Antenna and Radio Propagation

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Experiment: 2

Design & Analysis of a Probe-Fed Microstrip Patch Antenna

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1 (a) Design and Analysis of Probe-Fed Microstrip Antenna

This guide leads you step-by-step through creating, solving, and analysing the results of a microstrip patch antenna.

By following the steps in this guide, you will learn how to perform the following tasks in HFSS:

- Draw a geometric model.
- Modify a model's design parameters.
- Assign variables to a model's design parameters.
- Specify solution settings for a design.
- Validate a design's setup.
- Run an HFSS simulation.
- Create a 2D x-y plot of S-parameter results.
- Create a 2D x-y plot of gain, efficiency results.
- Create a 2D Polar/Rectangular plot of radiation pattern.
- Create a 3D plot of radiation pattern.
- Create a field overlay plot of results.

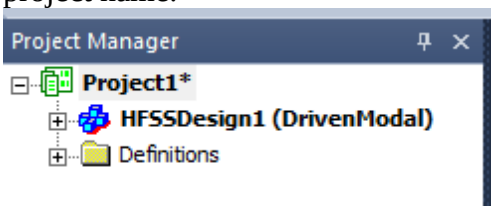
2 (b) Set up the Design

In this section you will complete the following tasks:

- Save a new project.
- Rename the HFSS design in the project.
- Select a solution type for the project.
- Set the drawing units for the design.

Open HFSS and Save a New Project

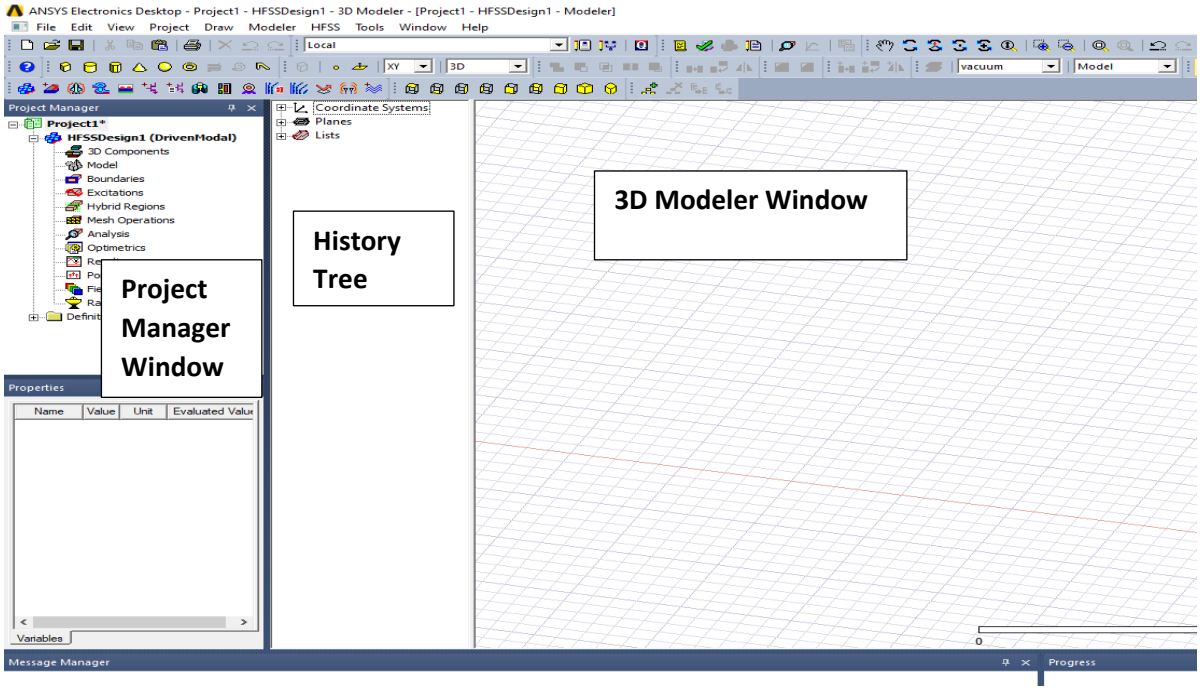
1. Double-click the **HFSS 14/19** icon on your desktop to launch HFSS.
   A new project is listed in the project tree in the **Project Manager** window and is named Project by default. Project definitions, such as material assignments, are stored under the project name.



2. Click **File>Save As**. The **Save As** dialog appears.
3. Use the file browser to locate the folder in which you want to save the project, (such as C:\Program Files\Ansoft\HFSS14 or 19.0\Projects), and then double-click the folder's name. Type DiA in the **File name** text box, and then click **Save**. The project is saved in the folder you selected to the file name **P_DiA.hfss**.

Rename the Design

You will now rename the default HFSS design in the project. The design is already listed in the project tree when HFSS opens. It is named HFSSDesignn by default. The **3D Modeler** window appears to the right of the Project Manager.



1. To rename the design: Right-click **HFSSDesignn** in the project tree, and then click Rename on the shortcut menu.
2. Type **P_DiAModel**, and then press **Enter**.

Select a Solution Type

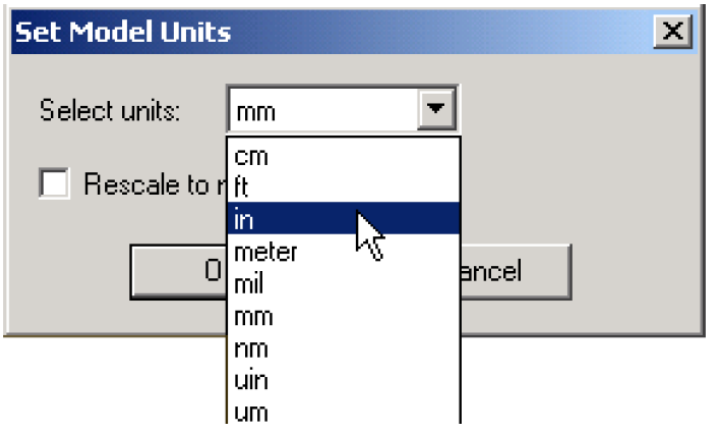
As you set up the design for analysis, available settings depend on the solution type. For this design, you will choose Driven Modal as the solution type, which is appropriate when designing microstrip patch antenna that is being "driven" by a source.

1. To specify the design solution type, click **HFSS>Solution Type**. The Solution Type dialog appears.
2. In the **Solution Type** dialog box, select **Driven Modal**, and then click **OK**.

Set the Drawing Units

To set the units of measurement for drawing the geometric model.

1. Click **Modeler>Units**. The **Set Model Units** dialog appears
2. Select **mm** from the **Select units** pull-down list, and then click **OK**.



2 (c) Create the Model

In this section you will complete the following tasks:

a. Draw the one side dipole of the dipole antenna and assign material
b. Draw the other side dipole of the dipole antenna and assign material
c. Draw a rectangle sheet between the dipoles connecting their edges and assign excitation.
d. Draw the radiation box/cylinder and assign material

a. Create Dipole:

The proposed antenna is planar dipole antenna. So here the planar dipole will be made on a substrate. The dipole will be made up of conducting material (consider PEC).

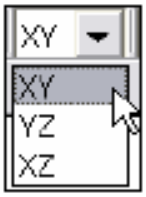
First you will draw the substrate, then one dipole will be created based on the above formula. Then duplicate this to design another part of the dipole.

How to draw?

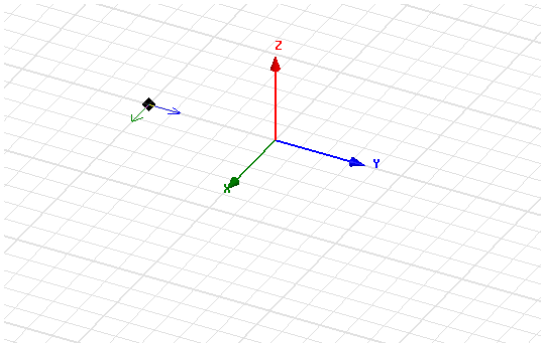
Substrate

1. Go to HFSS > Solution Type > Select Driven Modal

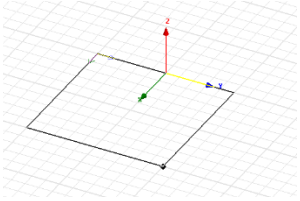
2. Select the menu item 3D Modeler → Grid Plane → XY



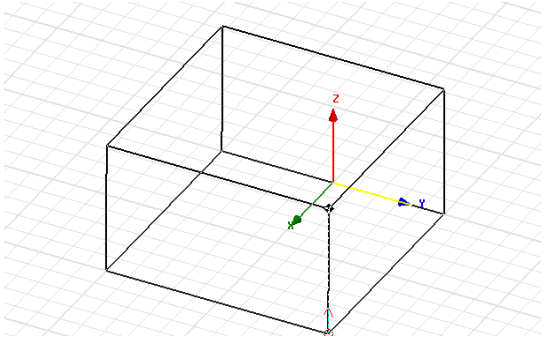
3. Use the mouse to create the base shape
    a. Set the start point by positioning the active cursor and click the left mouse button.



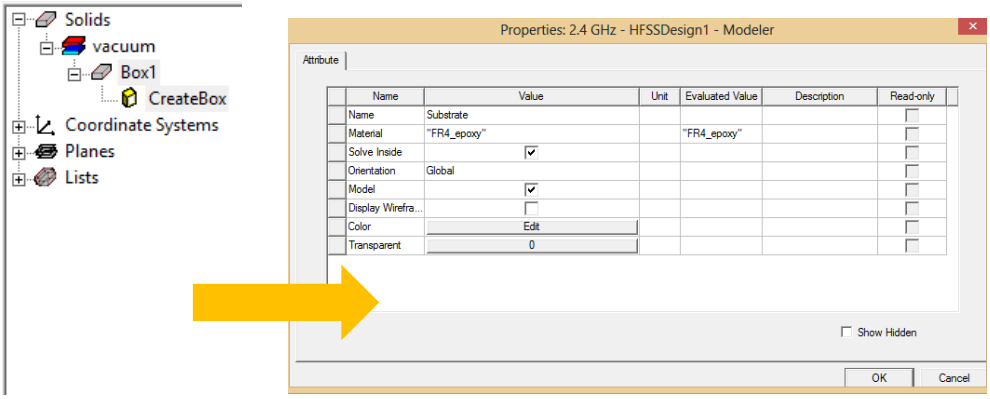
    b. Position the active cursor and click the left mouse button to set the second point that forms the base rectangle.



c. Set the Height by positioning the active cursor and clicking left mouse button.

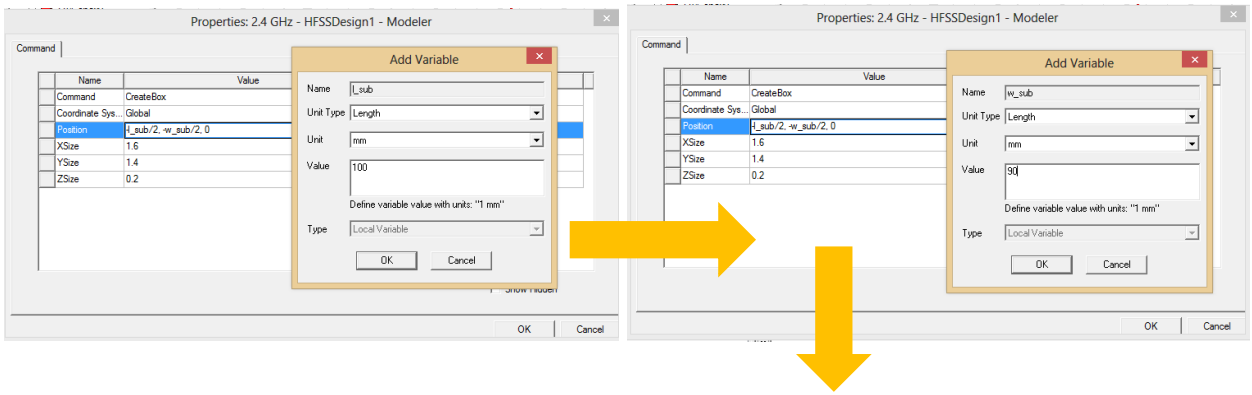


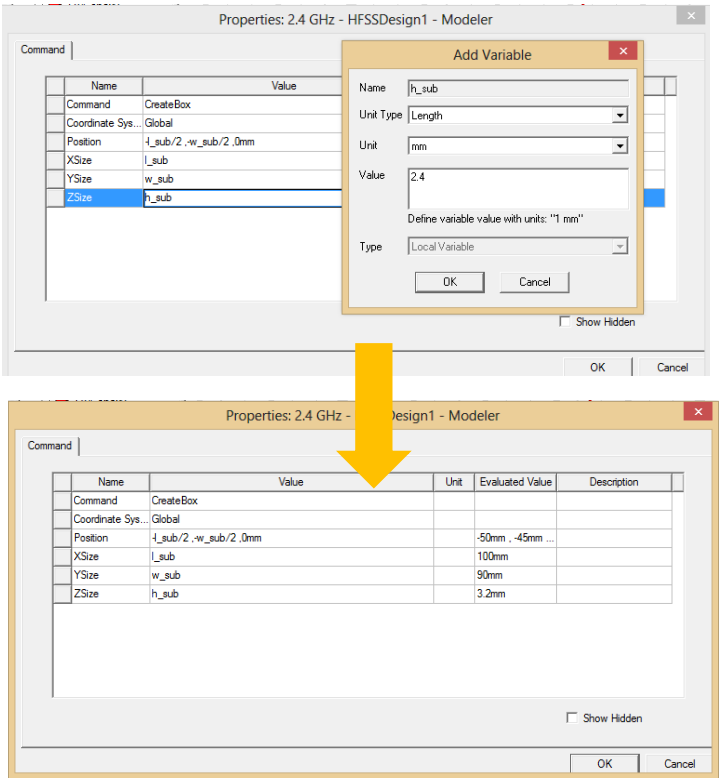
4. Check/Edit the properties of the box:
   Double click on Box1 → Name = Substrate → Material (RT/Duroid 5880)

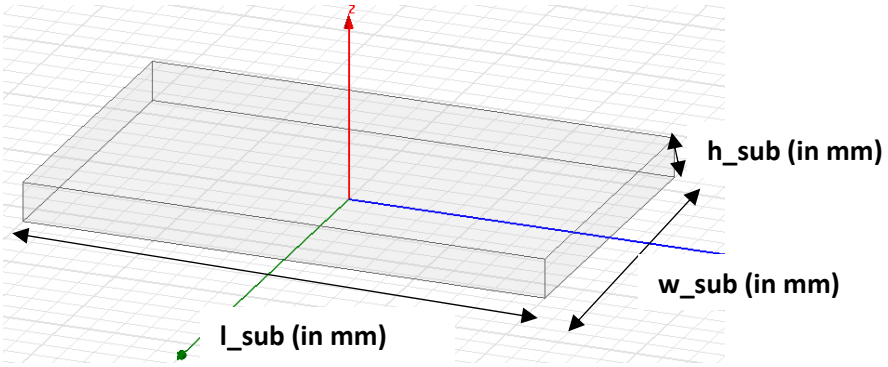


5. Check/Edit the properties of Box:
   Select Substrate → click on '+' → CreateBox → Poperies window

   Use parameters for different dimensions of the substrate:
   l_sub → length of the substrate (use 100 mm) → Ok
   w_sub → width of the substrate (use 90 mm) → Ok
   h_sub → height of the substrate (use 2.4 mm) → Ok



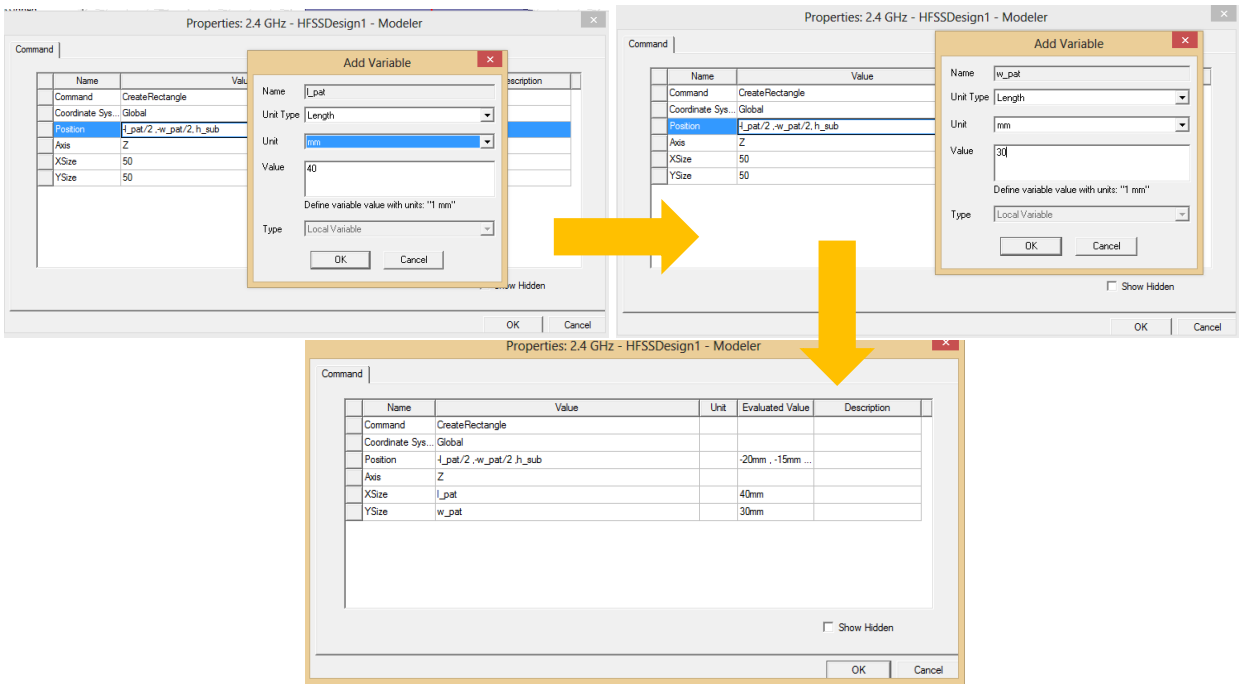

Properties: 2.4 GHz - HFSSDesign1 - Modeler
Command
Name
Value
Command
CreateBox
Coordinate Sys...
Global
Position
-l_sub/2 ,-w_sub/2 ,0mm
XSize
l_sub
YSize
w_sub
ZSize
h_sub
Add Variable
Name
h_sub
Unit Type
Length
Unit
mm
Value
2.4
Define variable value with units: "1 mm"
Type
Local Variable
OK
Cancel
Show Hidden
OK
Cancel
Properties: 2.4 GHz - Design1 - Modeler
Command
Name
Value
Unit
Evaluated Value
Description
Command
CreateBox
Coordinate Sys...
Global
Position
-l_sub/2 ,-w_sub/2 ,0mm
-50mm , -45mm ...
XSize
l_sub
100mm
YSize
w_sub
90mm
ZSize
h_sub
3.2mm
Show Hidden
OK
Cancel


Z
h_sub (in mm)
w_sub (in mm)
l_sub (in mm)

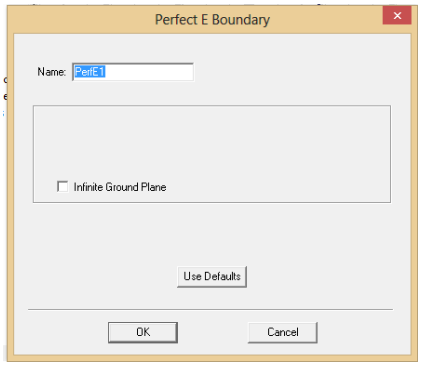
Patch

Draw a rectangle sheet and follow the below steps:

6. Use parameters for different dimensions of the rectangle sheet:
   l_pat → length of the dipole (use 40 mm) → Ok
   w_pat → width of the dipole (use 30 mm) → Ok



7. Check/Edit the properties of the rectangle sheet:
   Under sheet, Double click on Rectanagle1 → Name = Patch
   Right click on Patch → Assign boundary → Perfect E

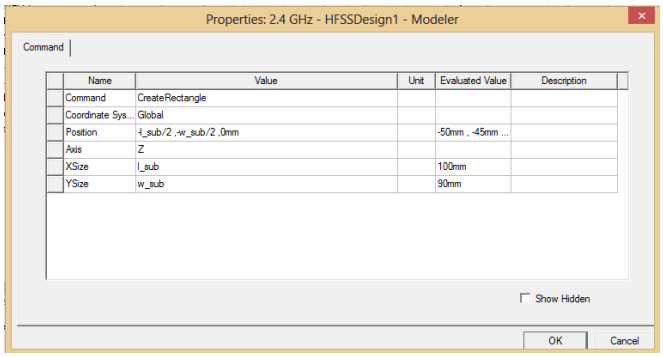


8. Double click on Patch and change the color to green.

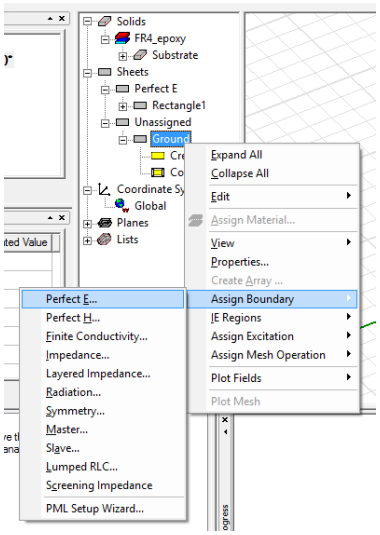
Ground

Draw a rectangle just below the substrate. Edit the rectangle name to ‘Ground’ and make it green color.

9. Now edit the dimension of the rectangle as follows.
   Parameters for different dimensions of the rectangle sheet: (Note: Substrate size= Ground size)
   l_sub→ length of the dipole (use 40 mm) → Ok
   w_sub → width of the dipole (use 30 mm) → Ok

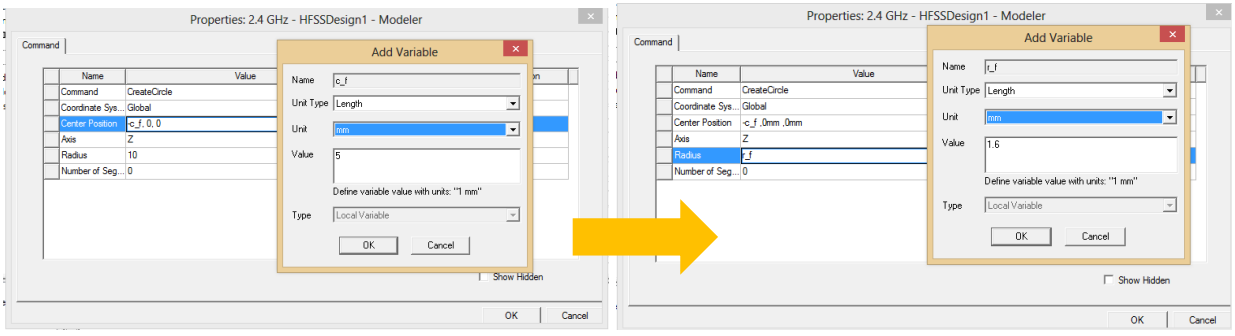


10. Check/Edit the properties of the ‘Ground’:
    Right click on Ground → Assign boundary → Perfect E

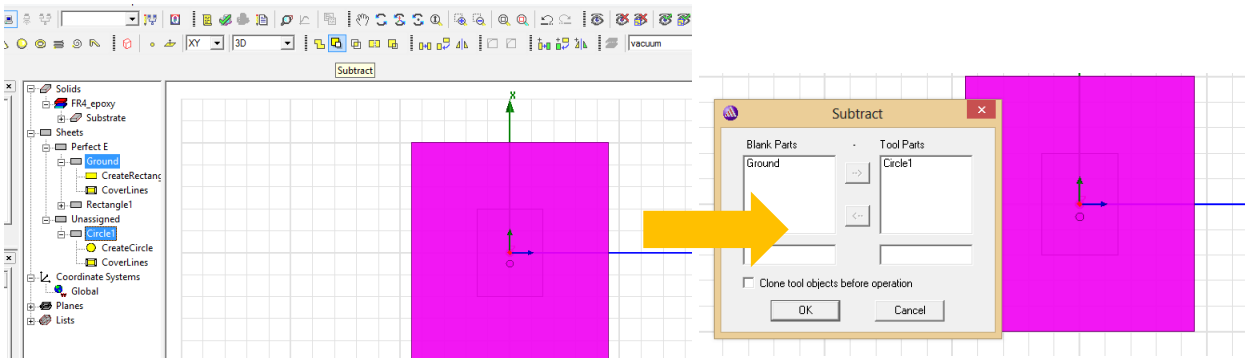


Now Feed arrangement will be done.

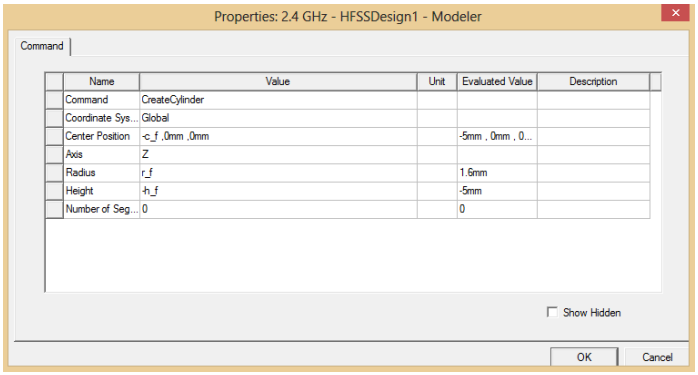
11. Draw a circle and substrate it from Ground. Circle dimension and subtract process is as follow.



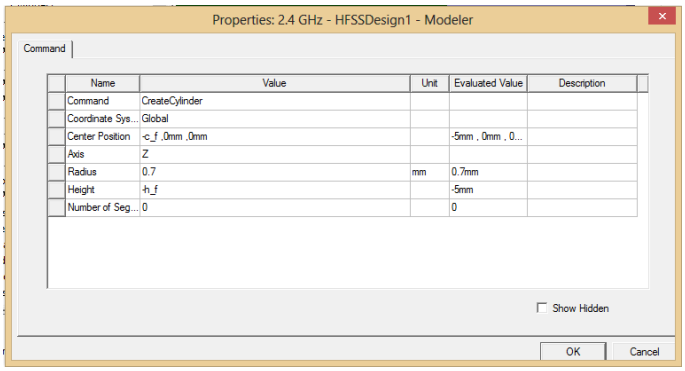
12. Subtract the circle from the ground.
    First Select Ground + Select Circle > Subtract



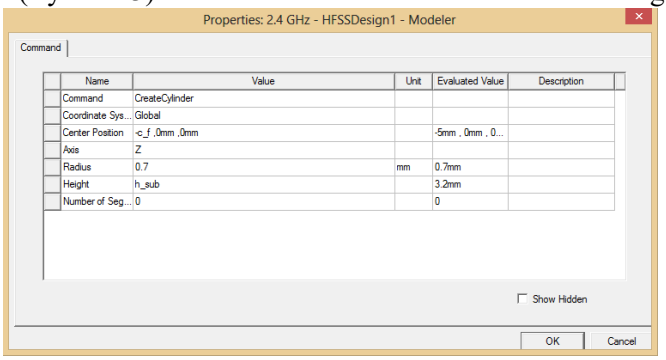
13. Draw another cylinder (Cylinder1) and edit dimensions as follows. Then assign material ‘air’



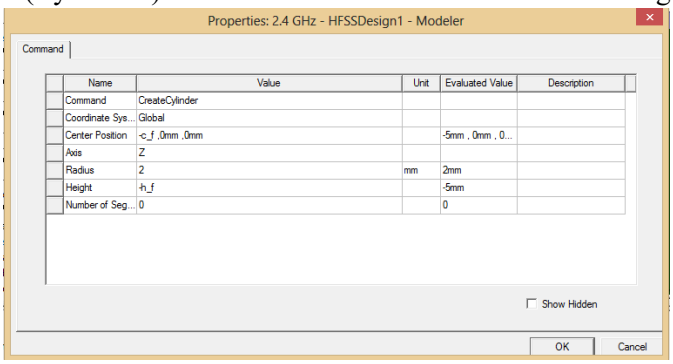
14. Draw another cylinder (Cylinder2) and edit dimensions as follows. Then assign material ‘PEC’



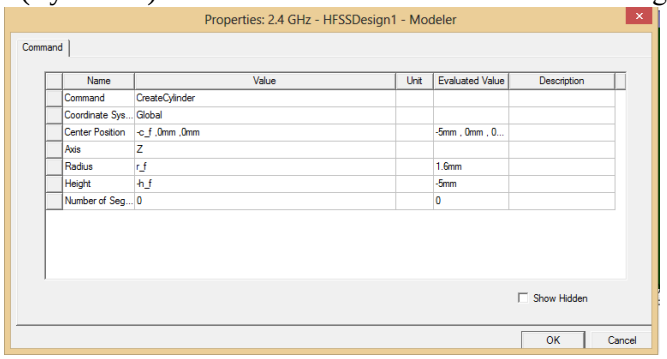
15. Draw another cylinder (Cylinder3) and edit dimensions as follows. Then assign material ‘PEC’



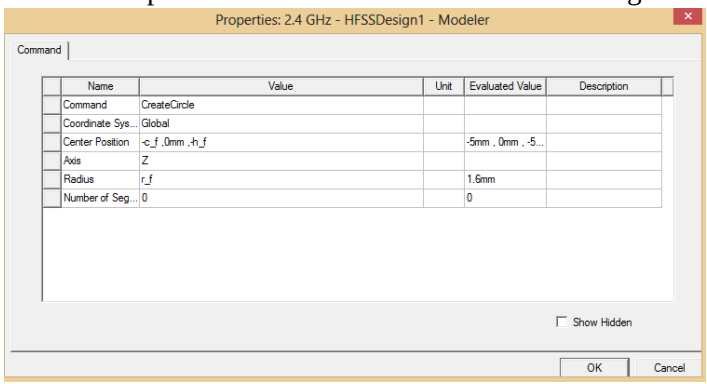
16. Draw another cylinder (Cylinder4) and edit dimensions as follows. Then assign material ‘PEC’



17. Draw another cylinder (Cylinder5) and edit dimensions as follows. Then assign material ‘PEC’

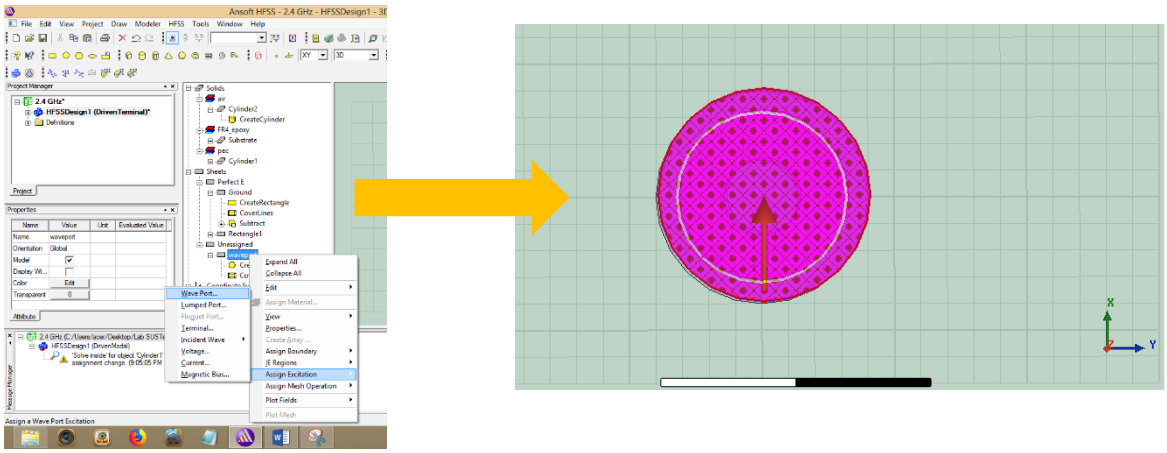


18. Subtract Cylinder 5 from Cylinder 4.
19. Draw a circle rename it as waveport. The dimension of the circle will be given as follows.

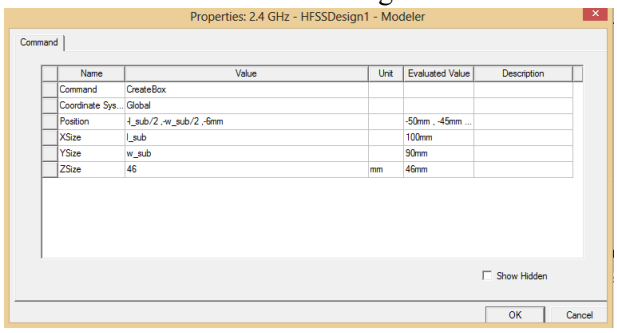


20. Turn the whole project and bring the bottom side to the Top.

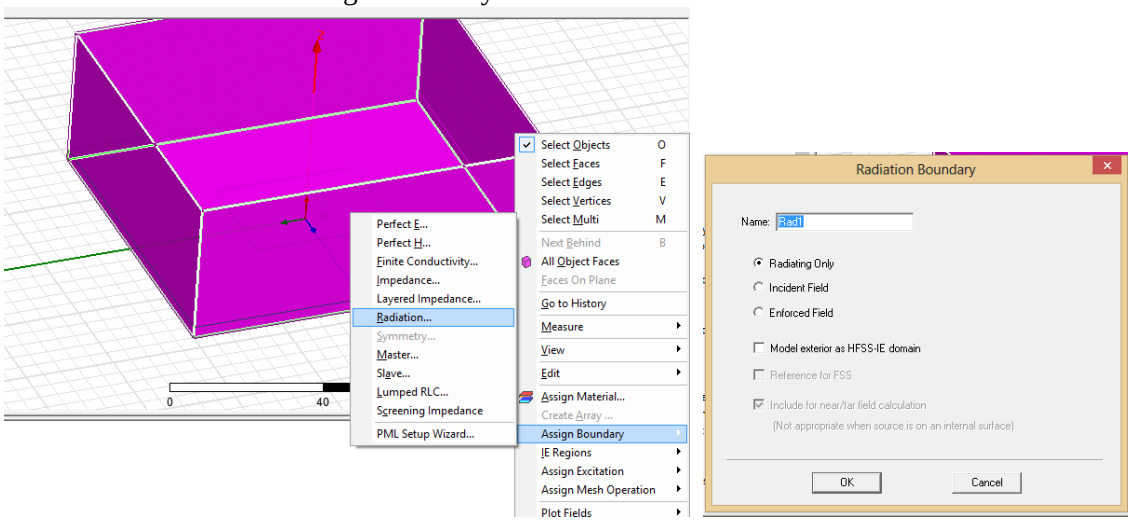
    Right click on waveport circle > assign excitation > wave port > then draw 50 ohm Integration line from outer side to inner side as shown in below figure.



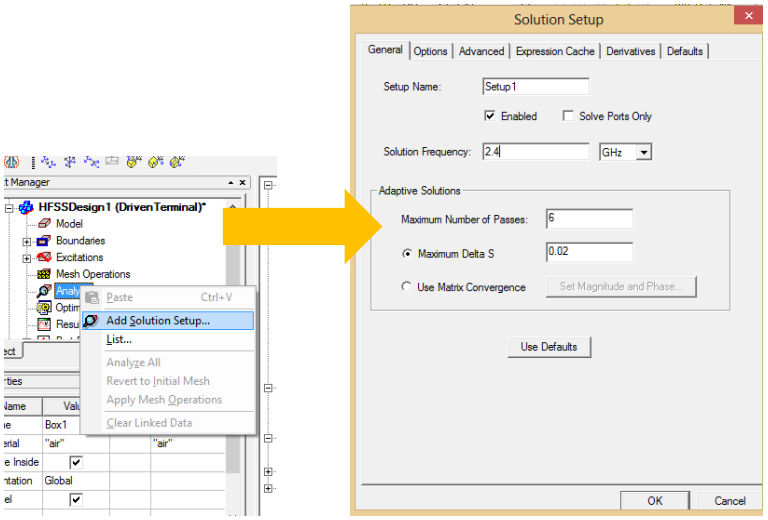
21. Draw radiation box with dimension as follows then assign material ‘Air’.



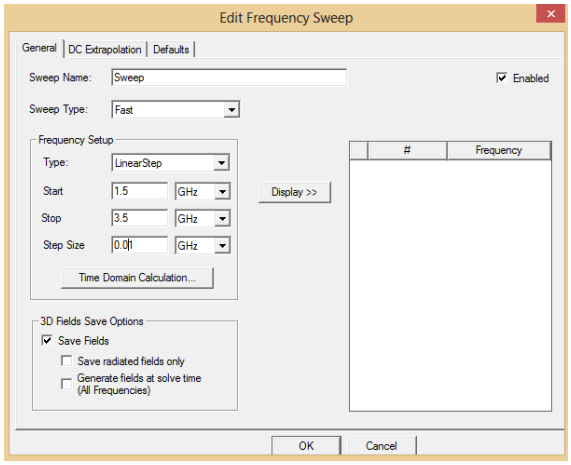
22. Select the radiation box > Assign Boundary > Radiation



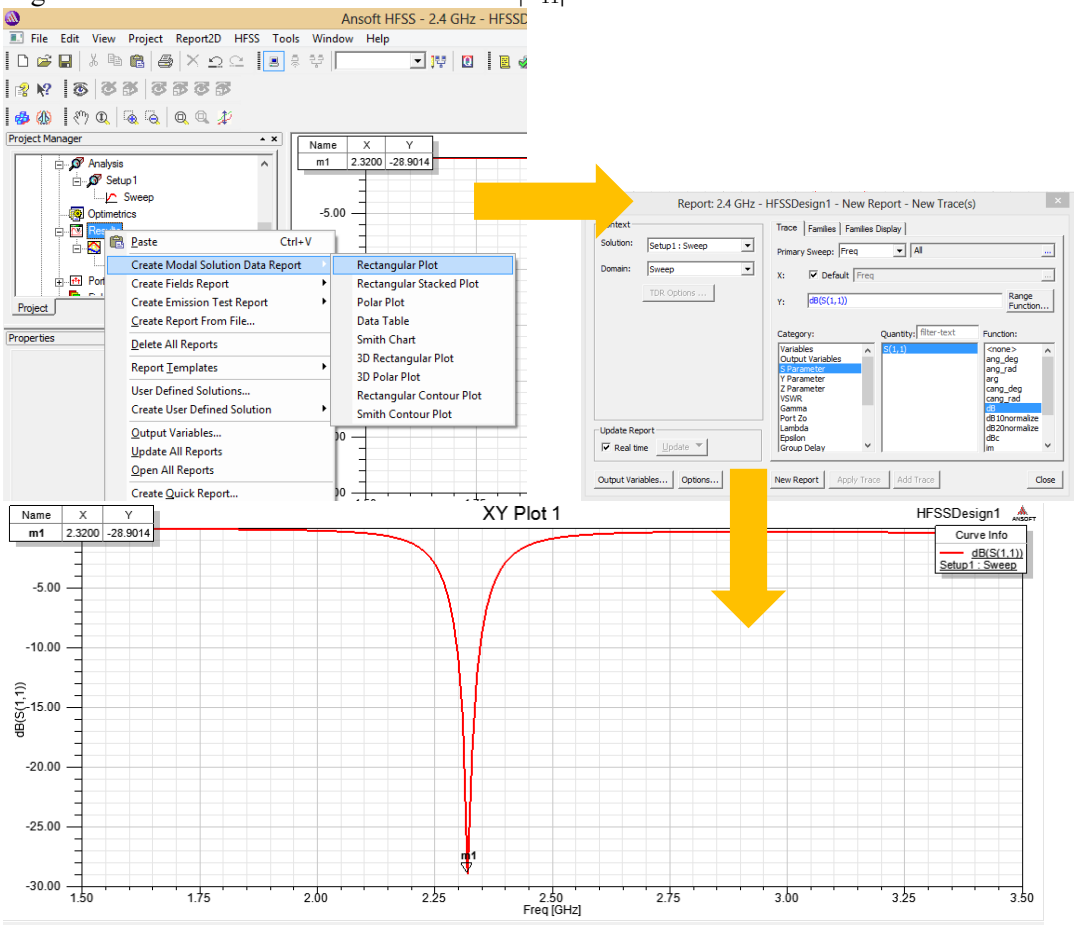
23. Right Click on analysis > Add solution setup → add 2.4 GHz > Ok



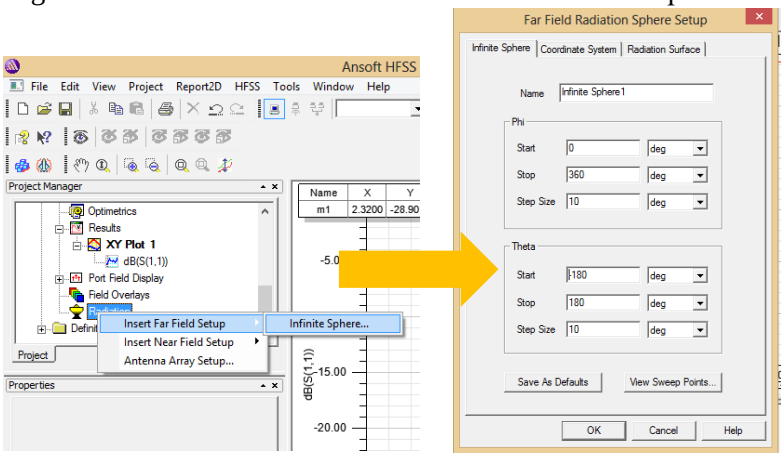
24. Click '+' of the analysis → Right click on setup → Add frequency sweep → Edit frequency sweep (Sweep type Fast, Frequency range 1.5 GHz to 3.5 GHz, Step size 0.01 GHz) → Ok



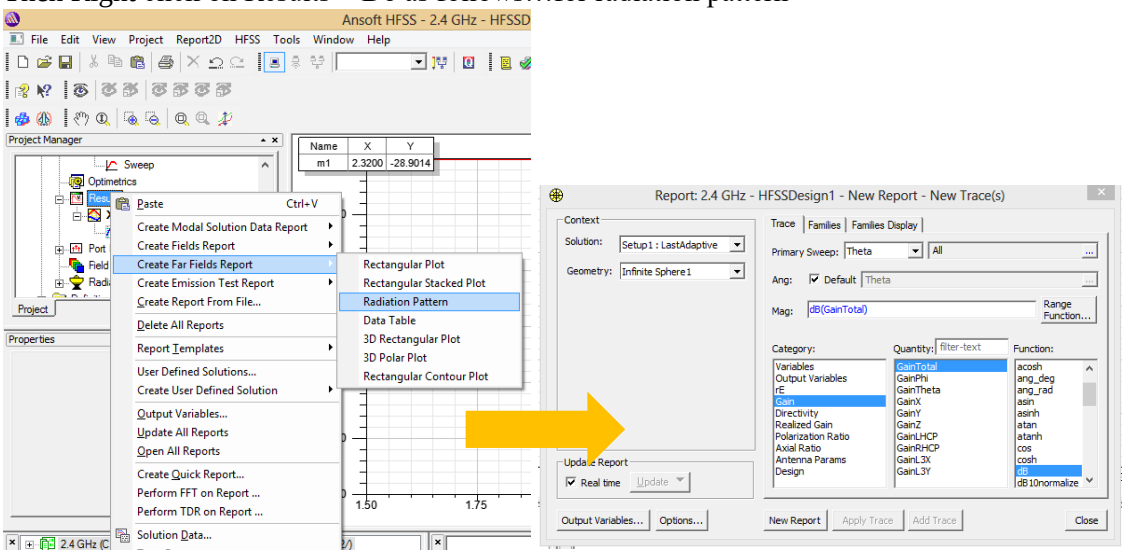
25. Right click on results > Do as follows…for $|S_{11}|$



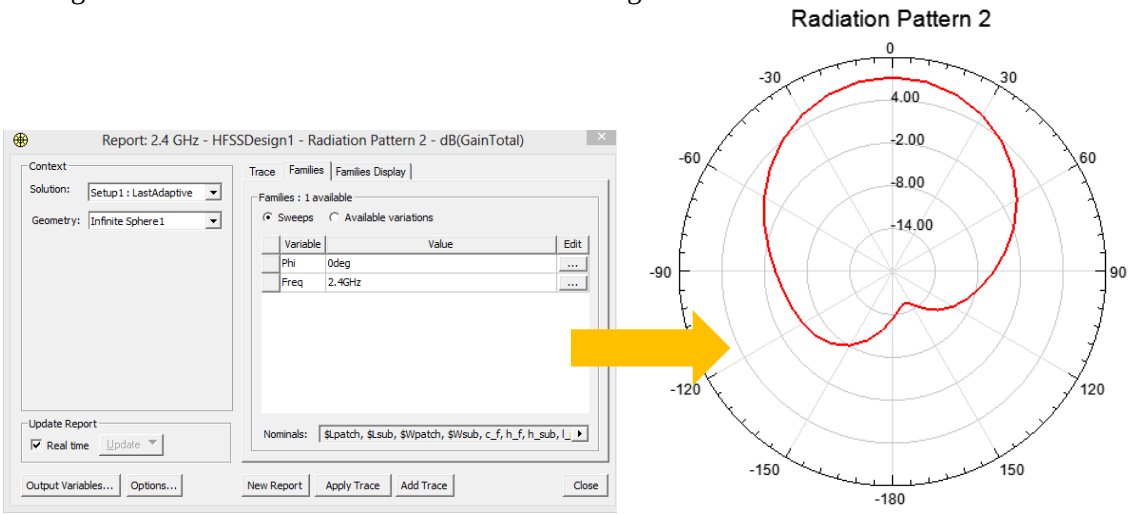
26. Right click on Radiation > Do as follows…for radiation pattern



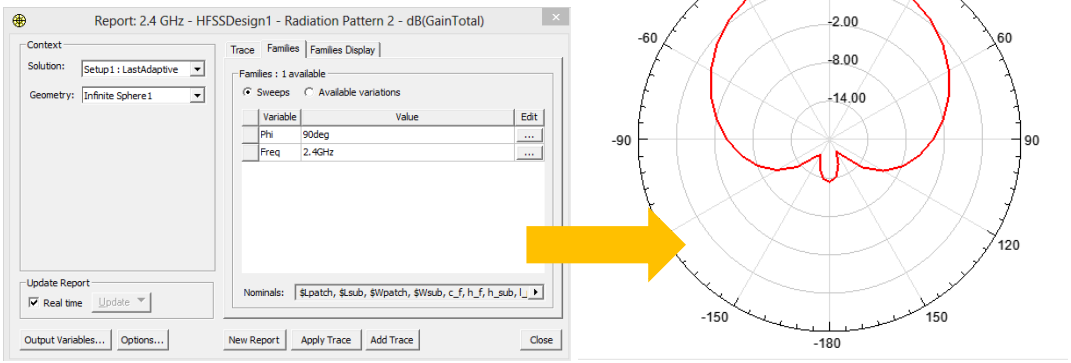
27. Then Right click on Results > Do as follows…for radiation pattern



Then go to Families and do as follows for Phi = 0 Degree



Then go to Families and do as follows for Phi = 90 Degree



Home work

Question:

Design a microstrip rectangular patch antenna with microstrip line feed using HFSS for operating at ~ 2.4 GHz. Plot its S_{11}, Gain, radiation efficiency, Radiation pattern.