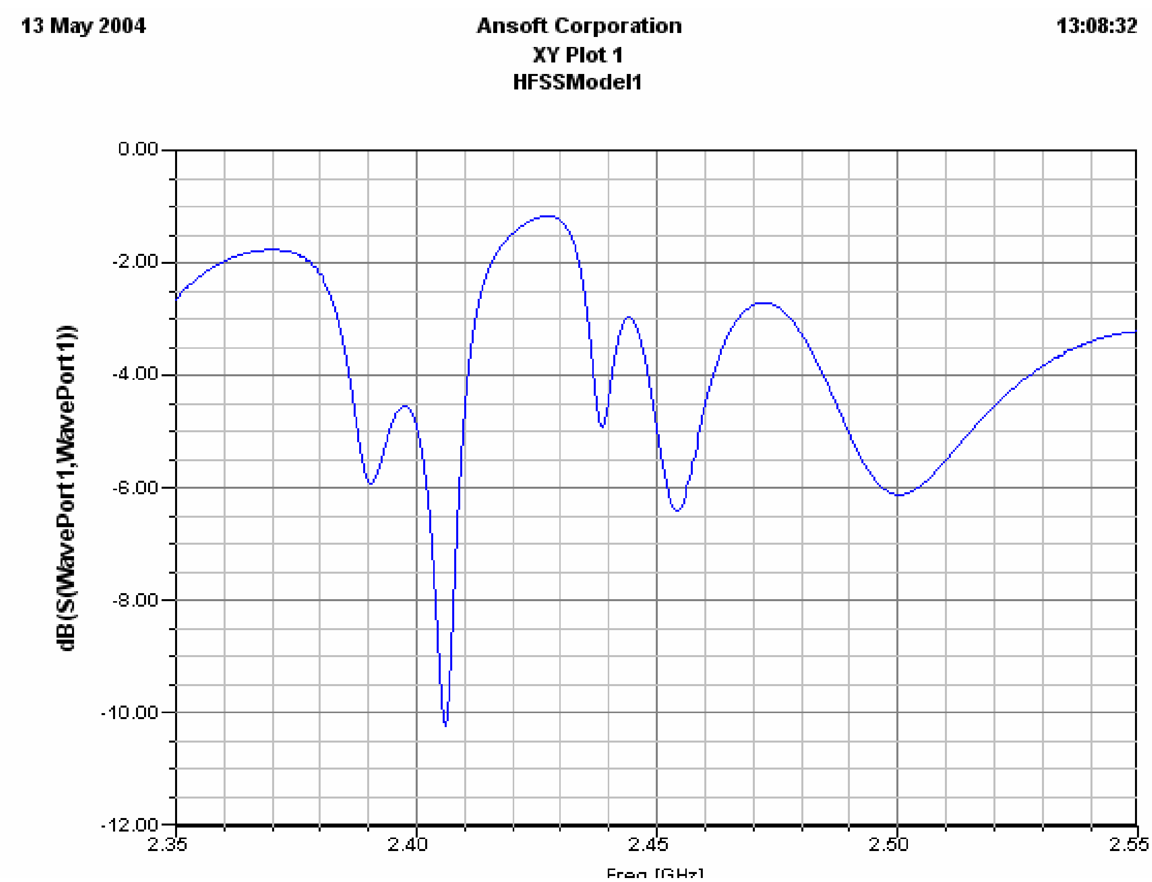
Once the simulation terminates, the user may view the results by pressing **HFSS>Results>Create Report**. This will cause a new window to appear where the user will enter the following parameters:



Next, enter the following:

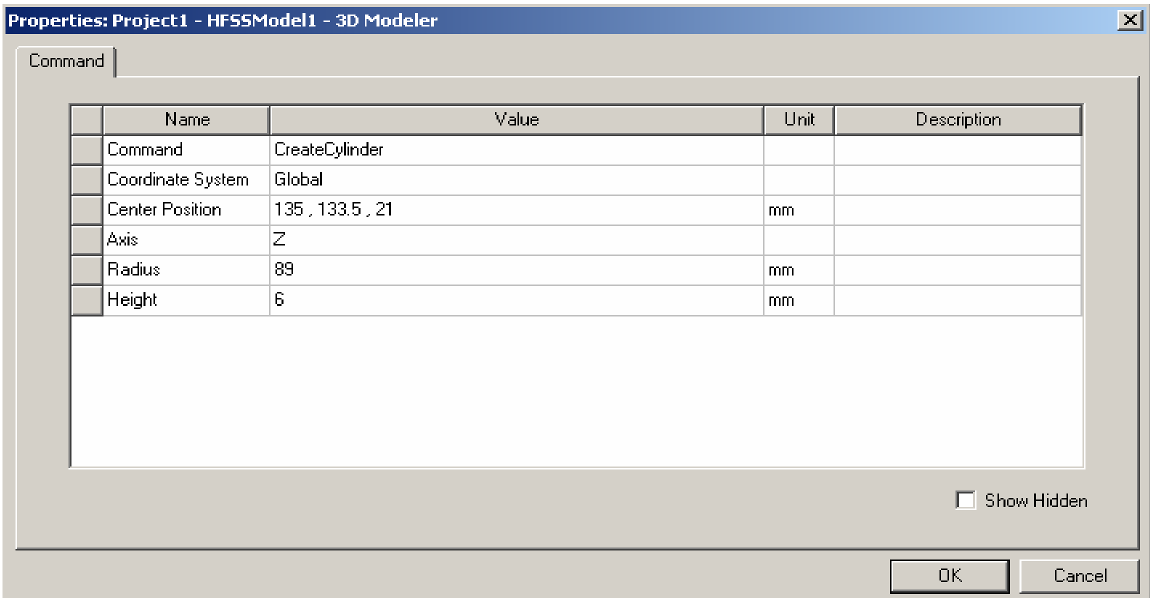


After following all these steps, the user should get the following graph for the frequency spectrum of the reflection coefficient of the loaded multimode cavity:



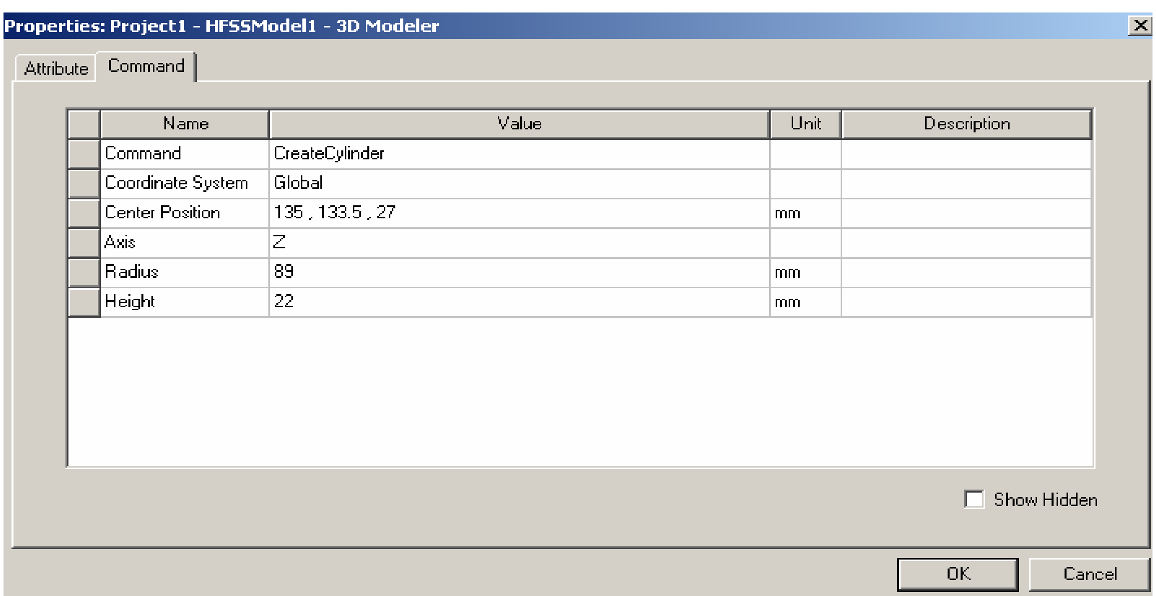
Pizza Simulation

A pizza load will also be simulated. To do this, all the previous steps hold except for drawing the sphere. Instead of drawing a sphere, the pizza will be represented by two cylinders on top of each other (representing two layers of the pizza). The cylinders will have the following parameters:



Name	Value	Unit	Description
Command	CreateCylinder		
Coordinate System	Global		
Center Position	135 , 133.5 , 21	mm	
Axis	Z		
Radius	89	mm	
Height	6	mm	

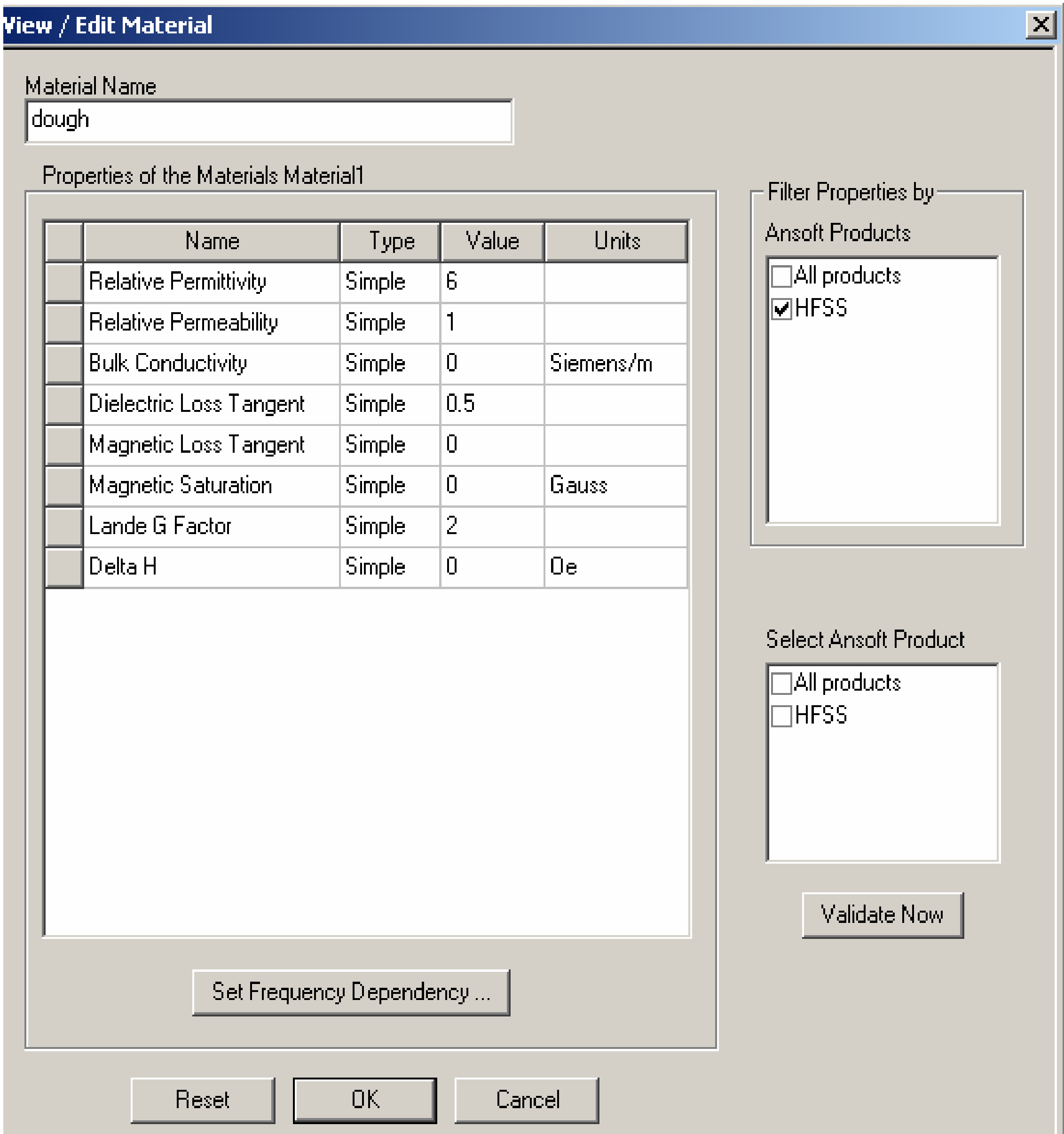
Lower layer of pizza



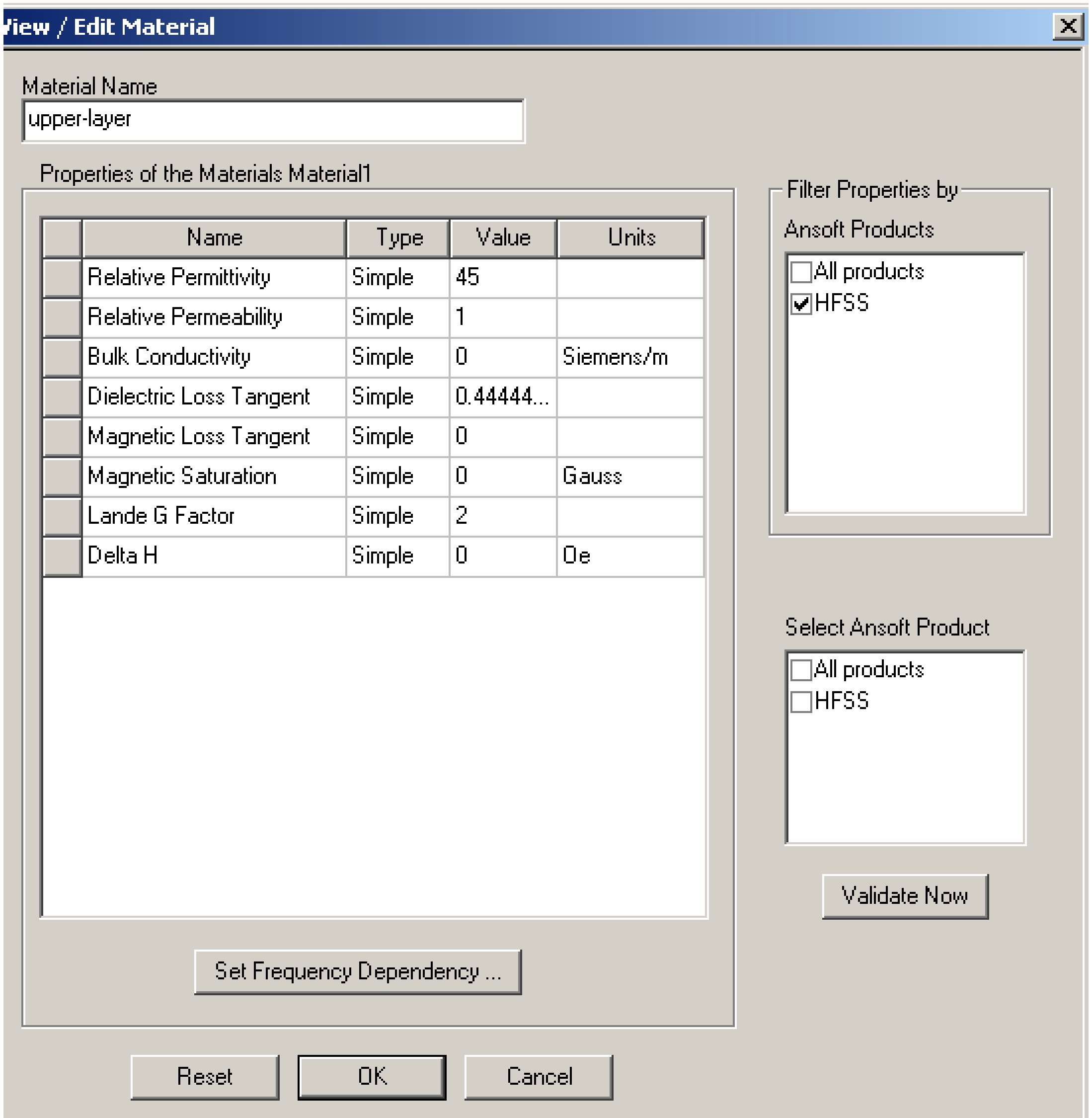
Name	Value	Unit	Description
Command	CreateCylinder		
Coordinate System	Global		
Center Position	135 , 133.5 , 27	mm	
Axis	Z		
Radius	89	mm	
Height	22	mm	

Upper layer of pizza

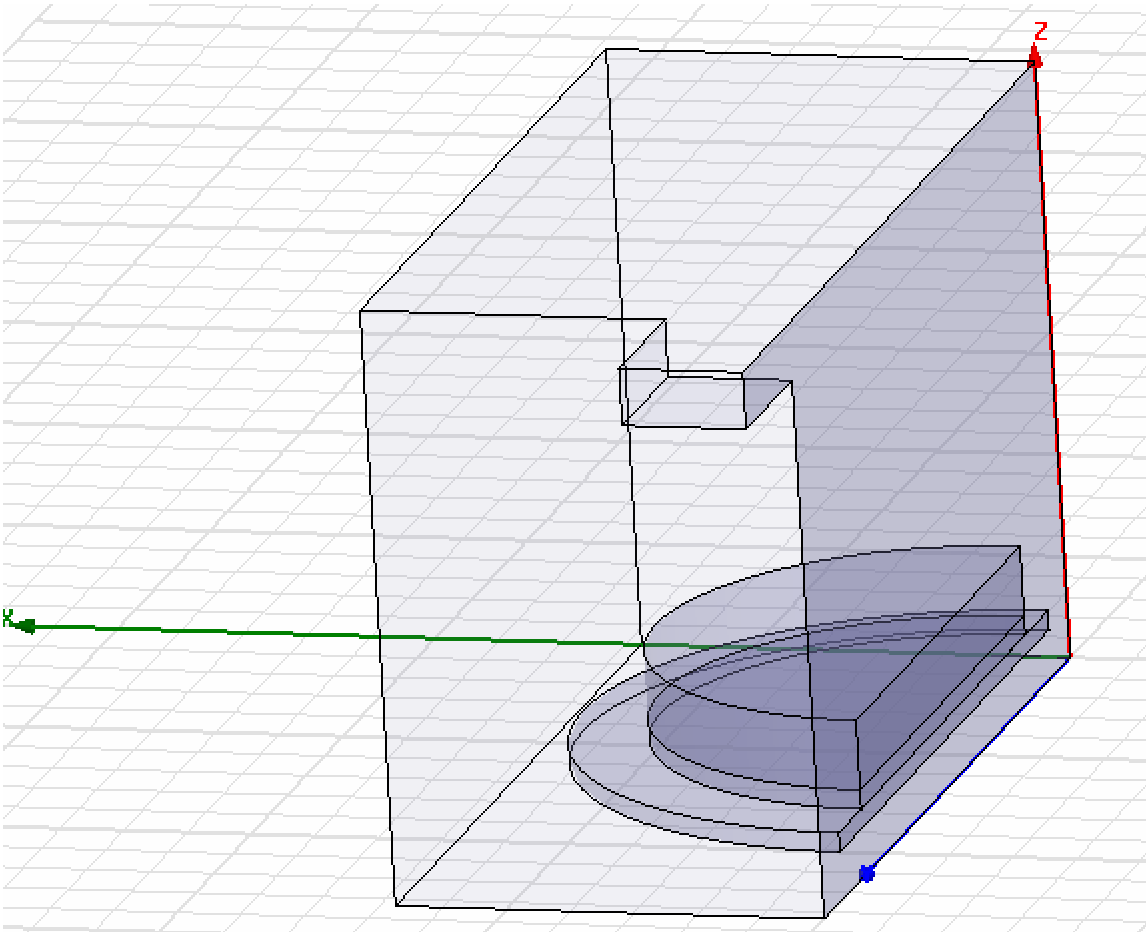
The lower cylinder will be assigned the following material properties:



The upper cylinder will be assigned the following material properties:

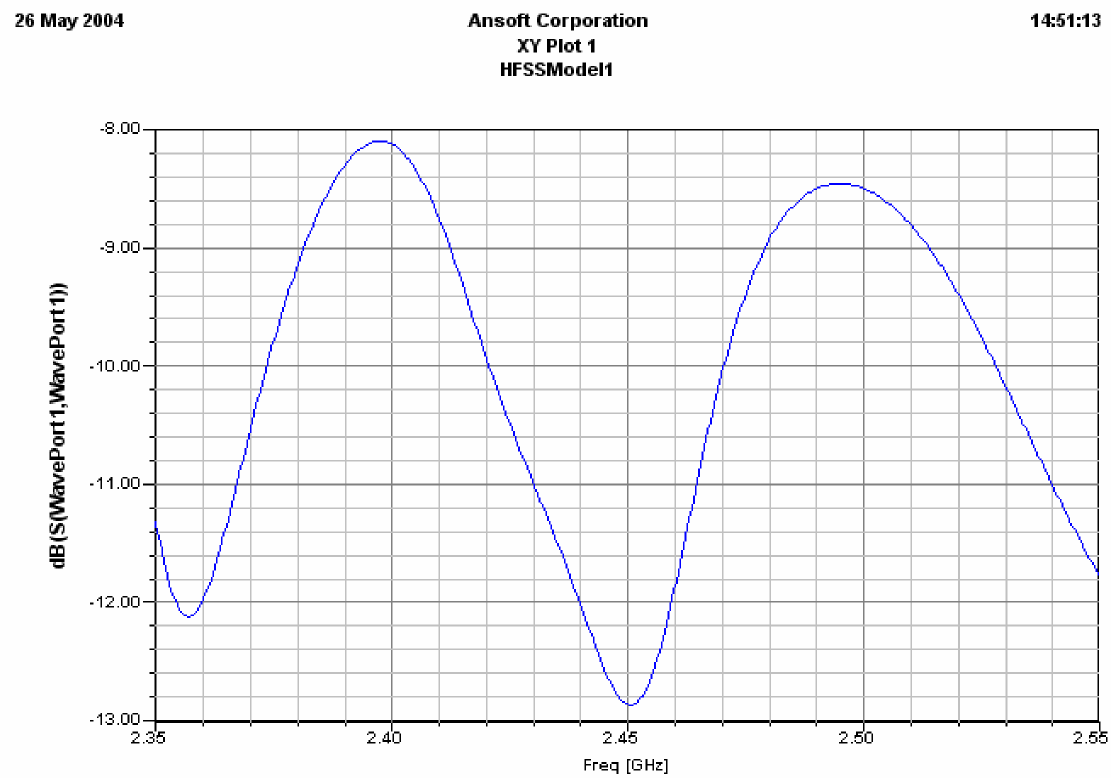


The resulting model should be similar to the one shown below.

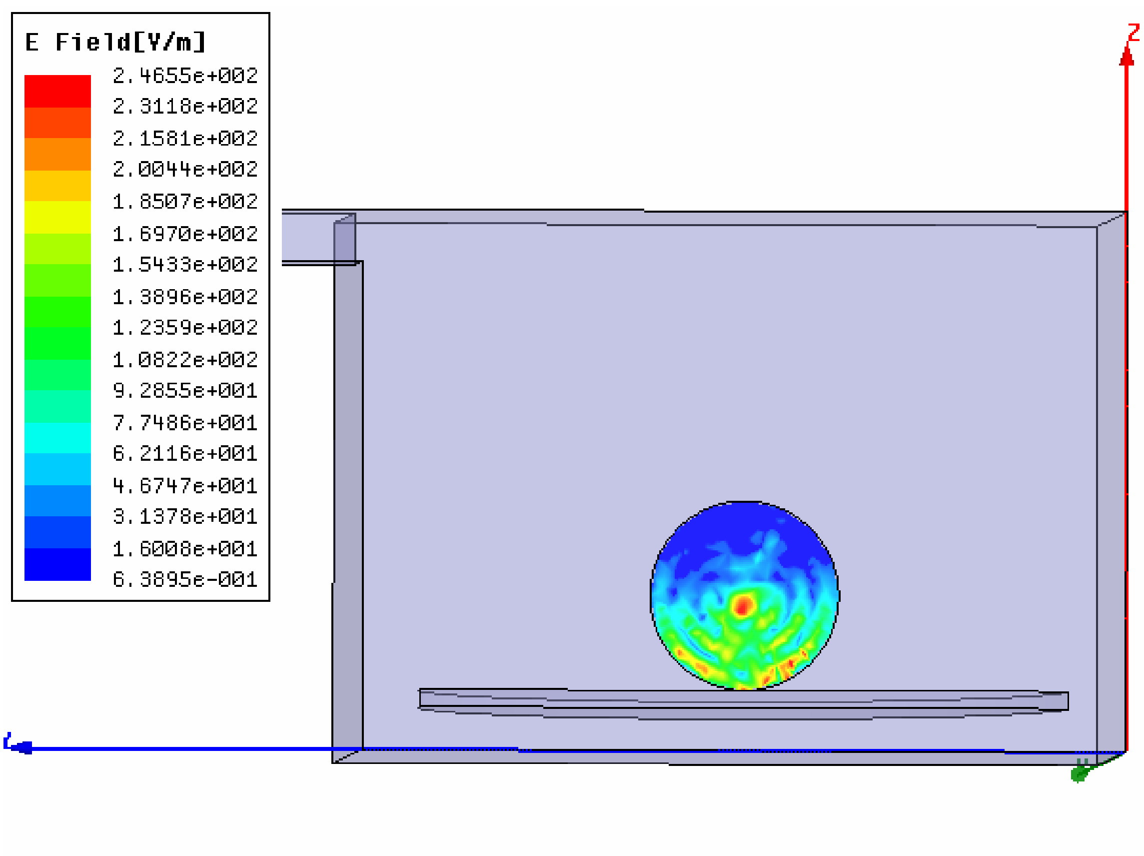


Final model with pizza

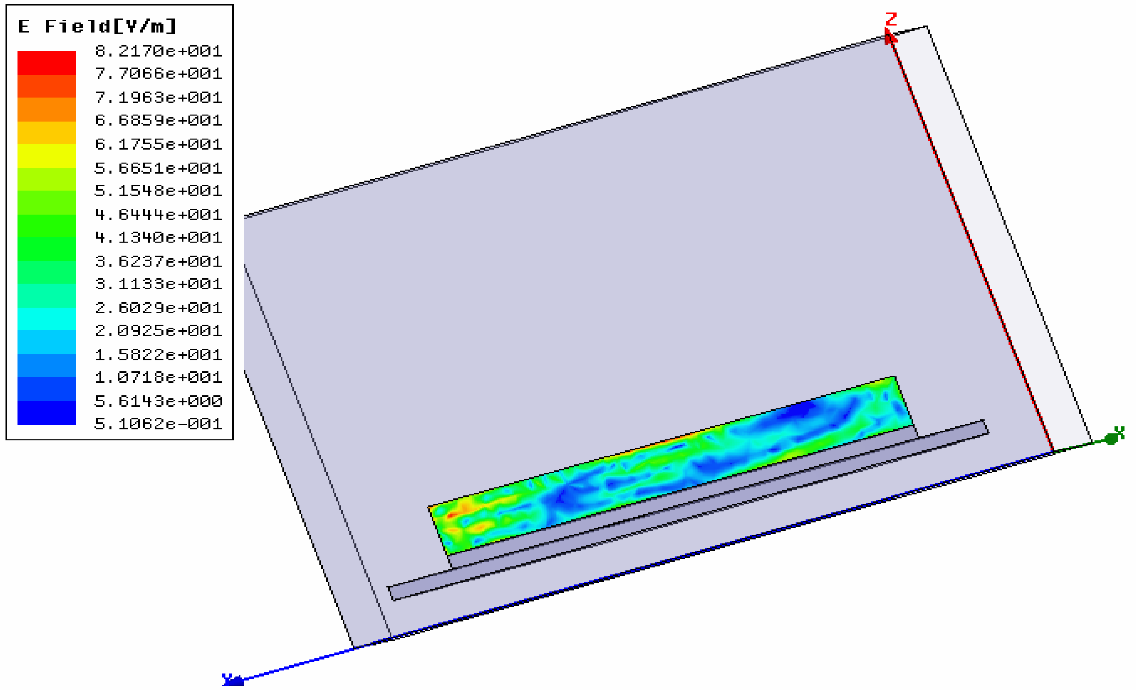
The following is the S_{11} graph for the pizza model:



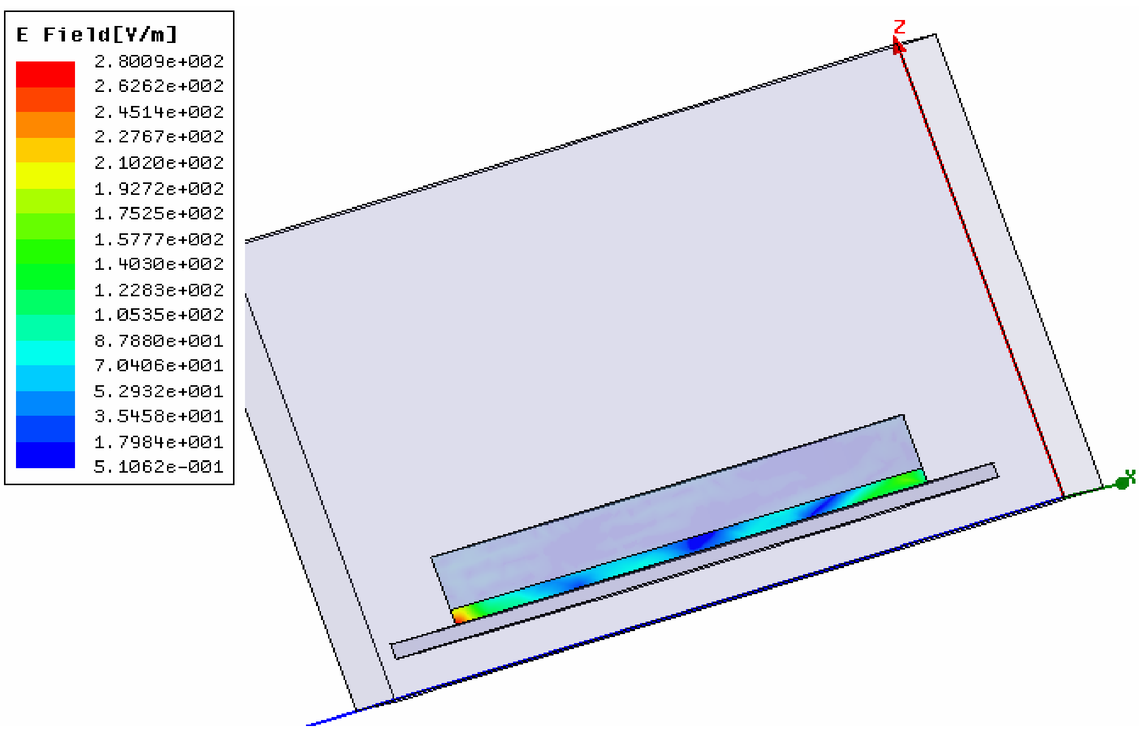
Field Plots:



Potato field plot



Upper layer of pizza field plot



Lower layer of pizza field plot