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Aim:

To design a radiation pattern of Probe-fed microstrip patch antenna at 5GHz and to plot S and VSWR parameters.

Introduction:

Probe-fed microstrip patch antennas have emerged as a popular choice for 5G applications, particularly at the 5 GHz frequency range, due to their compact size, low profile, and ease of integration with other electronic components. These antennas consist of a metallic patch on top of a dielectric substrate, with a ground plane on the bottom and a coaxial probe feed connecting directly to the patch through the substrate. The probe feeding method offers several advantages, including efficient power transfer, controllable input impedance, and reduced spurious radiation compared to edge-fed designs. When designing a probe-fed microstrip patch antenna for 5 GHz operation, key considerations include substrate selection, patch dimensions, feed point location, and bandwidth enhancement techniques. Proper design can yield antennas with return loss better than -10 dB, bandwidth of 2-5% of the center frequency, gain of 5-8 dBi, and a broadside radiation pattern with a half-power beamwidth of about 60-70 degrees. These characteristics make probe-fed microstrip patch antennas well-suited for various 5G applications, such as small cell base stations, customer premises equipment (CPE), and Internet of Things (IoT) devices, where compact and efficient antennas are crucial for optimal performance in the sub-6 GHz frequency band.

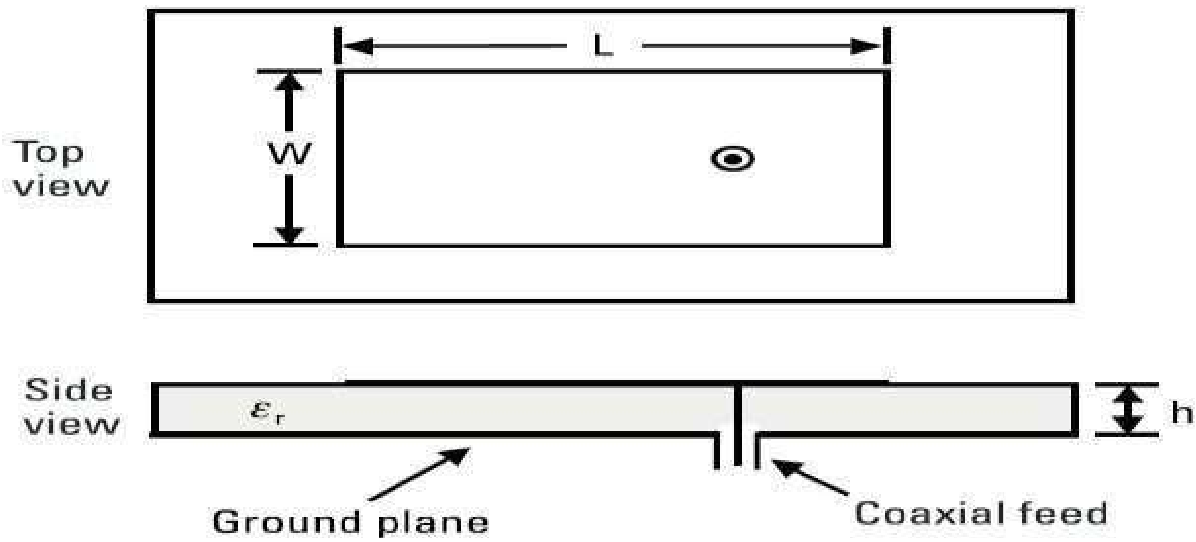
A probe-fed microstrip patch antenna for 5G applications at 5 GHz typically consists of the following components:

1. Patch: A thin metallic layer on top of the substrate that acts as the radiating element. For a rectangular patch, the width and length are calculated based on the desired frequency and substrate properties.

2. Substrate: A dielectric material that separates the patch from the ground plane. For 5 GHz applications, low-loss materials like Rogers RT/Duroid 5880 are often used.

3. Ground plane: A conductive layer on the bottom of the substrate.

4. Probe feed: A coaxial cable that connects to the patch through a via in the substrate.



Antenna Designs:

1. Design parameters:

- Frequency(fo) – 2.4GHz
- Relative permittivity of substrate(εr) – 4.4
- Thickness of substrate(h) – 1.6 mm

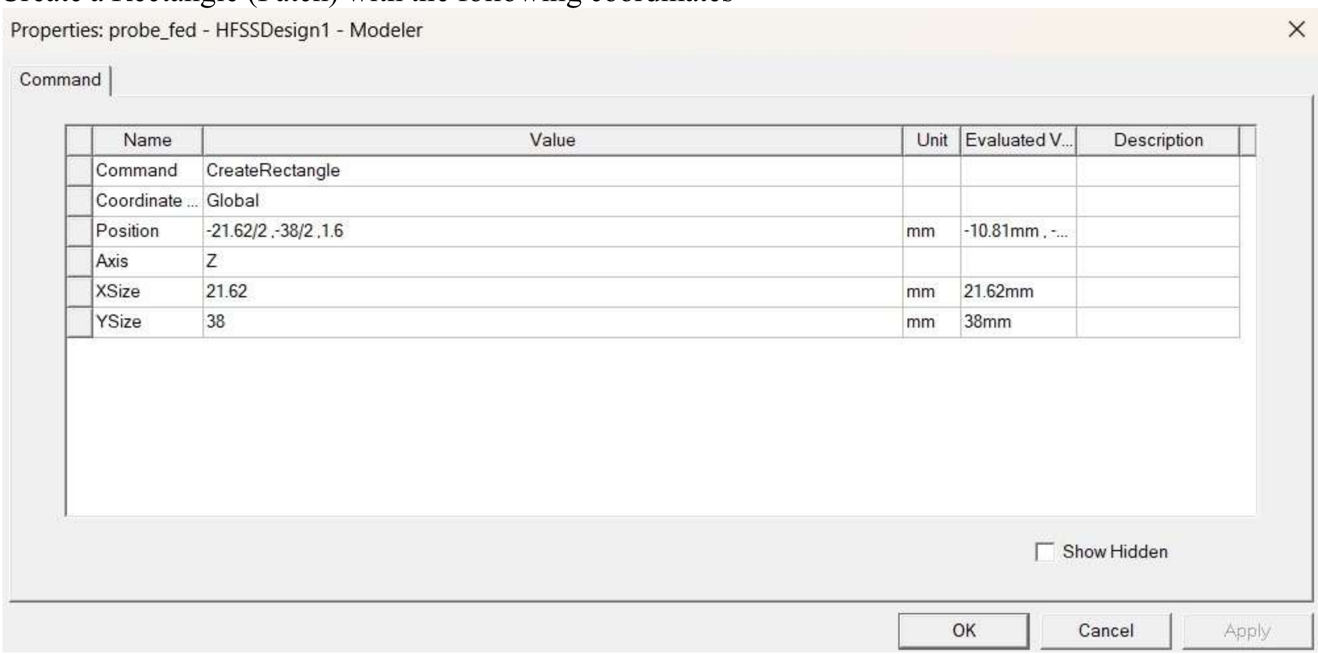
2. Design Equation:

$$Width = \frac{c}{2f_o\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}}\right]$$

$$Length = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

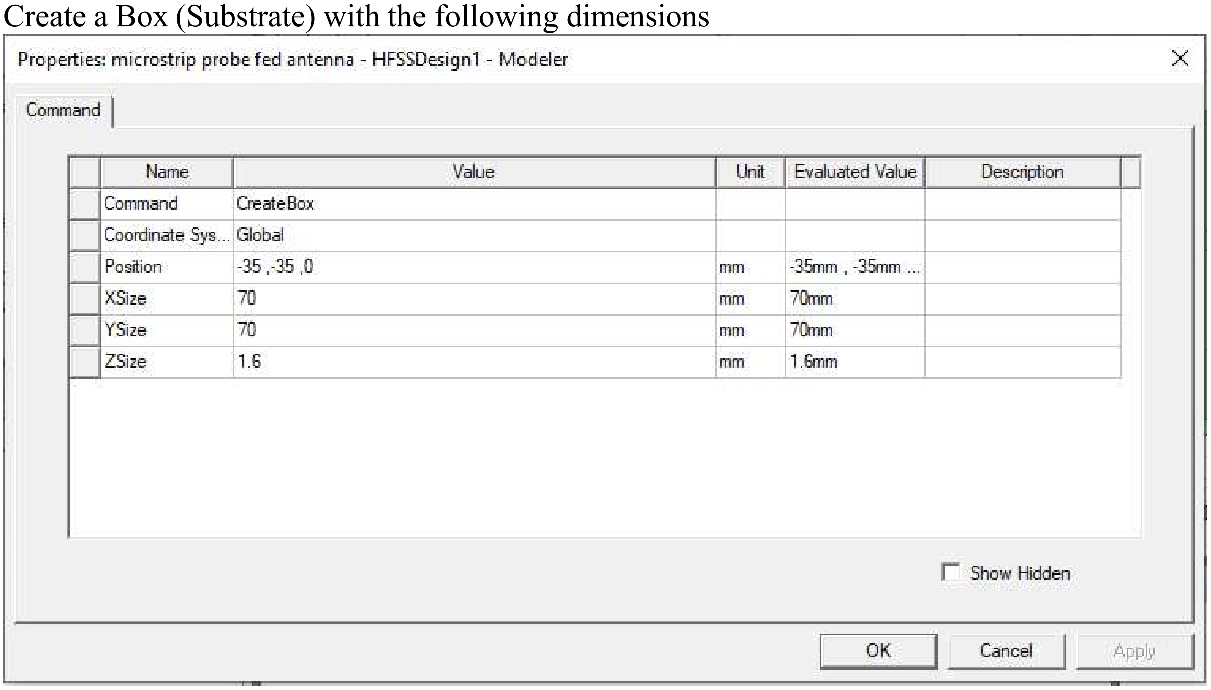
Simulation Steps:

Create a Rectangle (Patch) with the following coordinates



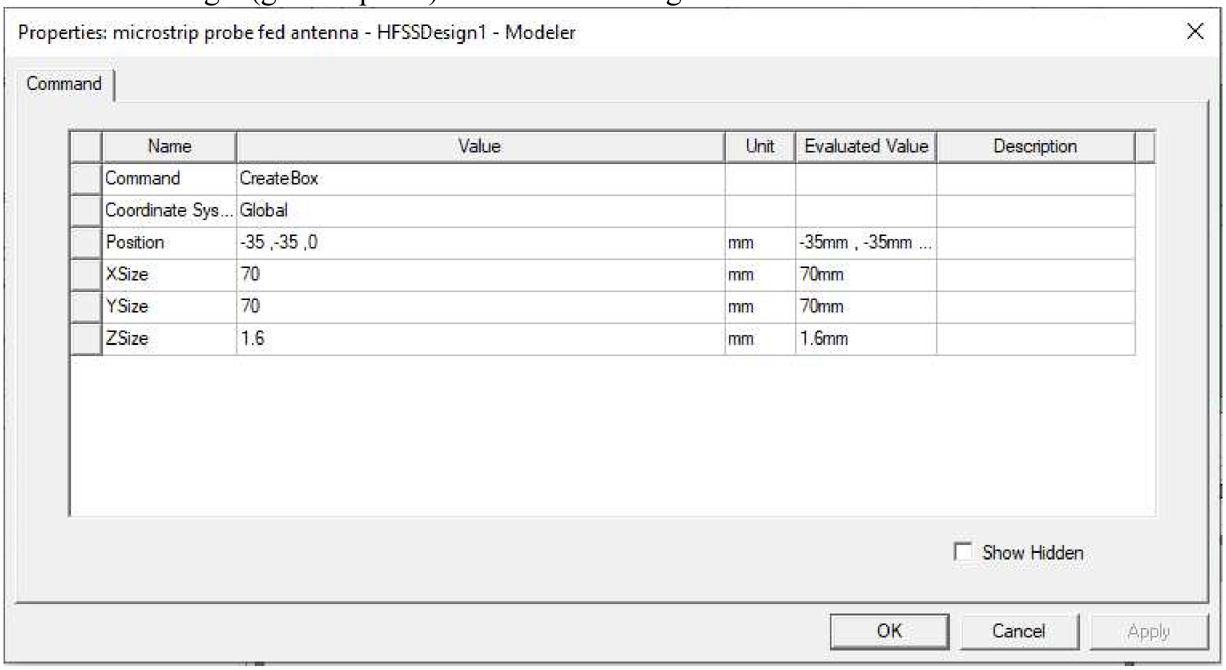
Name	Value	Unit	Evaluated V...	Description
Command	CreateRectangle			
Coordinate ...	Global			
Position	-21.62/2 ,-38/2 ,1.6	mm	-10.81mm , -...	
Axis	Z			
XSize	21.62	mm	21.62mm	
YSize	38	mm	38mm	

Create a Box (Substrate) with the following dimensions



Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-35 ,-35 ,0	mm	-35mm , -35mm ...	
XSize	70	mm	70mm	
YSize	70	mm	70mm	
ZSize	1.6	mm	1.6mm	

Create a Rectangle (ground plane) with the following dimensions


Properties: microstrip probe fed antenna - HFSSDesign1 - Modeler

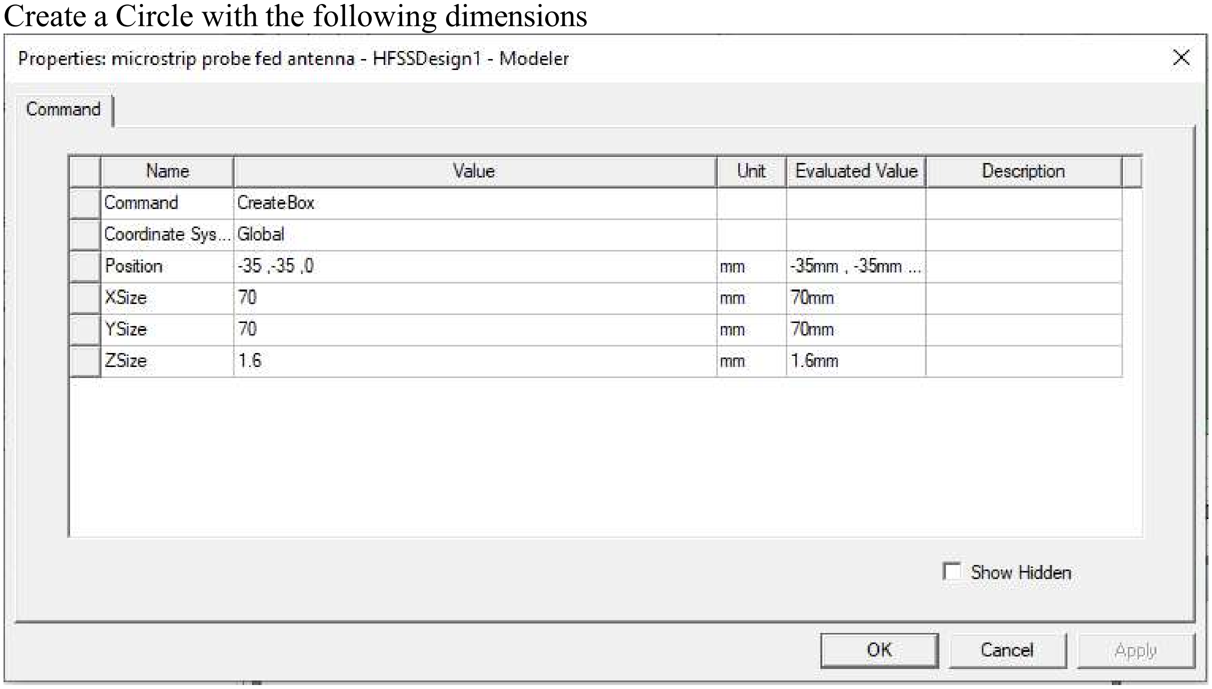
Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-35 ,-35 ,0	mm	-35mm , -35mm ...	
XSize	70	mm	70mm	
YSize	70	mm	70mm	
ZSize	1.6	mm	1.6mm	

Show Hidden

OK Cancel Apply

Create a Circle with the following dimensions


Properties: microstrip probe fed antenna - HFSSDesign1 - Modeler

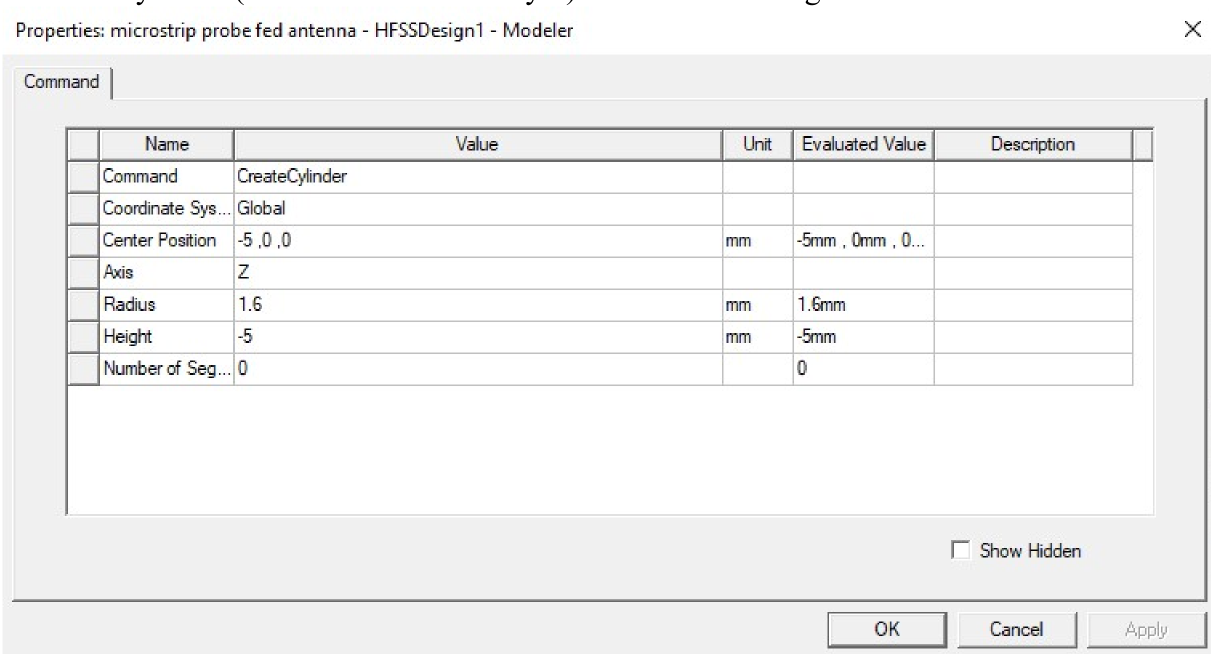
Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-35 ,-35 ,0	mm	-35mm , -35mm ...	
XSize	70	mm	70mm	
YSize	70	mm	70mm	
ZSize	1.6	mm	1.6mm	

Show Hidden

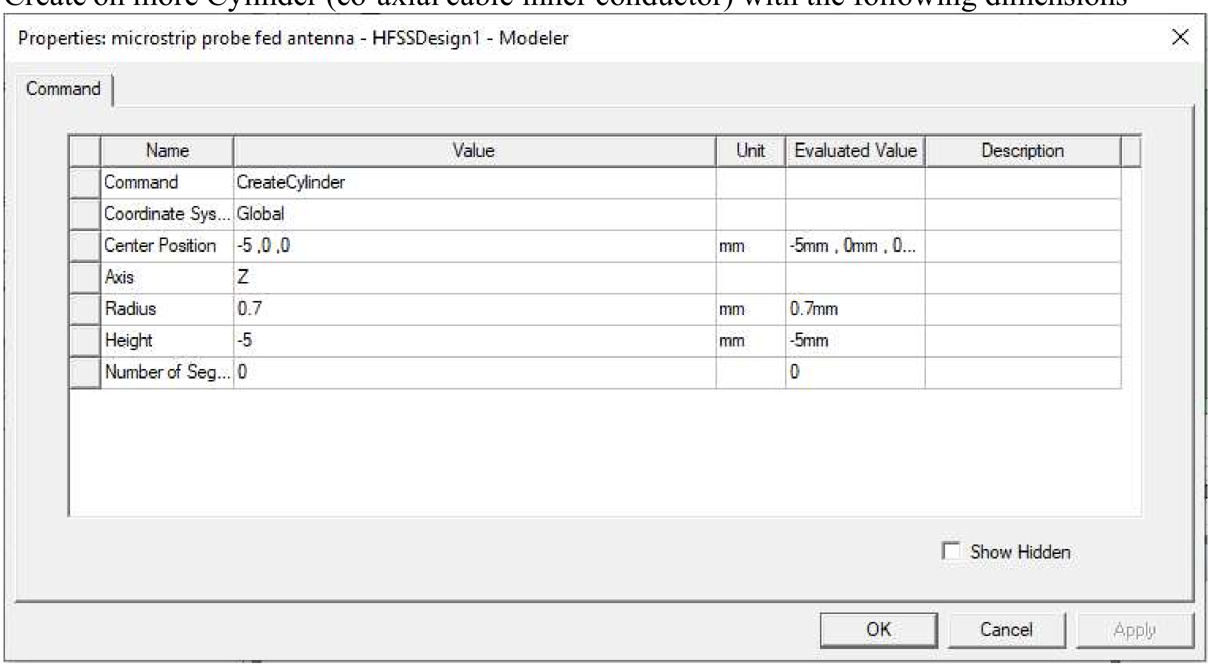
OK Cancel Apply

Create a Cylinder (co-axial cable outer layer) with the following dimensions



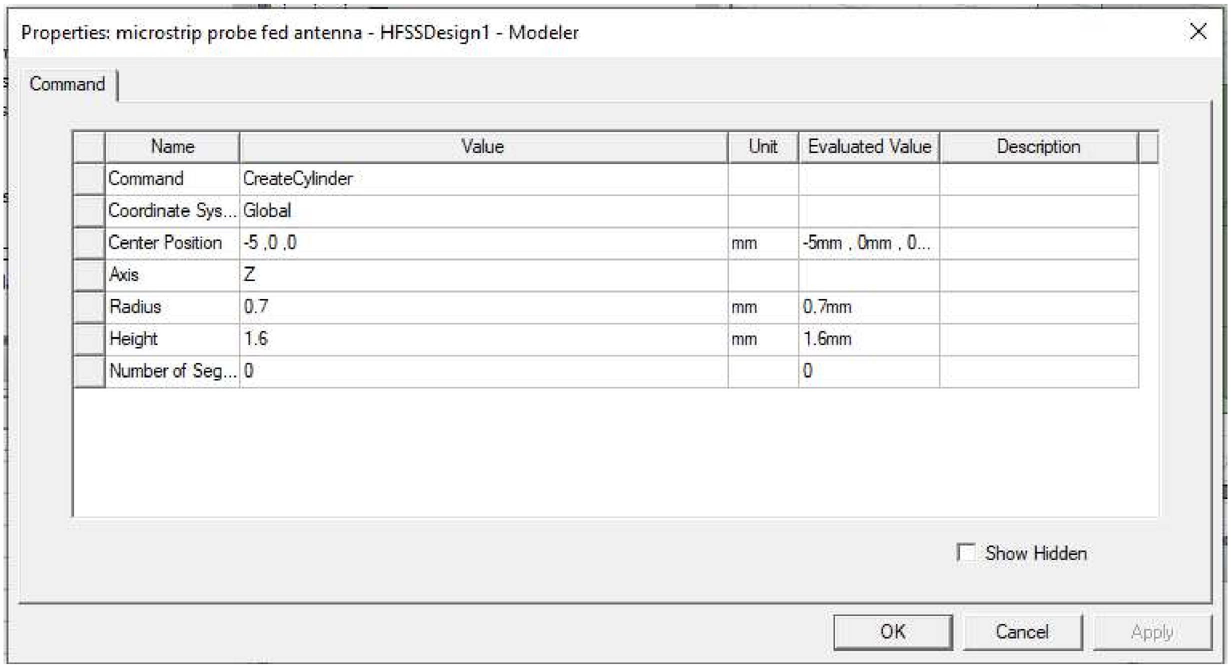
Name	Value	Unit	Evaluated Value	Description
Command	CreateCylinder			
Coordinate Sys...	Global			
Center Position	-5 ,0 ,0	mm	-5mm , 0mm , 0...	
Axis	Z			
Radius	1.6	mm	1.6mm	
Height	-5	mm	-5mm	
Number of Seg...	0		0	

Create on more Cylinder (co-axial cable inner conductor) with the following dimensions



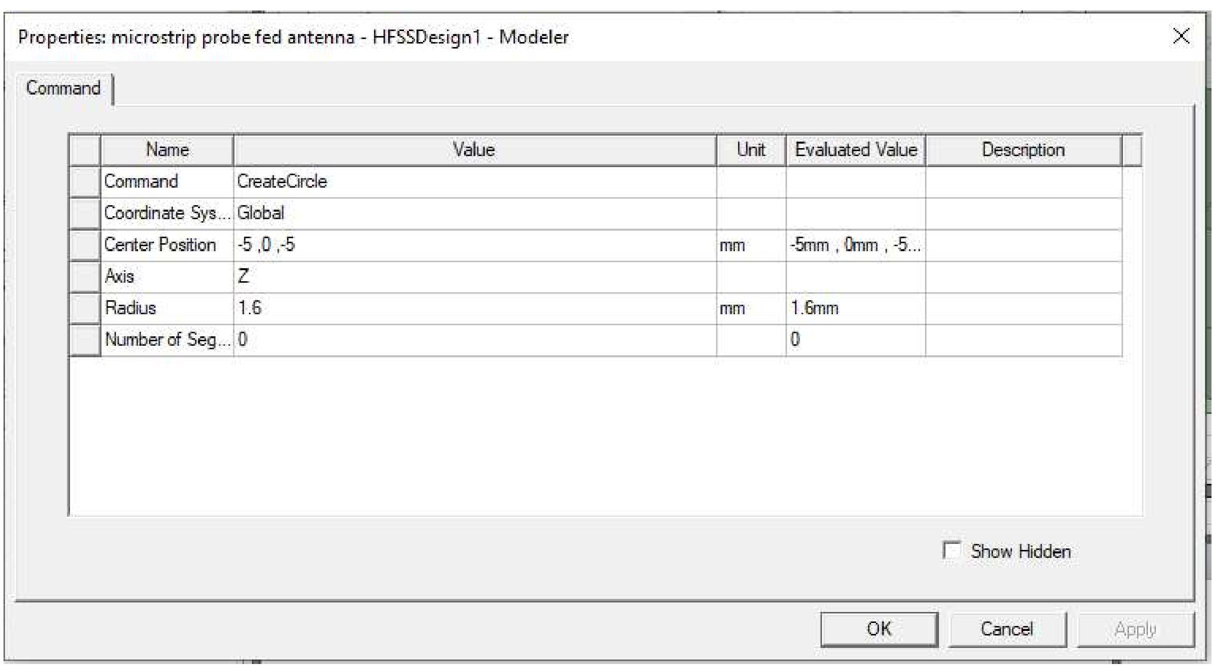
Name	Value	Unit	Evaluated Value	Description
Command	CreateCylinder			
Coordinate Sys...	Global			
Center Position	-5 ,0 ,0	mm	-5mm , 0mm , 0...	
Axis	Z			
Radius	0.7	mm	0.7mm	
Height	-5	mm	-5mm	
Number of Seg...	0		0	

Create on more Cylinder (co-axial cable inner conductor-probe) with the following dimensions



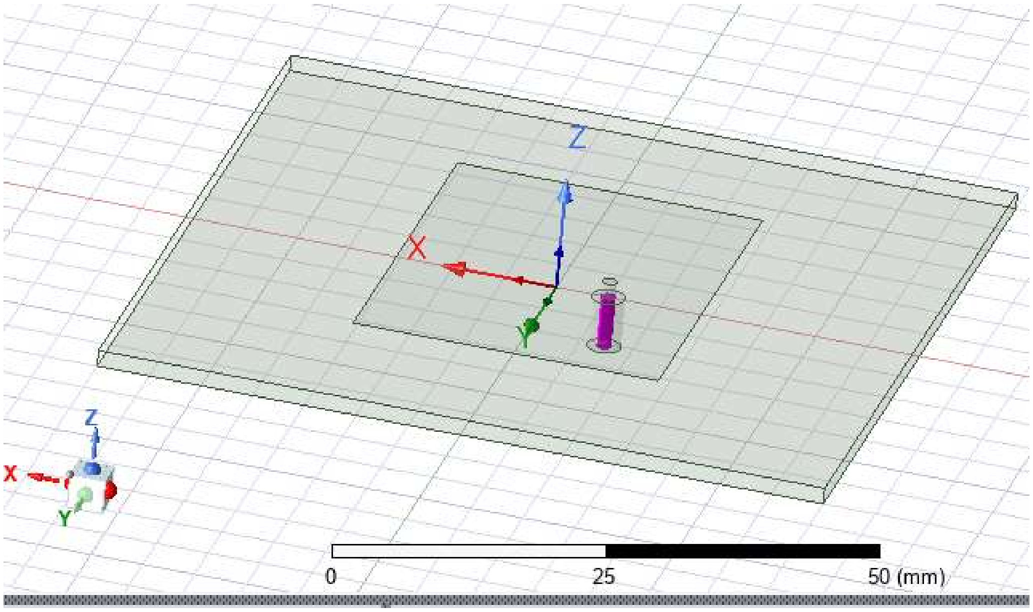
Name	Value	Unit	Evaluated Value	Description
Command	CreateCylinder			
Coordinate Sys...	Global			
Center Position	-5 ,0 ,0	mm	-5mm , 0mm , 0...	
Axis	Z			
Radius	0.7	mm	0.7mm	
Height	1.6	mm	1.6mm	
Number of Seg...	0		0	

Create circle with the following dimensions

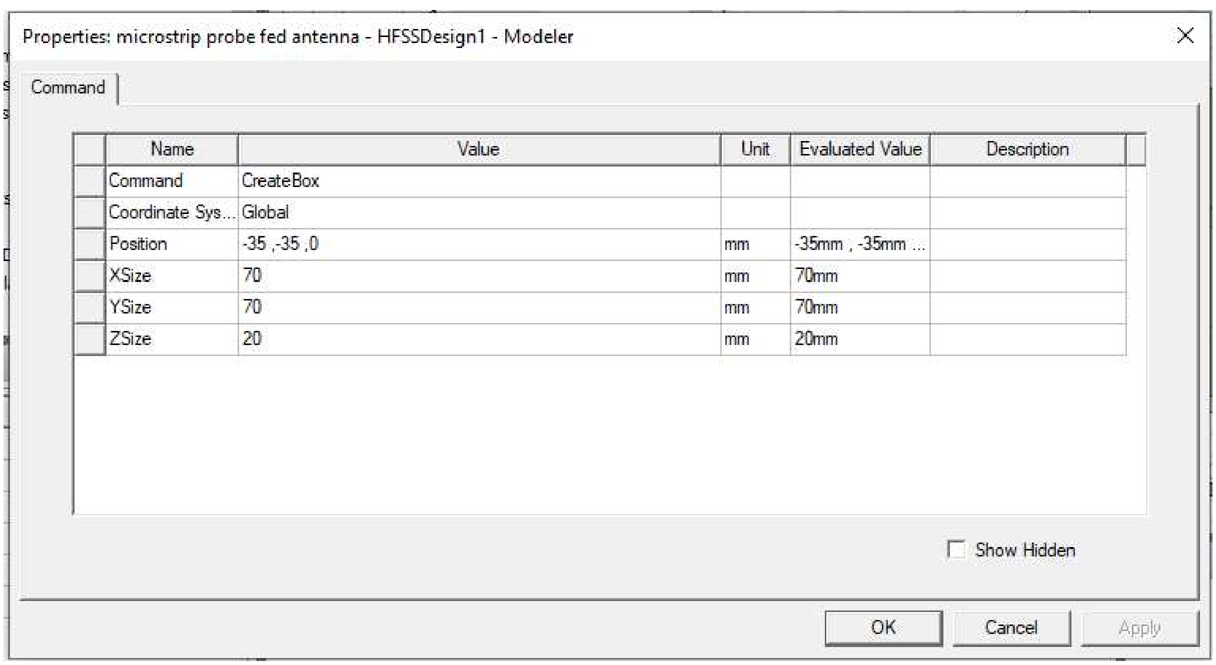


Name	Value	Unit	Evaluated Value	Description
Command	CreateCircle			
Coordinate Sys...	Global			
Center Position	-5 ,0 ,-5	mm	-5mm , 0mm , -5...	
Axis	Z			
Radius	1.6	mm	1.6mm	
Number of Seg...	0		0	

Now the model looks like this



Create box(radiation box) with the following dimensions


Properties: microstrip probe fed antenna - HFSSDesign1 - Modeler

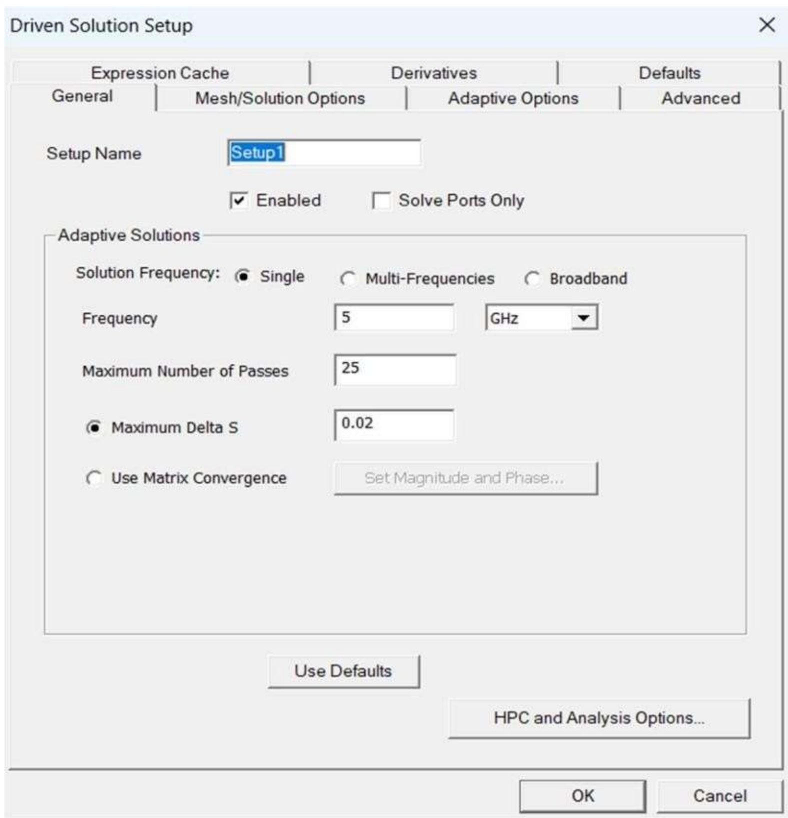
Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate Sys...	Global			
Position	-35 ,-35 ,0	mm	-35mm , -35mm ...	
XSize	70	mm	70mm	
YSize	70	mm	70mm	
ZSize	20	mm	20mm	

Show Hidden

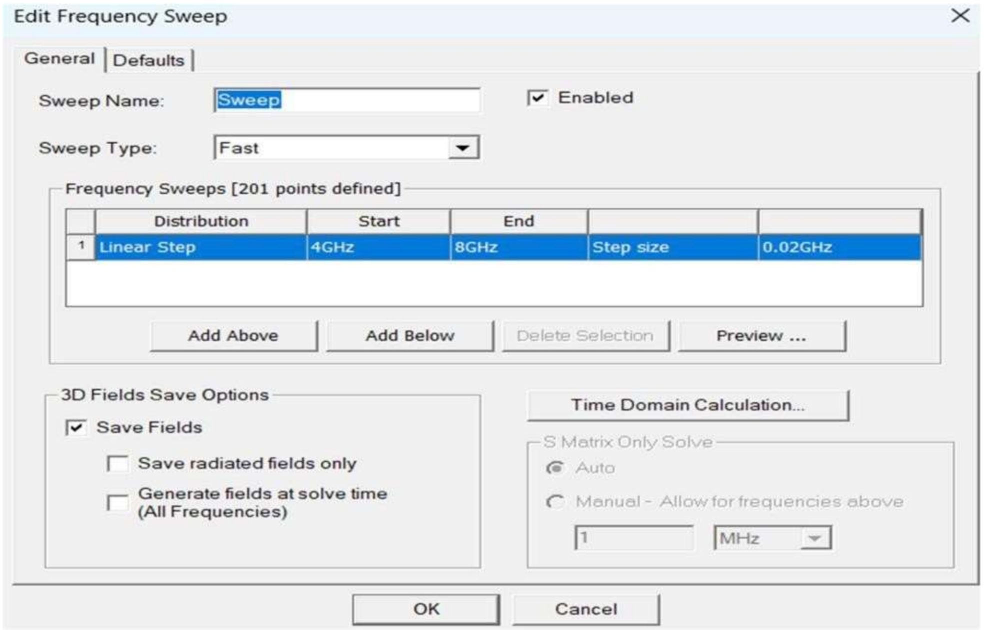
OK Cancel Apply

- Assign the material of box2 as “air”
- Right click in the work area, selection mode, faces
- Now you can select individual faces of an object instead of an entire object
- Now select 5 faces of box2 i.e. radiation box using control button except the bottom face
- Right click, assign boundary, radiation, ok
- Now your model is constructed along with radiation boundary.



Click on ok

In the next window that appears after clicking ok, enter the values as given below

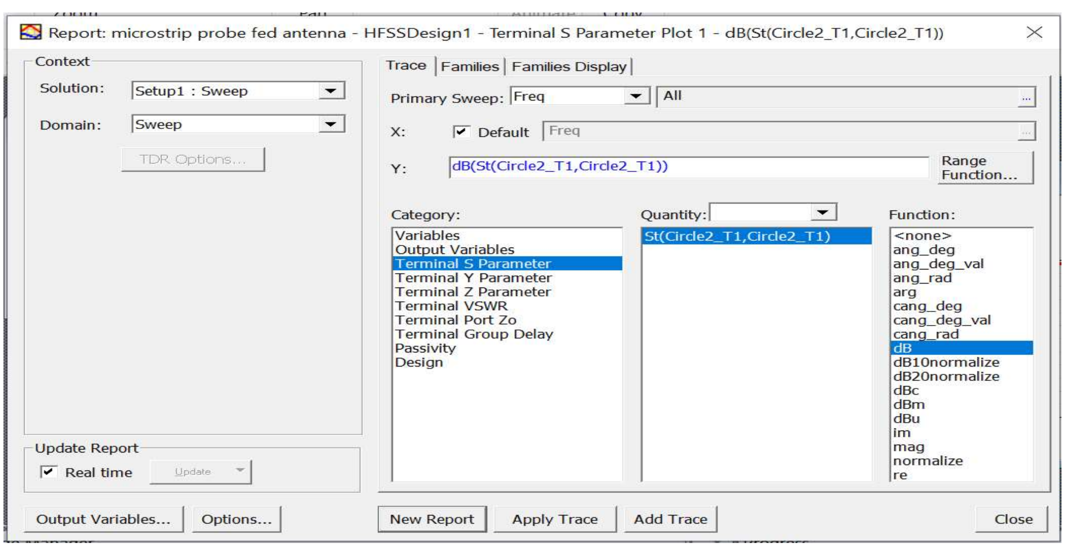


Go to HFSS, validation Check, Close the validation window.Go to HFSS, analyze all, no errors proceed.

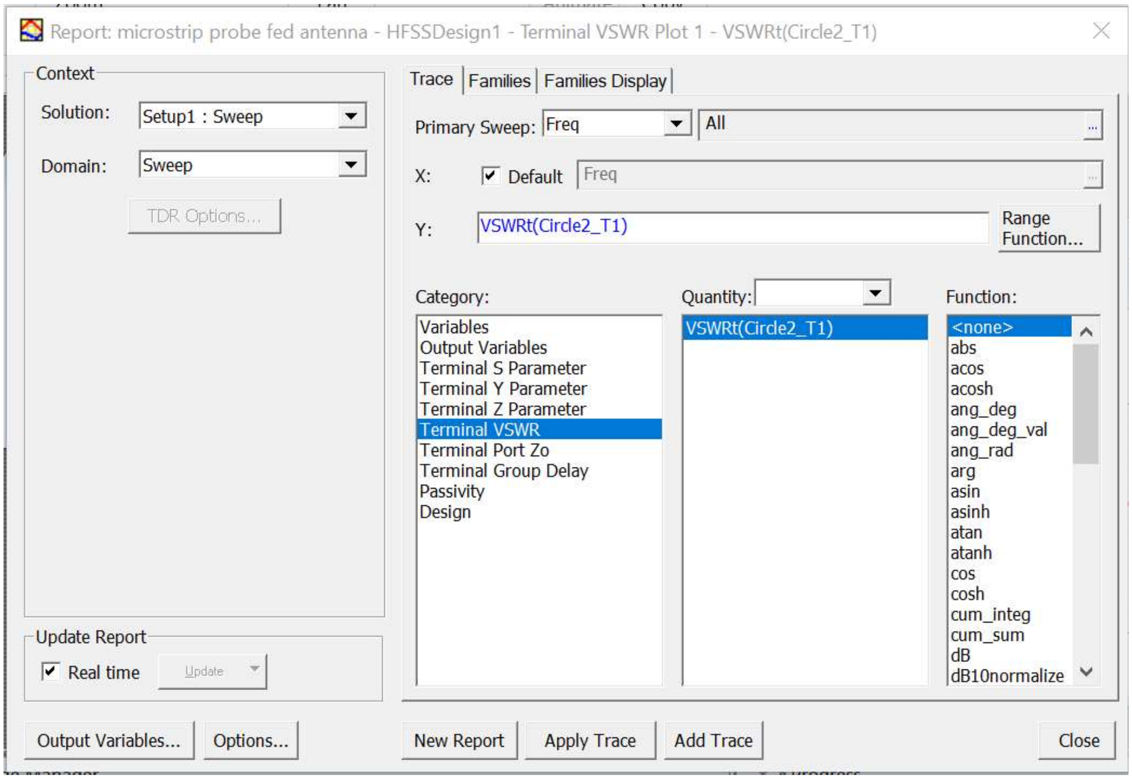
Right click on Result in Project manager section, create terminal solution data report, rectangularplot.

The following window will appear

Click on new report, close.

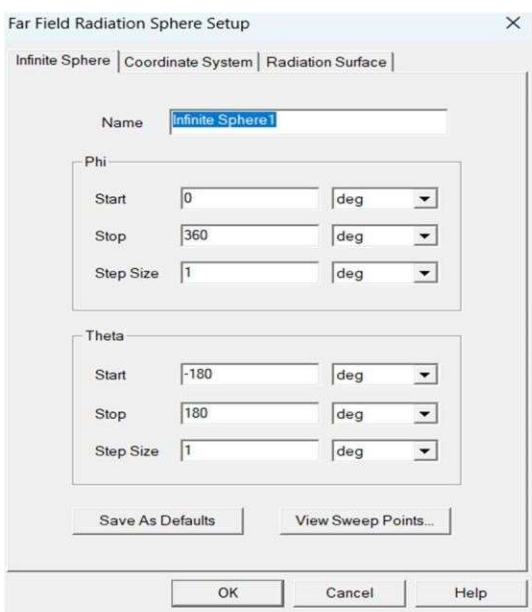


In the same way, right click on results in project manager section, create modal solution data report, rectangular plot, select VSMR in category section, click on new report as given below.



Right click on radiation in project manager window, insert far field setup, infinite sphere.

Enter the values as given below



Right Click on results, create far fields report, 3D polar plot