Antenna and Radio Propagation

Theory Class Instructor: Prof. Qingsha S. Cheng
Lab Instructor: Dr. Rusan Kumar Barik
Office: 1110, A7, Nanshan *i*Park

Experiment: 5

Design & Analysis of a 1 × 2 Circular Patch Antenna Array for 2.4 GHz Applications

Southern University of Science and Technology, Shenzhen, P.R. China

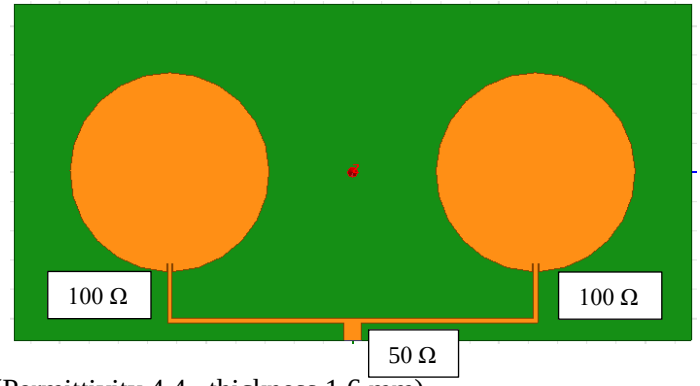
1 (a) Design & Analysis of a 1 × 2 Circular Patch Antenna Array for 2.4 GHz Applications

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.

1 (b) Project overview



- FR4 Substrate (Permittivity 4.4 , thickness 1.6 mm)
- Each patch is connected to 100 Ω feed line.
- The equivalent at the junction of the two 100 Ω lines is 50 Ω.
- The 50 Ω feed line is connected to edge feed.
- The calculated dimensions are given below;

Components	Dimensions
Radius of the patch	17 mm
Inter-element spacing	62.5 mm
Width of the 100 Ω feedline	0.7 mm
With of the 50 Ω feedline	3 mm

- Radius (a) of the patch can be calculated using the below formula (Where, h = thickness of substrate, f = Frequency):

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad (1)$$

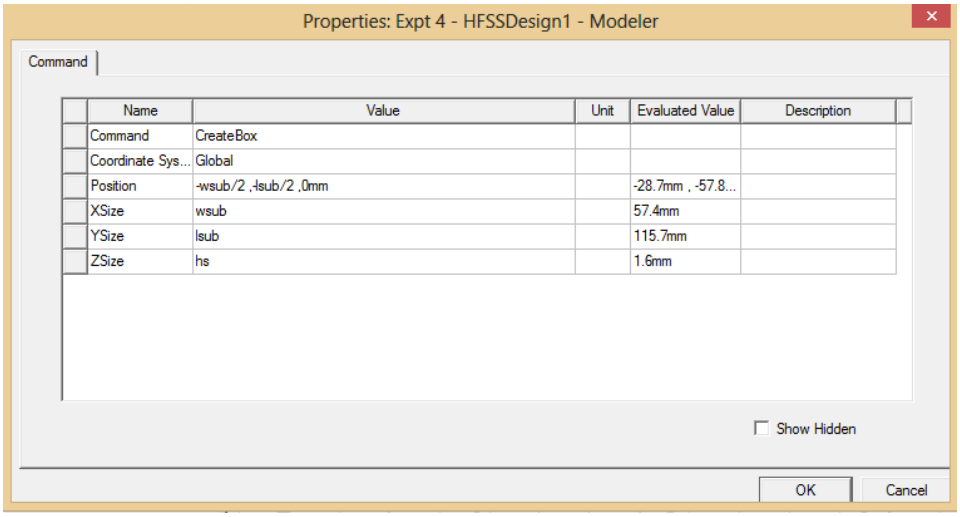
Where,

$$F = \frac{8.791\times10^{9}}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

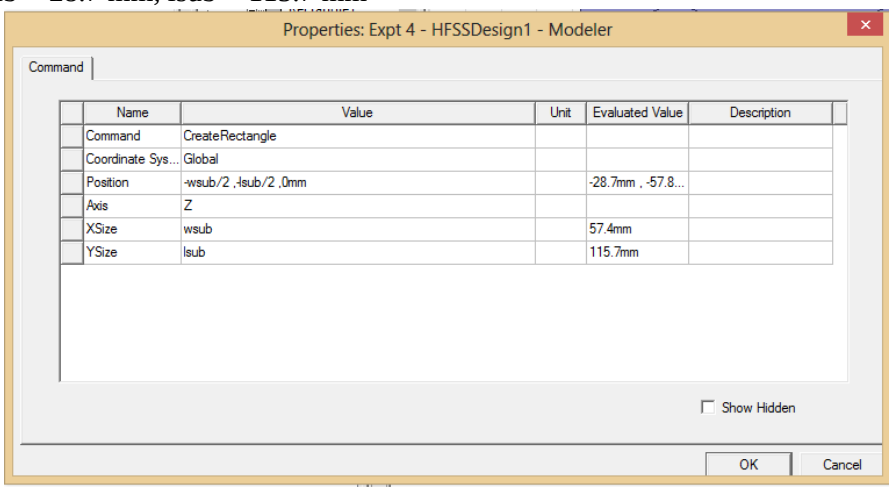
- Different dimensions can be calculated from: https://www.emtalk.com/mscalc.php

2 (a) Create the Model

1. For Substrate: Centre (-wsub/2 ,-lsub/2 , hs), X size = wsub, Y size= lsub, Z size = hs
   Where; wsub = 28.7 mm, lsub = 115.7 mm, hs = 1.6 mm

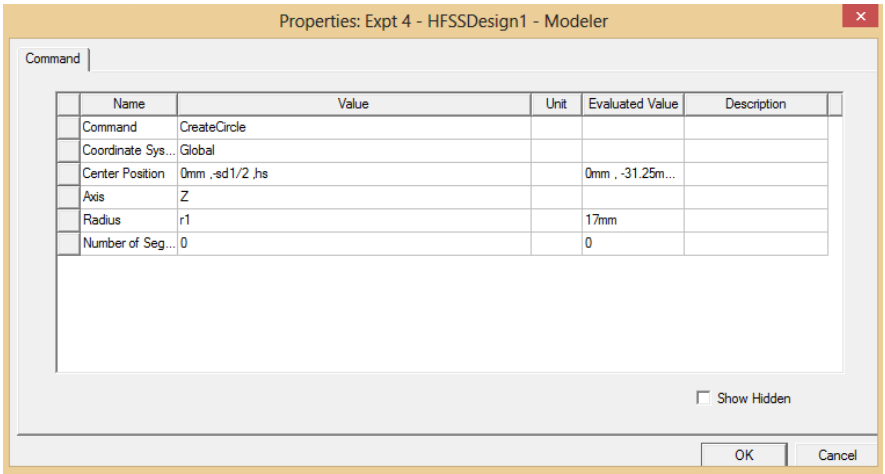


2. For Ground Plane: Centre (-wsub/2 ,-lsub/2 ,0mm), X size = wsub, Y size= lsub
   Where, wsub = 28.7 mm, lsub = 115.7 mm

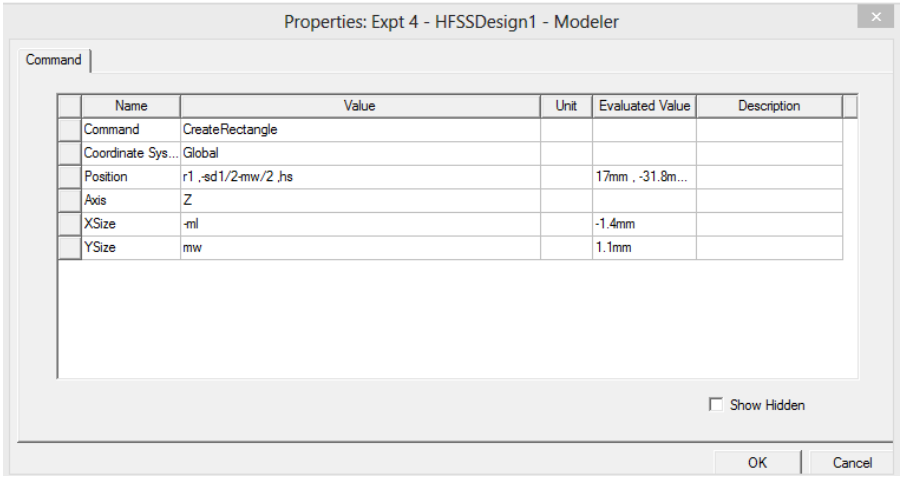


3. Assign Perfect E boundary to the ground plane. Right click > Assign boundary > Perfect E

4. For Patch 1: Create Circle 1. Centre of Circle 1: (0, -sd1/2, hs) and radius = r1.
   Where; sd1 = 62.5 mm, r1 = 17 mm, hs = 1.6 mm

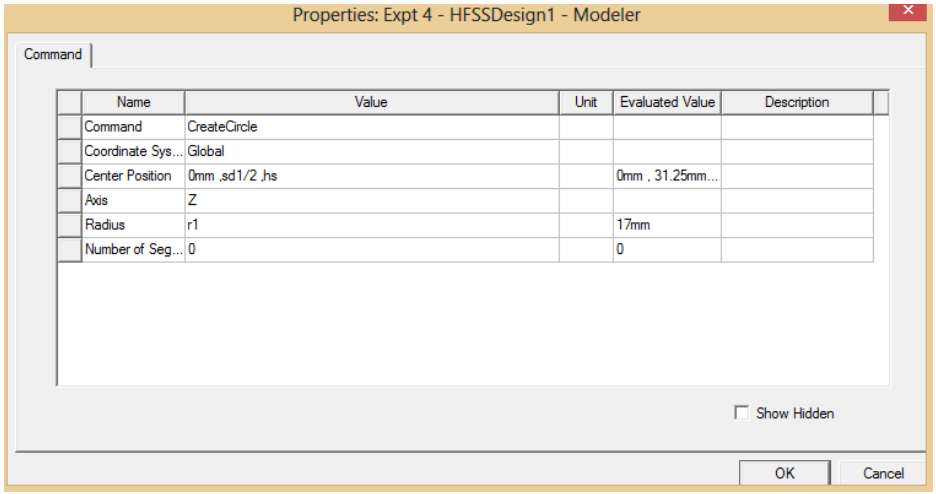


5. For matching at Patch 1: Create rectangle, Centre (r1, -sd1/2-mw/2, hs), X size = -ml, Y size = mw
Where, sd1=62.5 mm, ml = 1.4 mm, mw = 1.1 mm, hs = 1.6 mm

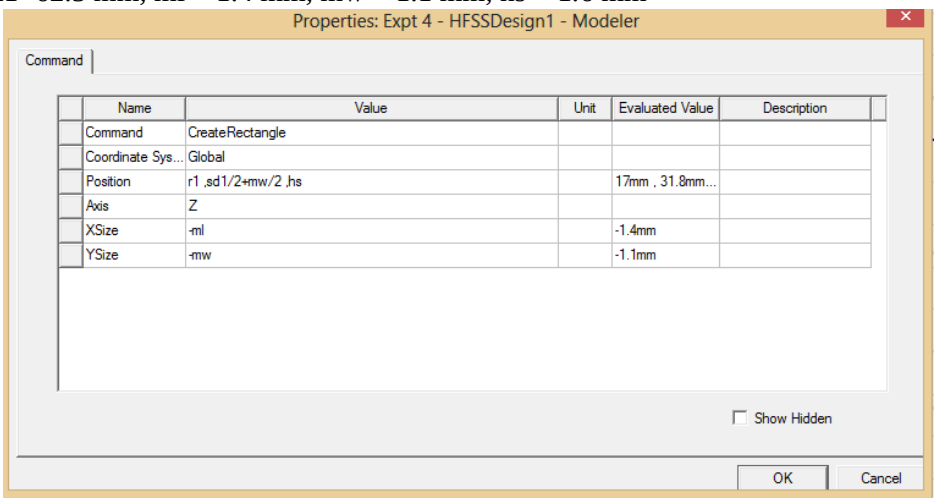


6. Now subtract the Object created in Step 4 from the Object created in Step 3.

7. For Patch 2: Create Circle 2. Centre of Circle 1: (0, sd1/2, hs) and radius = r1.
Where; sd1 = 62.5 mm and r1 = 17 mm, hs = 1.6 mm

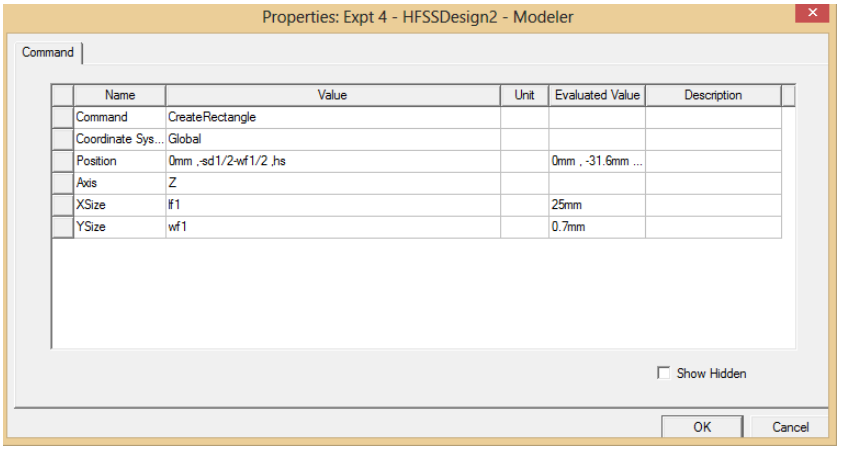


8. For matching at Patch 2:Create rectangle, Centre (r1, sd1/2+mw/2, hs), X size = -ml, Y size = -mw
Where, sd1=62.5 mm, ml = 1.4 mm, mw = 1.1 mm, hs = 1.6 mm

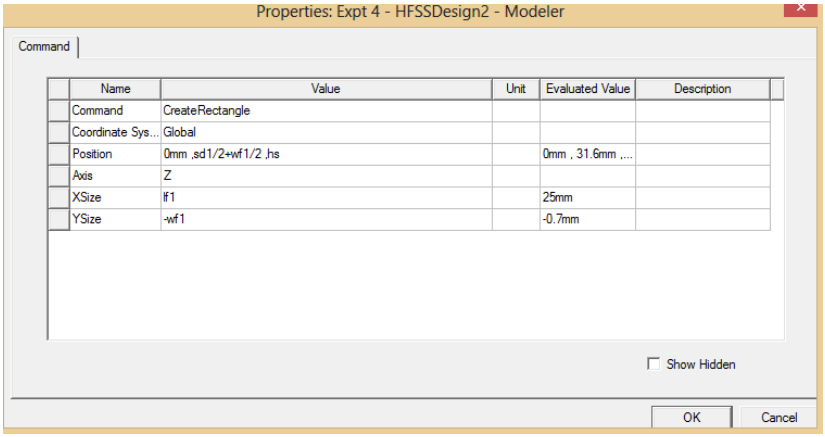


9. Now subtract the Object created in Step 7 from the Object created in Step 6.

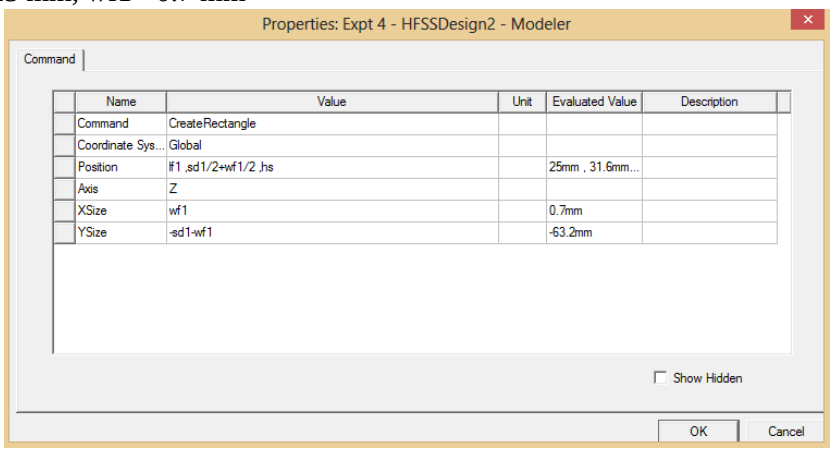
10. For feed to Patch 1: Create Rectangle 1. Centre: (0mm ,-sd1/2-wf1/2 , hs), X size = lf1, Y size = wf1
    Where, lf1 = 25 mm, wf1 =0.7 mm



11. For feed to Patch 2: Create Rectangle 2. Centre: (0mm ,sd1/2+wf1/2 ,hs), length = lf1, width =-wf1
    Where, lf1 = 25 mm, wf1 =0.7 mm

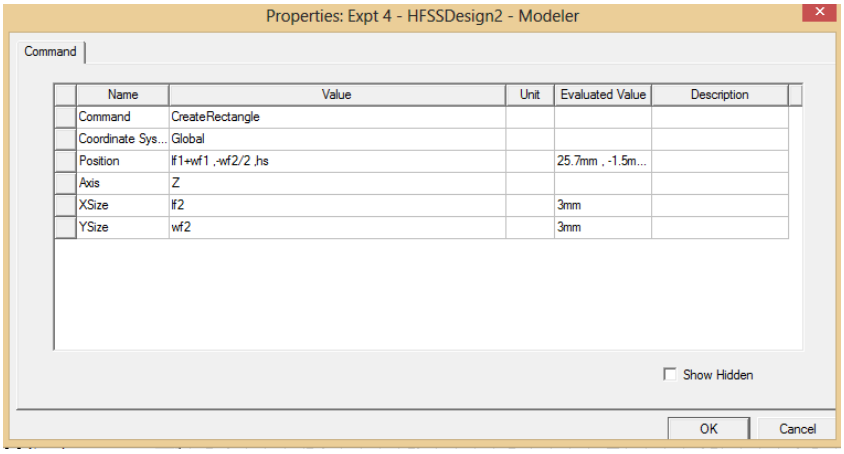


12. For Connection between feeds of Patch 1 and Patch 2:
    Create Rectangle 3. Centre: (lf1, sd1/2+wf1/2, hs), X size = wf1, Y size = -sd1-wf1
    Where, lf1 = 25 mm, wf1 =0.7 mm

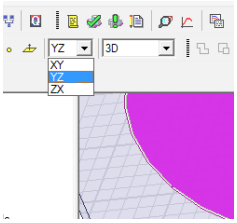


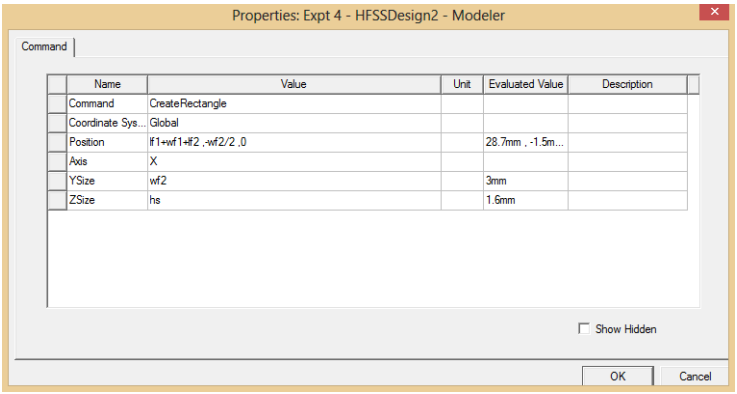
13. Now Select all (i.e. Patch 1, Patch 2, all Feeds) and Unite all. Right click > Assign boundary > Perfect E
14. Assign Perfect E boundary to the above united objects.

15. For Final feed:
    Create Rectangle 4. Centre: (lf1+wf1, -wf2/2, hs), X size = lf2, Y size = wf2,
    Where, lf2 = 3 mm, wf2 = 3 mm

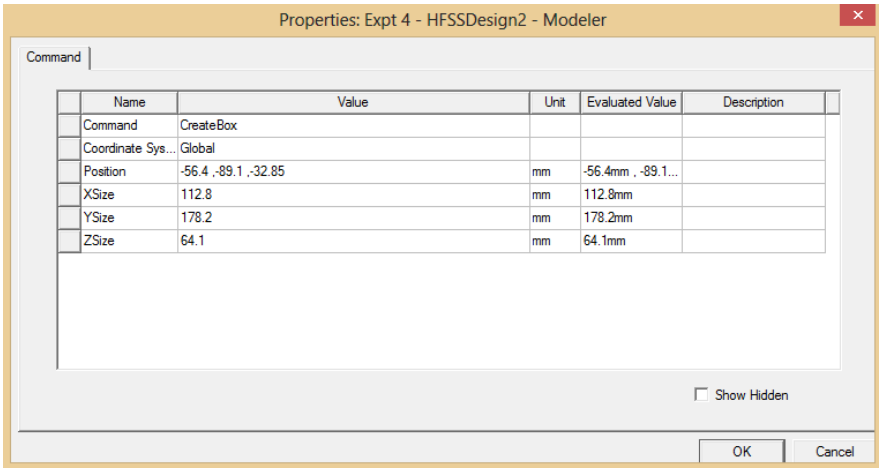


16. For excitation, create a rectangle in YZ plane.
    Create Rectangle. Centre: (lf1+wf1+lf2, -wf2/2, 0), X size = wf2, Z size = hs,
    Where, wf2 = 3 mm





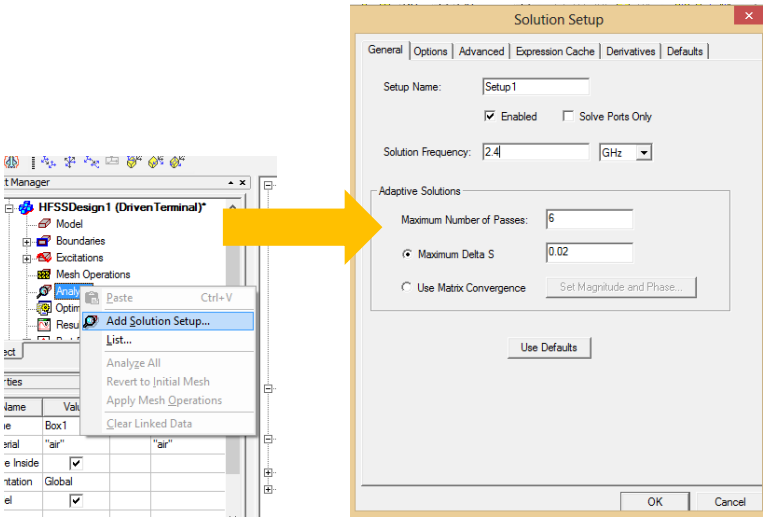
17. Now create the radiation box with dimension as shown below. All are in millimeter.



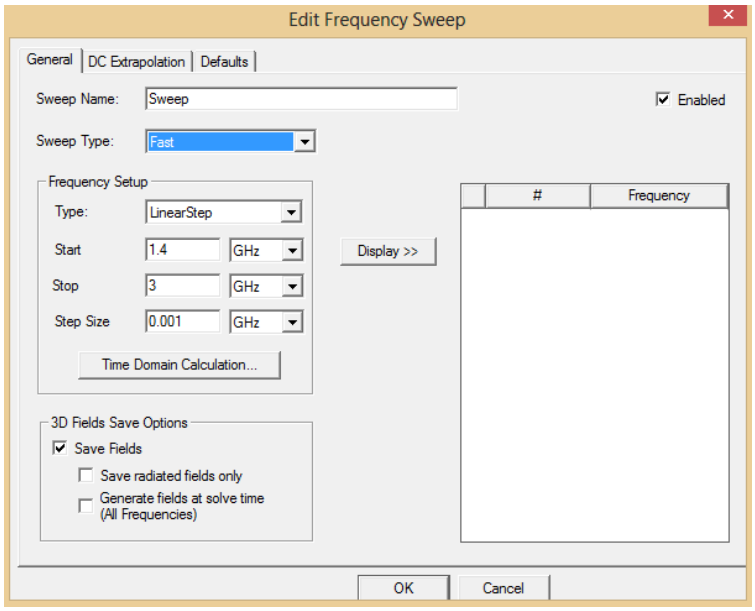
18. Assign radiation only boundary to the radiation box. Right click > Assign boundary > Radiation

19. Now assign Lumped port excitaton (Draw the ecitation line from the ground plance to the feed)

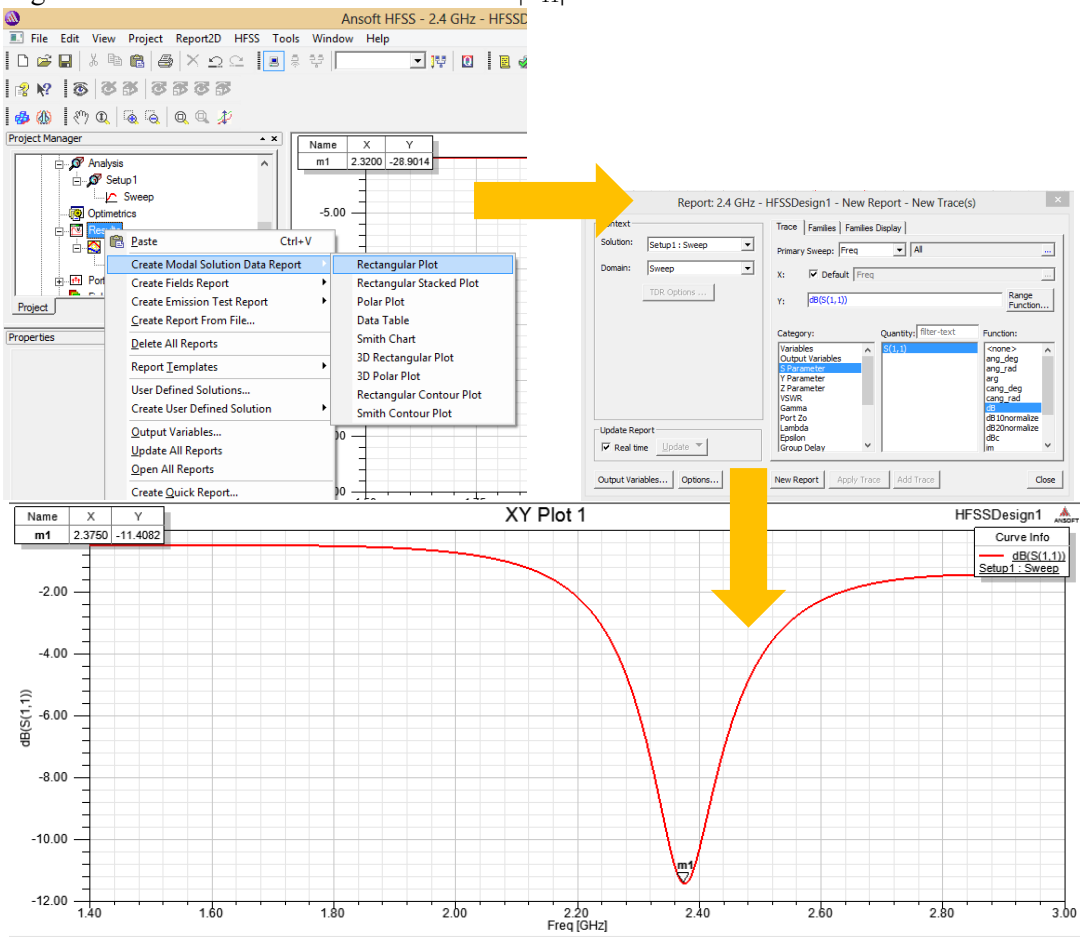
20. Right Click on analysis > Add solution setup → add 2.4 GHz > Ok



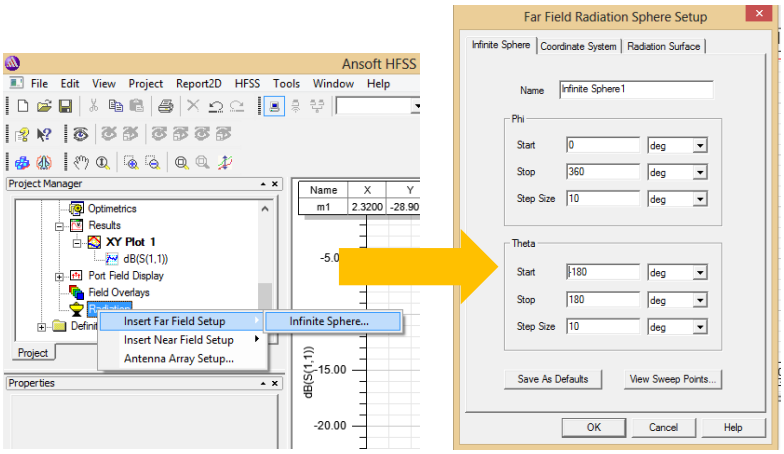
21. Click '+' of the analysis → Right click on setup → Add frequency sweep → Edit frequency sweep (Sweep type Fast, Frequency range 1.4 GHz to 3 GHz, Step size 0.001 GHz) → Ok



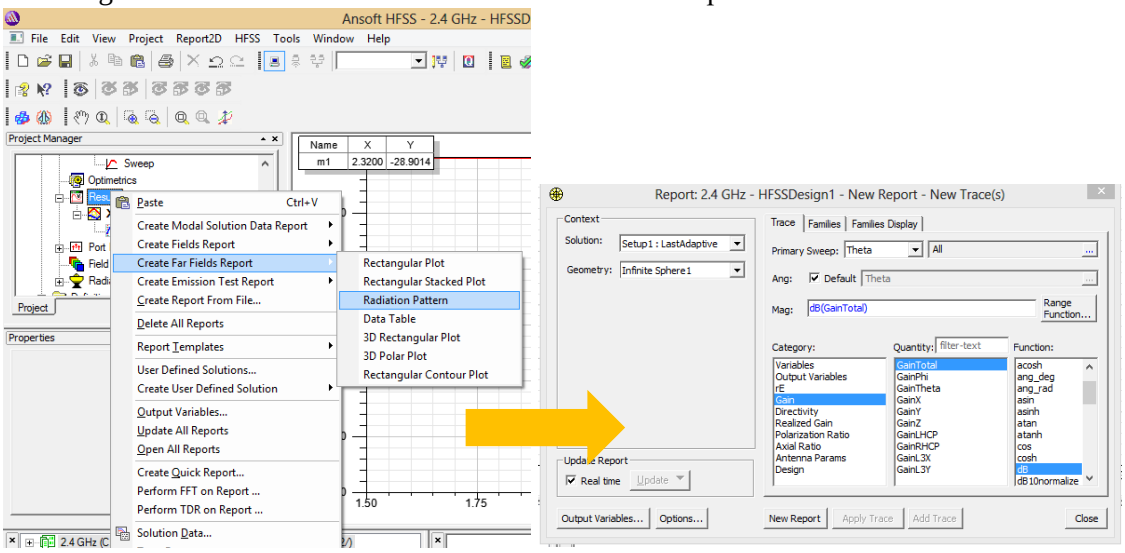
22. Right click on results > Do as follows…for $|S_{11}|$



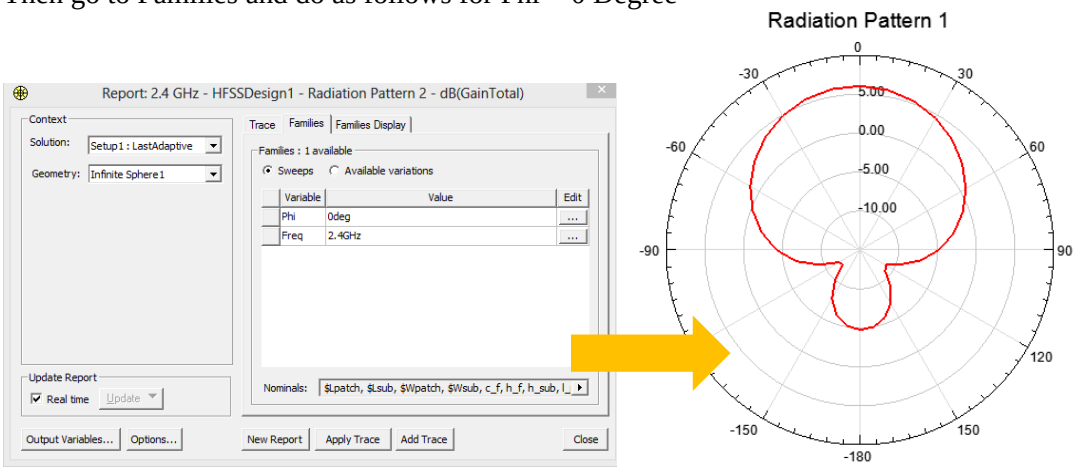
23. Right click on Radiation > Do as follows…for radiation pattern



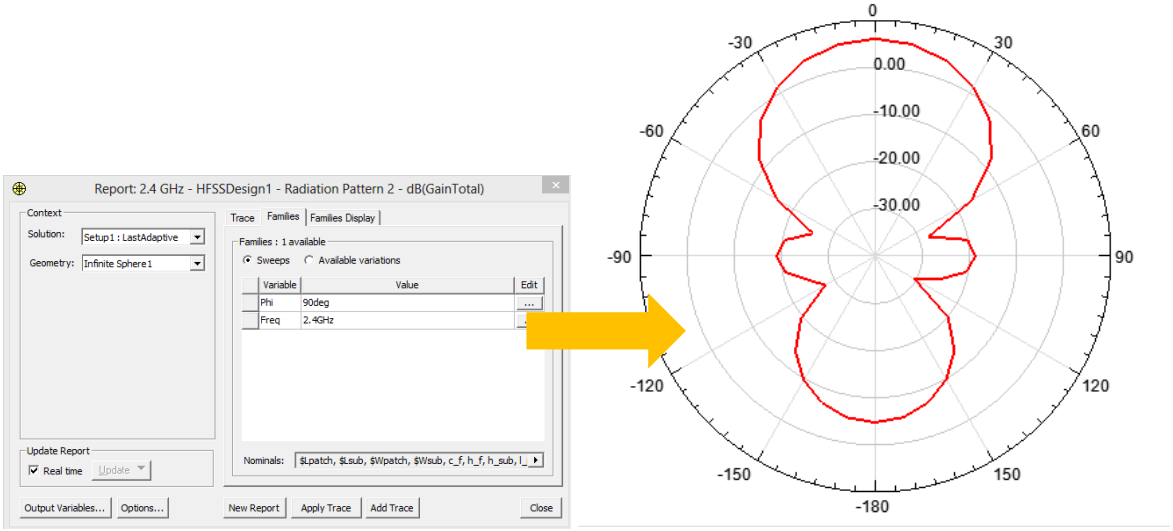
24. Then Right click on Results > Do as follows…for radiation pattern



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



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



25. To plot the gain of the antenna, do as follows;