Experiment No. 7

Aim:

To study and Simulate Electromagnetic Radiation of a Half-wave Dipole Antenna using FEM Simulation.

What will you learn by performing this experiment?

This experiment explains the principle of electromagnetic radiation. It helps in understanding how electric and magnetic fields are part of a single entity known as an electromagnetic wave.

Software Required:

1. COMSOL Multiphysics or any other FEM EM simulation software.

Theory:

Antenna definition: An antenna is defined as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The IEEE Standard Definitions of Terms for Antennas (IEEE Std 145–1983) defines the antenna or aerial as "a means for radiating or receiving radio waves." In other words, the antenna is the transitional structure between free-space and a guiding device, as shown in Figure 7.1. The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna, or from the antenna to the receiver. In the former case, we have a transmitting antenna and, in the latter, a receiving antenna.

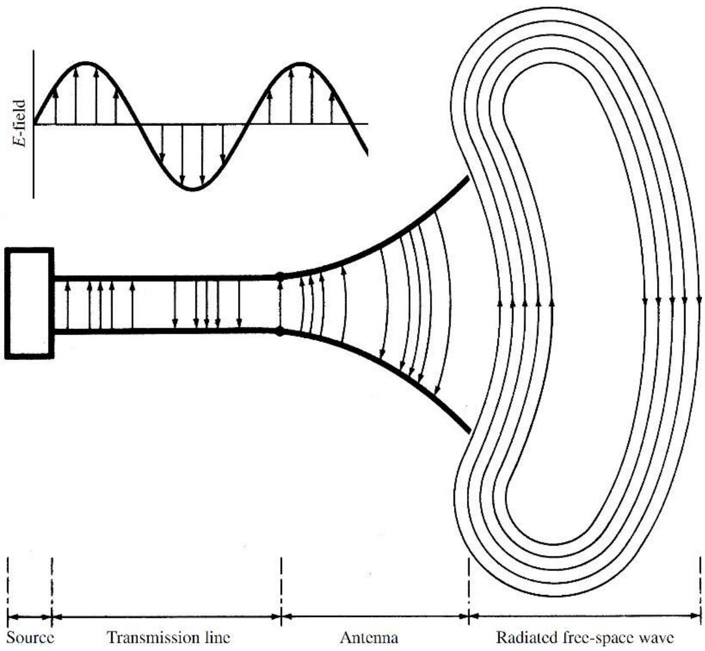


Fig. 7.1: Antenna as a transition device

Simple Dipole Antenna or Half-Wavelength Dipole Antenna: The half-wavelength dipole antenna is a simple dipole whose length is half-wavelength of the operation frequency. The current and voltage waveform along the length of the dipole is shown in Fig. 7.2. These antennas have omnidirectional (broadside) with a torus like radiation pattern (Fig. 7.3 and Fig. 7.4 (3D)) with a maximum theoretical directivity of 1.643 and an input impedance of 73 Ω.

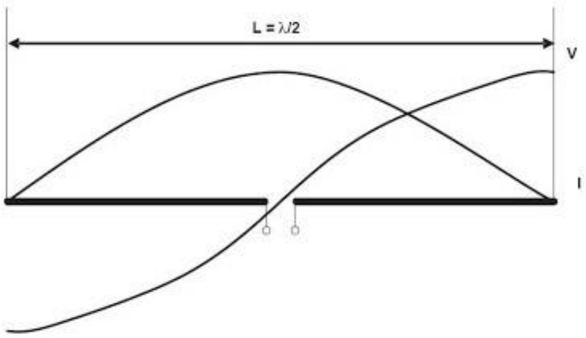


Fig. 7.2: Simple Dipole Antenna (Half wave)

The theoretical radiation pattern of the dipole is shown in Fig. 7.3. The radiation pattern is like '∞ infinity' symbol in E-plane and circular in H-plane.

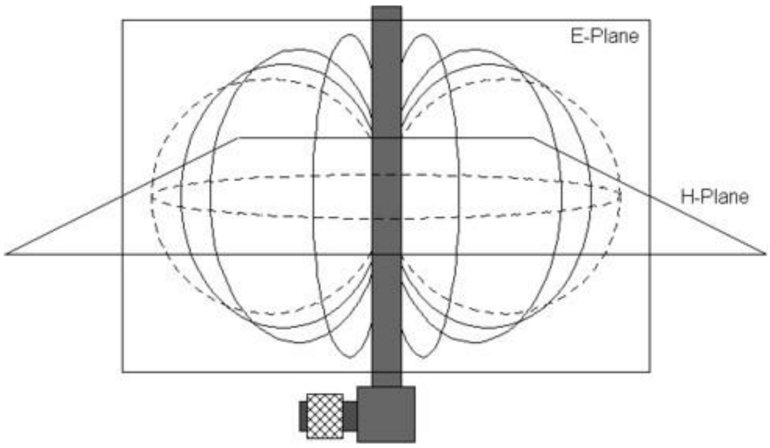


Fig.7.3: Radiation pattern of a half-wavelength dipole antenna

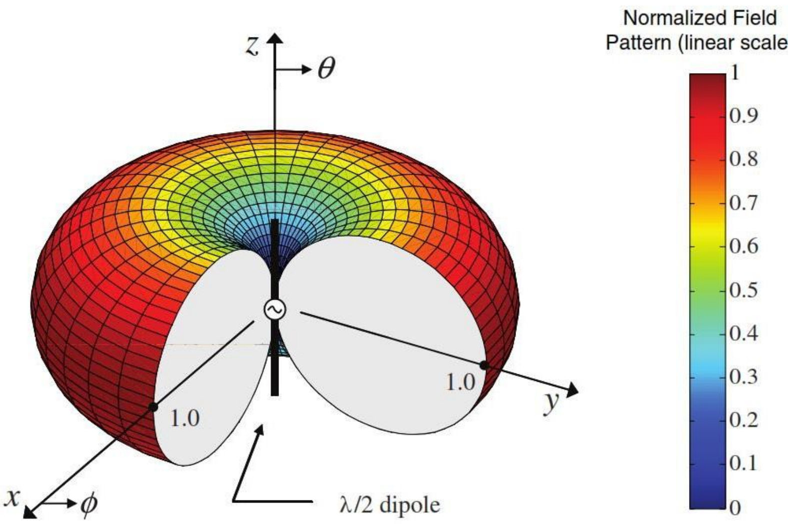


Fig. 7.4: Three-Dimensional radiation pattern of a half-wave dipole antenna.

Procedure:

1. Install FEM Simulation Software.

2. Define design dimensions/parameters.
3. Create Model Geometry.
4. Assign Material to the geometry domains.
5. Define Boundary Conditions.
6. Observe the Results/Plots.

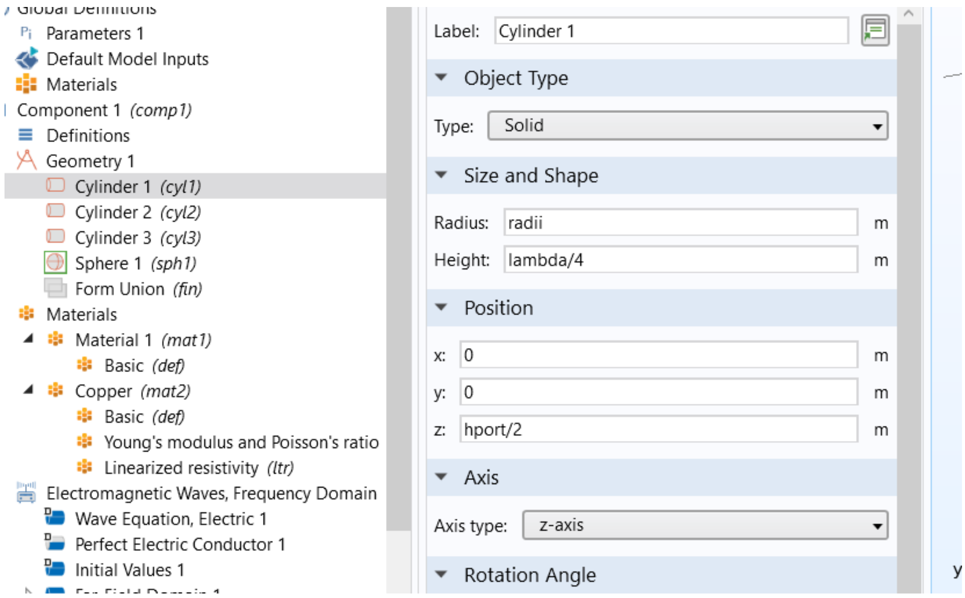
The detailed procedure is explained as follows:

- Choose Electromagnetic Waves, Frequency Domain Solver under Radio Frequency.
- Declare the design frequency and other design parameters as shown below:

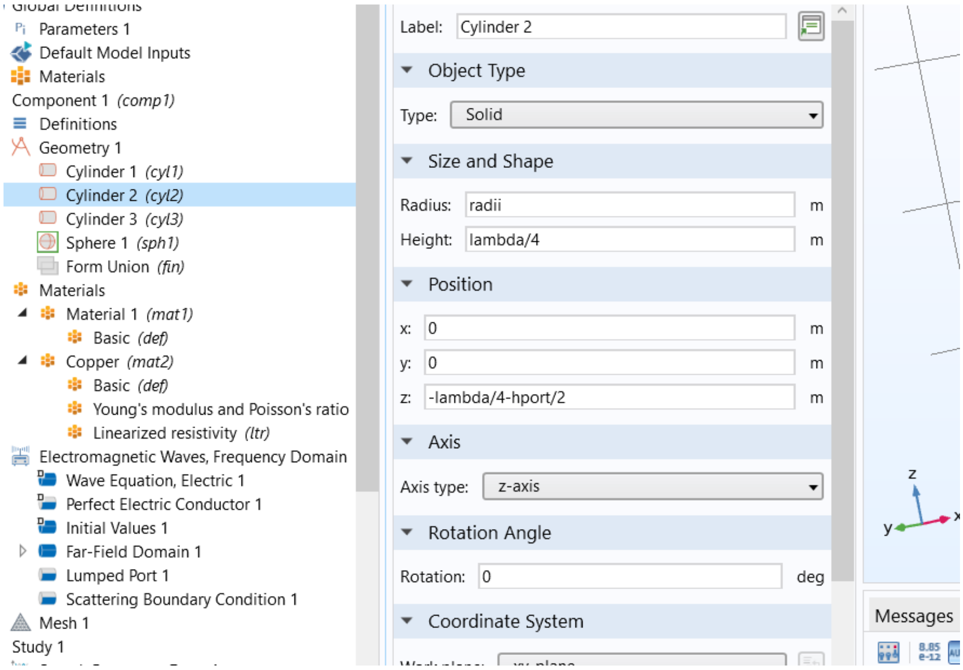
Parameters

Name	Expression	Value	Descripti
lambda	c/freqq	0.4 m	
freqq	.75[GHz]	7.5E8 Hz	
c	3*10^8[m/s]	3E8 m/s	
radii	lambda/40	0.01 m	
hport	lambda/50	0.008 m	

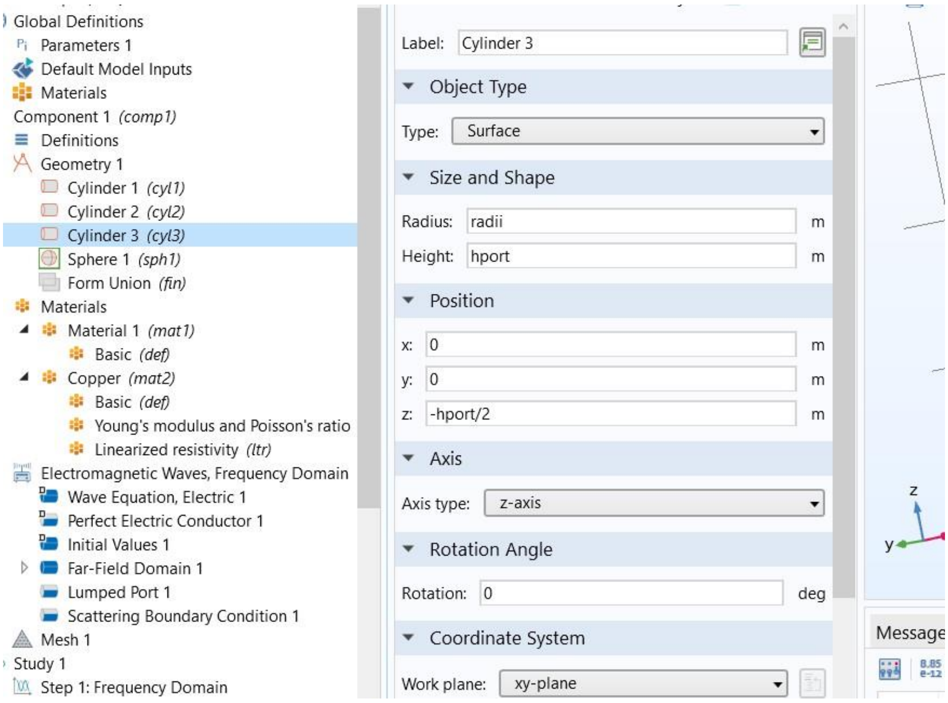
- Create first dipole arm using cylindrical geometry



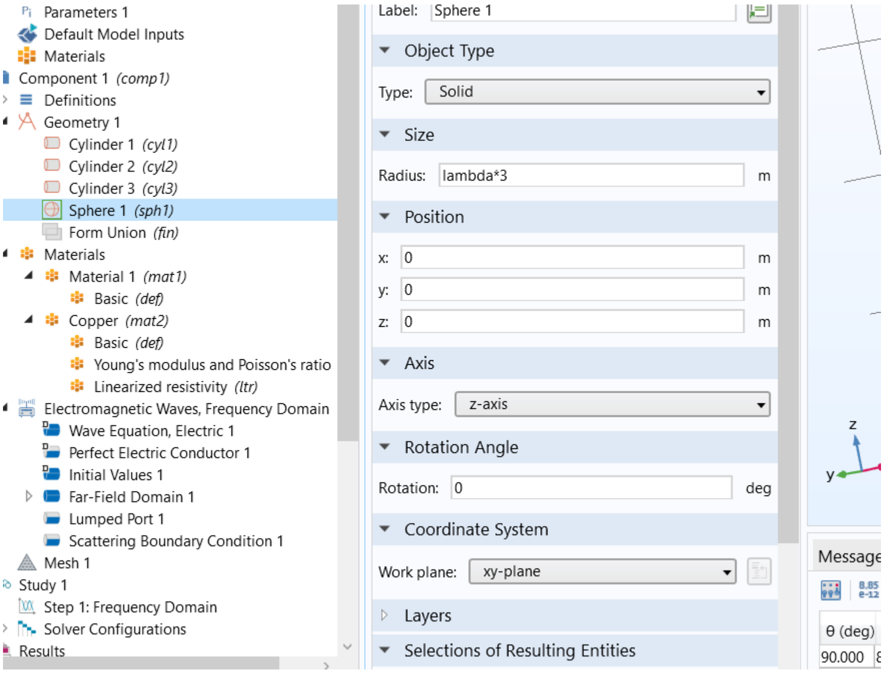
- Create second dipole arm using cylindrical geometry



- Create the surface for providing input or feed signal to the antenna.

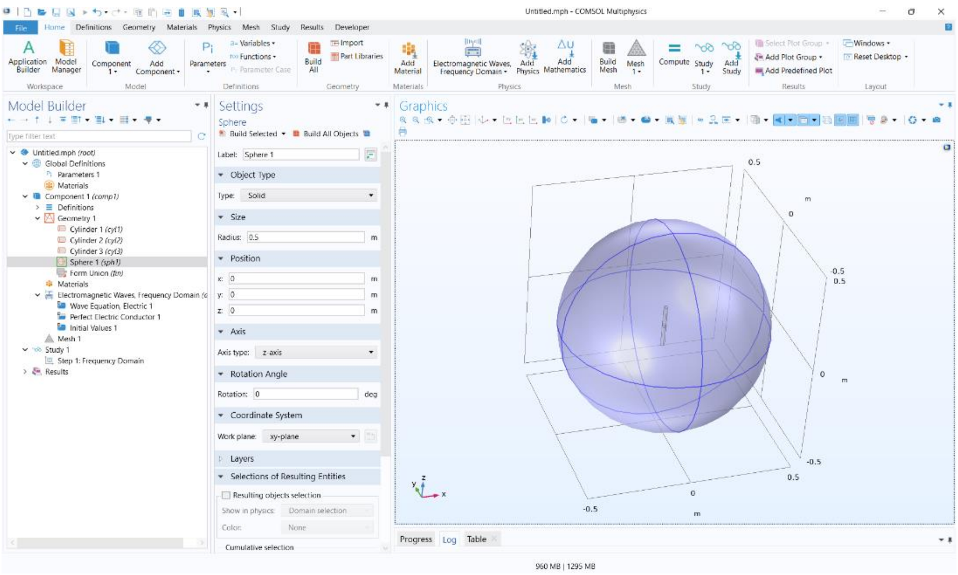


- Create outer sphere of Air.

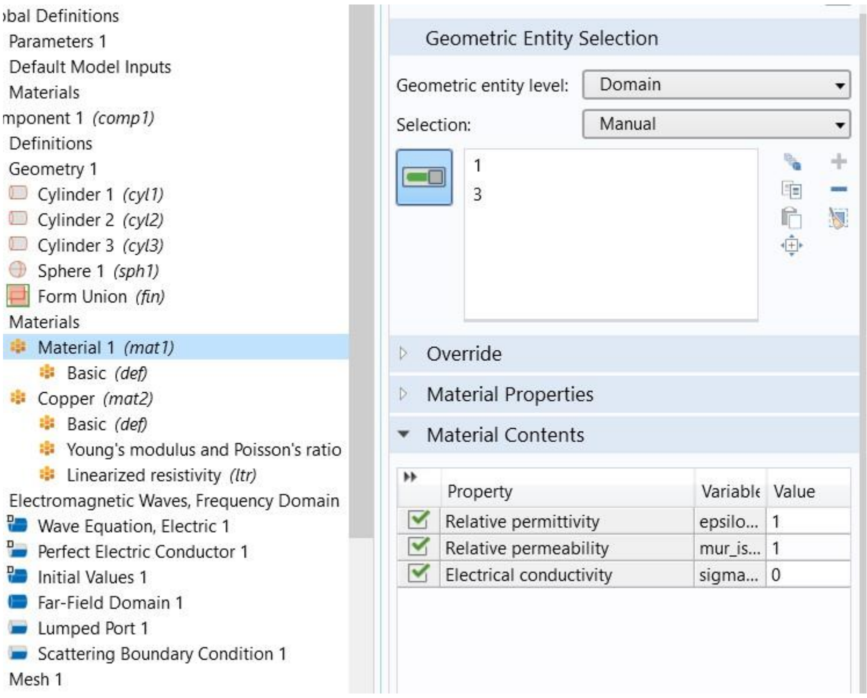


- The geometry is shown below:

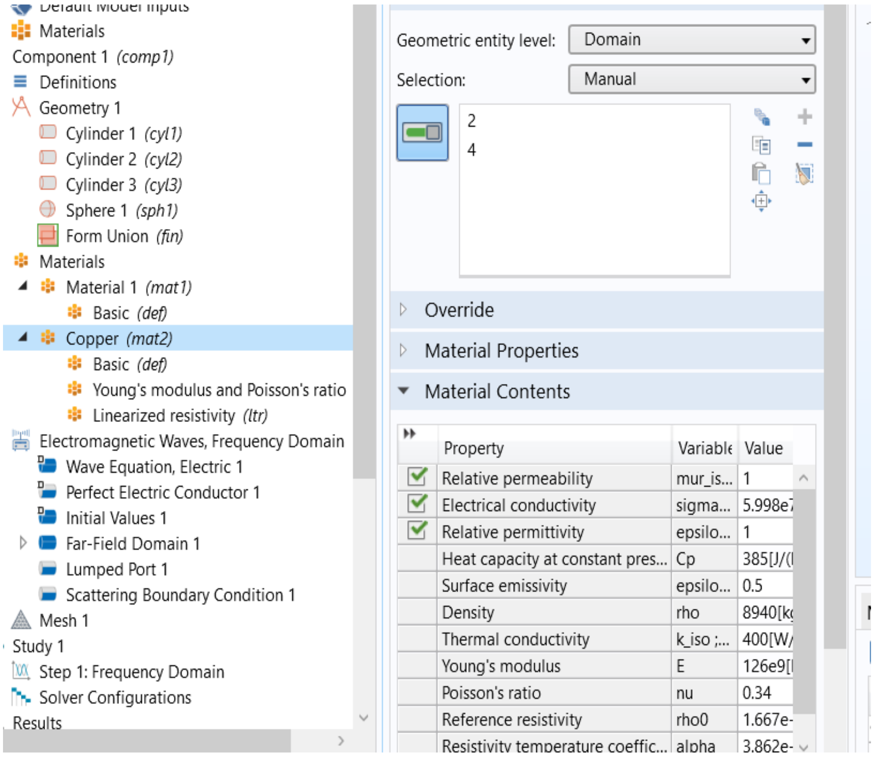
- Create a blank material and choose outer sphere and feed surface domains.



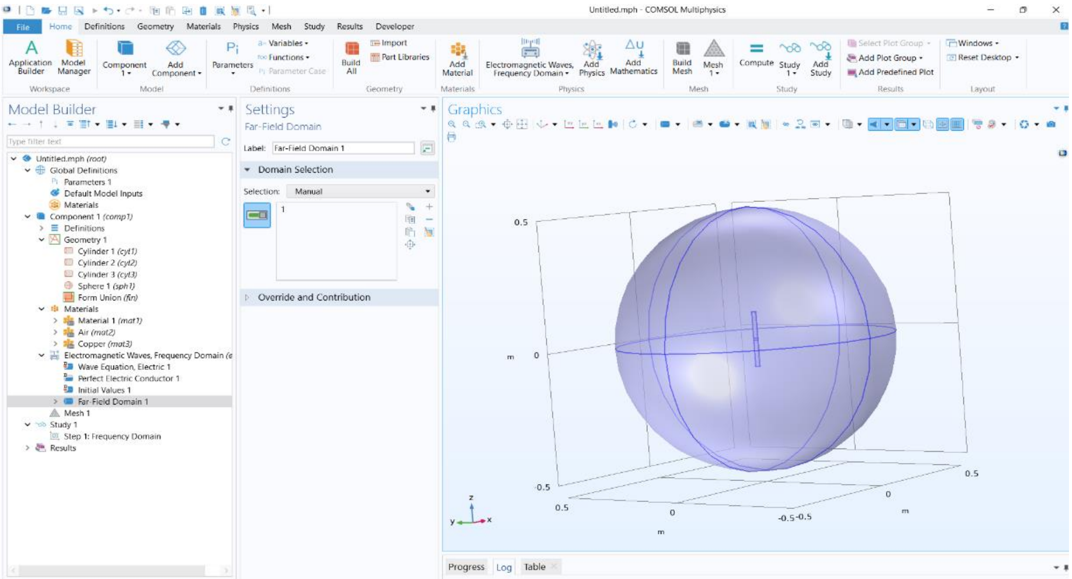
Declare mu, eps and sigma values corresponding to air.



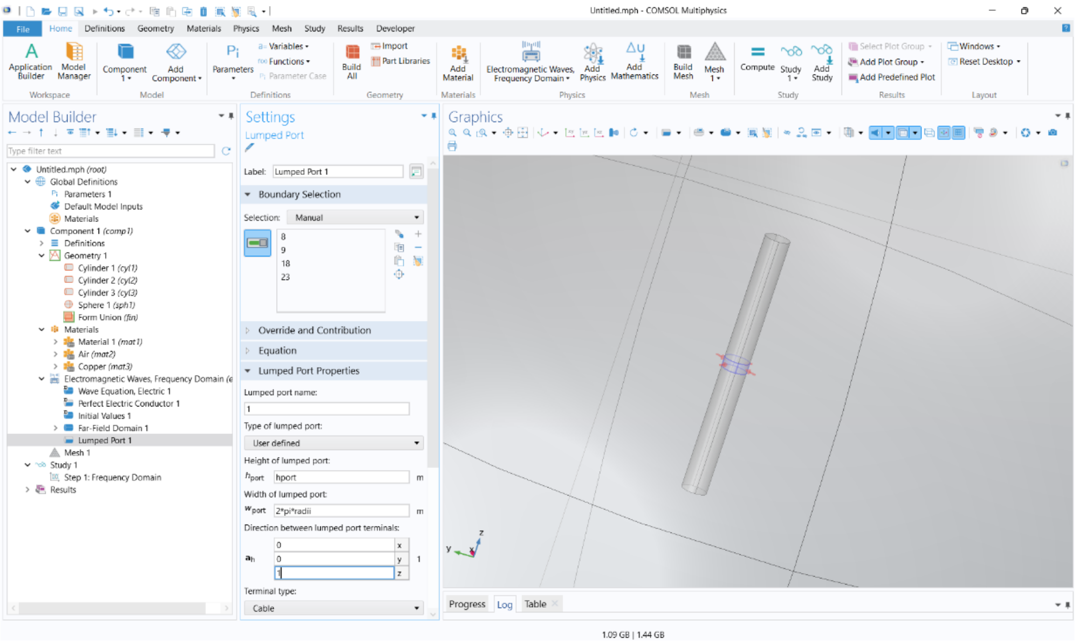
- Select Copper from material library and select the dipole arms.



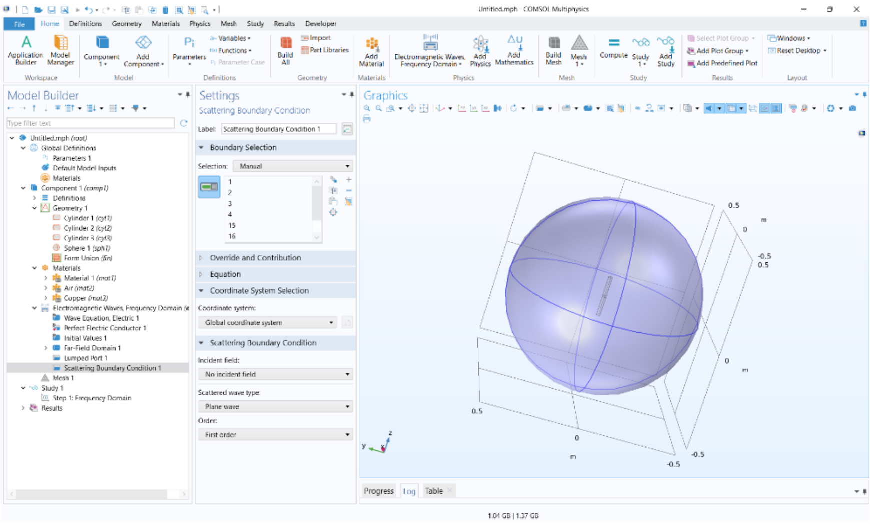
- Declare outer sphere of Air as far-field domain



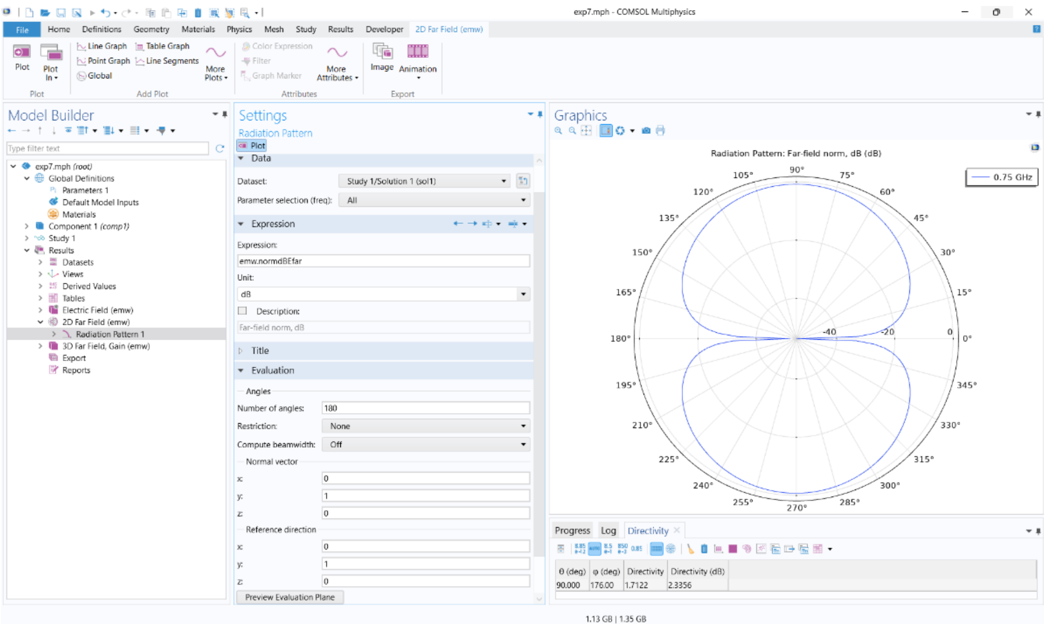
- Declare lumped port (as user defined and select the port faces). Mention height, width and orientation for feed.

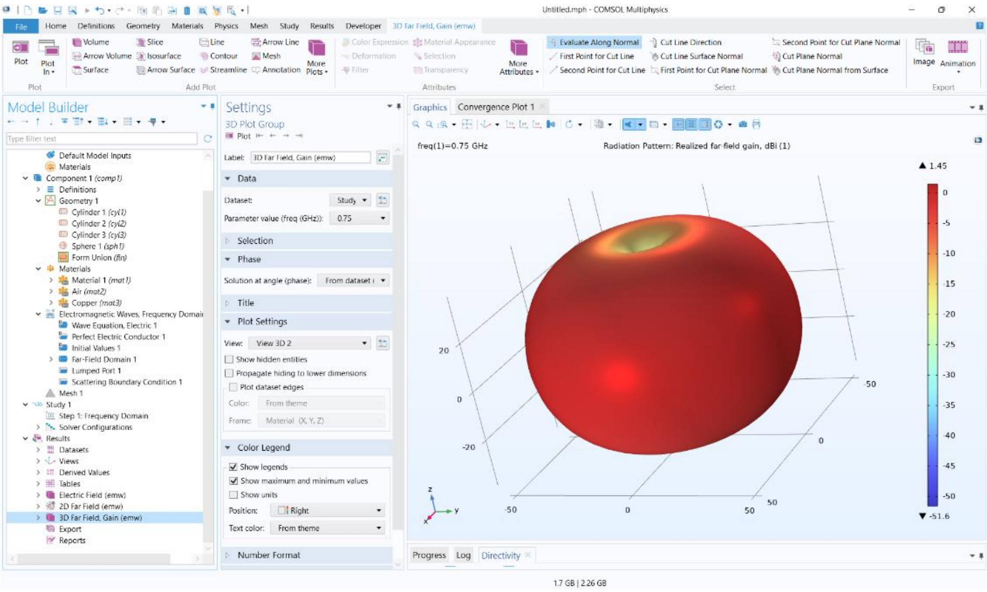


- Choose Scattering Boundary Condition and select the complete outer surface of air sphere (to improve accuracy).



- In Study->Frequency Domain declare the design frequency. Then Mesh and Compute.
- Obtain the 2D and 3D Radiation Pattern Plots. Choose Electric Field Norm (V/m) or Electric Field Norm (dB)





Conclusion

References:

1. Constantine A. Balanis, “Antenna Theory: Analysis and Design”, 4th ed. Wiley, 2016.
2. https://www.antenna-theory.com/antennas/dipole.php
3. https://www.youtube.com/watch?v=T-SbBlNgUTU