DAYALBAGH EDUCATIONAL INSTITUTE, DAYALBAGH, AGRA

Manual

Experiment 6

Dipole Antenna

Experiment 6

Objective:

To design the Dipole Antenna at 3 GHz

1. Calculate the length and width of Dipole Antenna at 3 GHz

To simulate the Dipole Antenna

1. Specify the Dipole Antenna parameter
2. Define the geometric modal
3. Define the material data and boundary condition
4. Run the simulation
5. Analyze the simulation results.

Requirement:

1. Computer facility
2. EMgine Simulation Software

Theory:

Dipole antenna is one of the simplest but more widely used types of antenna. A dipole antenna considered as straight collinear wire with a small space between them as shown in fig.1. These wires are conducting wires normally of equal length. The most important thing to notice about a dipole antenna is that it has two parts, hence the term “Di” considered in its name. The space between two wires is used to apply a radio frequency voltage in an antenna. This dipole antenna is invented in 1886 by a German physicist Heinrich Hertz. Its radiation pattern is Omni directional in the H-plane, which is required by many applications including mobile communications.

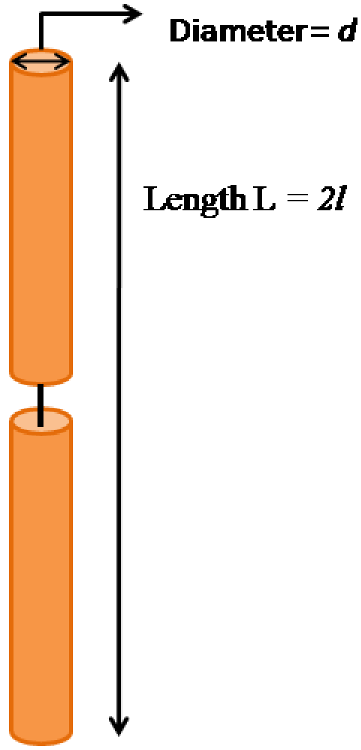


Figure1: Dipole Antenna

Half Wavelength Dipole Antenna:

The term half wavelength of dipole antenna means that the length of the dipole antenna is equal to the half of the wavelength at any operating frequency.

Characteristics of Half Wavelength Dipole Antenna:

All dipoles are resonant near half wavelength (due to the non-zero radius, the resonant length is slightly shorter than $\lambda/2$), but not at one wavelength.

The flatter (larger radius) the dipole, the broader the bandwidth

Its directivity (2.15 dBi) is reasonable – larger than short dipole although smaller than that of the full wavelength dipole.

The antenna is longer than a short dipole but much shorter than the full wavelength dipole, hence it is a good tradeoff between the directivity and the size.

The input impedance is not sensitive to the radius and is about 73 Ω, which is well matched with a standard transmission line of characteristic impedance 75 Ω or 50 Ω (with VSWR < 2). This is probably the most important and unique reason.

Formula Used:

The wavelength of the antenna is given by:

$$\lambda = \frac{c}{f}$$

Since the preferred dipole antenna is half wavelength dipole antenna hence the length of the antenna is

$$L = \frac{\lambda}{2}$$

Procedure for calculations:

To design the Dipole antenna, we have to calculate the wavelength which is equal to length

Procedure for calculations:

Expression for wavelength of the driven element of Dipole Antenna is:

λ = c/f

Example: Calculate the wavelength (length) of Dipole antenna at 3 GHz .

Given Parameters:

Frequency *f* = 3 GHz

Diameter of metallic wire = 2 mm

Space between dipole antenna = 2 mm

Speed of light c = 3×10^8

Calculate the wavelength λ:

λ = c/f

$$\lambda = \frac{3 \times 10^8}{3 \times 10^9} = 0.1\ m\ or\ 100\ mm$$

Length of dipole antenna = λ/2 = 50 mm

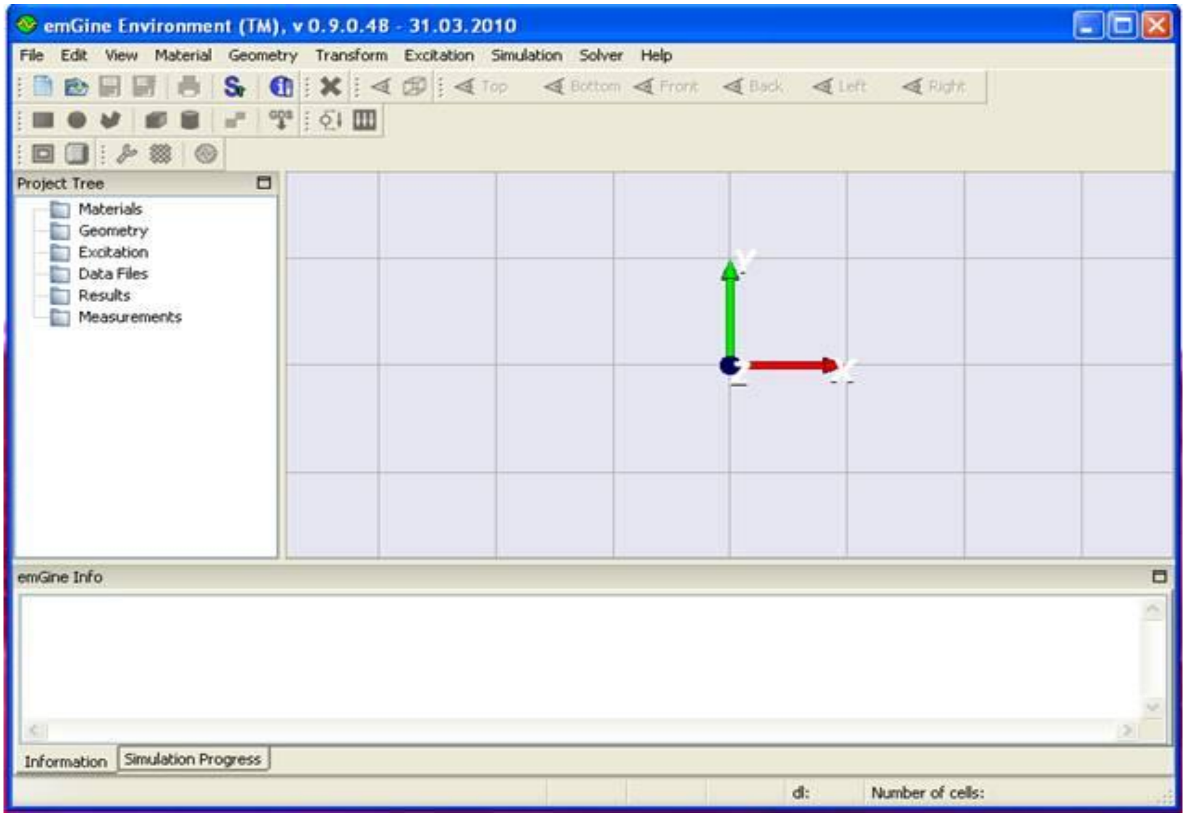
Procedure for simulation:

Introduction and Model Dimensions

In this tutorial you will learn how to simulate planar devices. As a typical example for a planar device, you will analyze a planar antenna. The following explanations on how to model and analyze this device can be applied to other planar devices, as well.

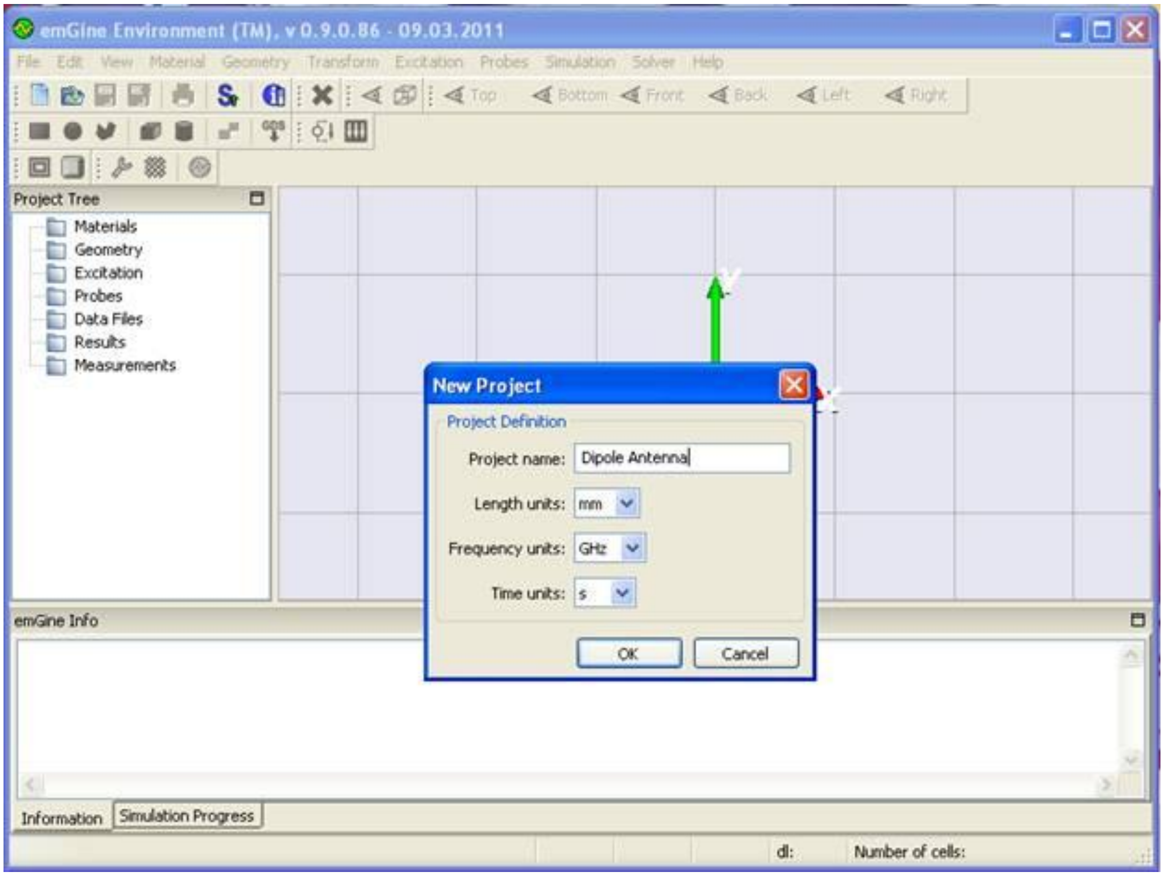
Geometric Construction Steps

This tutorial will take you step by step through the construction of your model, and relevant screen shots will be provided so that you can double-check your entries along the way. Download the given link of emGine Environment. Go to emGine in the program file and double click to open the simulator.



Select a Template

Once you have started emGin, go to file and click on new project a dialog box will open to give the appropriate name for the new project. You should set the units in mm, GHz and s and press ok.



Now again go to file click on save project and save your project at any location in my computer.

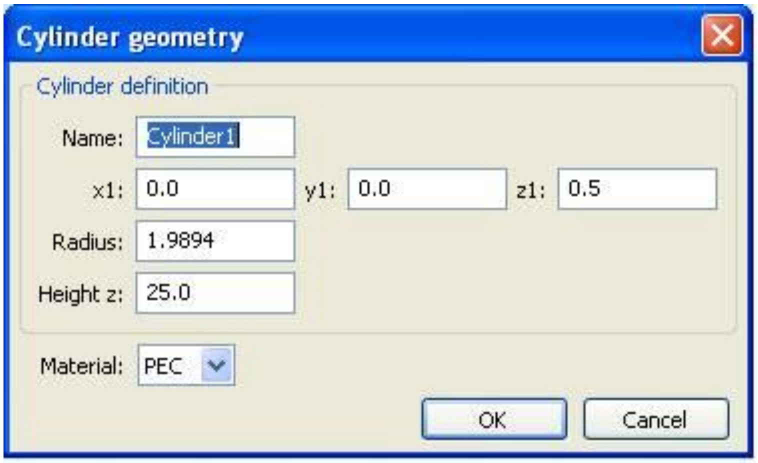
Set the Working Planes Properties

The next step is usually to set the material properties. In this dialog box you should define a new *Material name* (e.g. New_Mtarial). Afterwards, specify the material properties in the *Epsilon* and *Mue* fields. As we know that dipole antenna is a metal wire made antenna hence we choose the material of the wire is PEC and the material properties of PEC are already defined. Hence there is no need to define any new material.

Draw the Cylinder

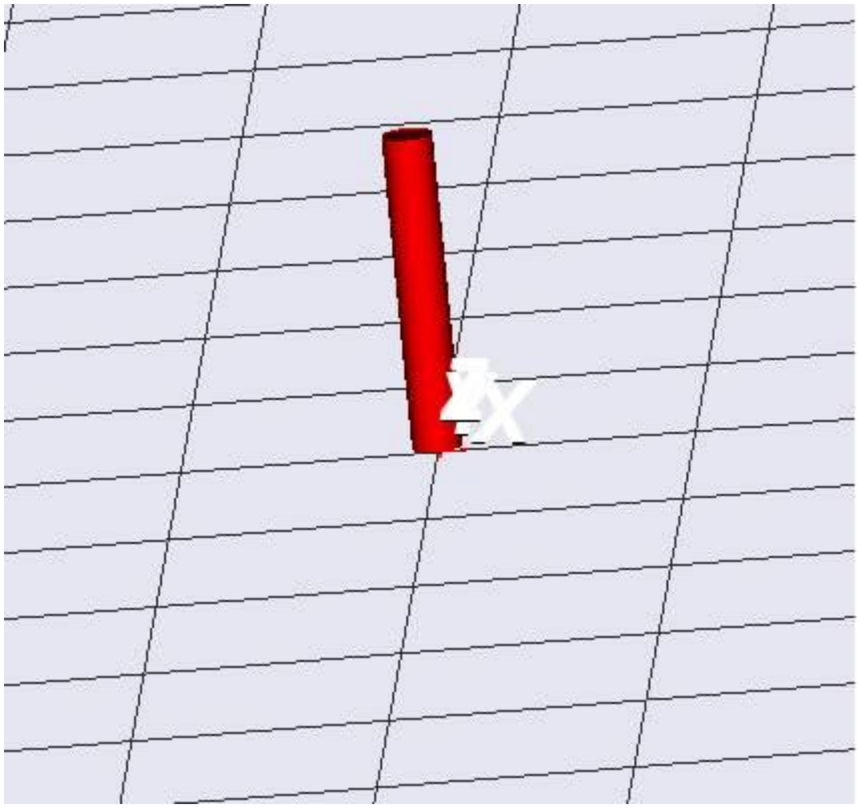
The first step is to design a cylindrical structure for the modeling of wire type dipole antenna. This can be easily achieved by creating a cylinder made of the PEC material. Please activate the cylinder creation mode (*Geometry - Cylinder*).

When you are prompted to define the first point, you can enter the coordinates numerically by clicking Cylinder that will open the following dialog box:

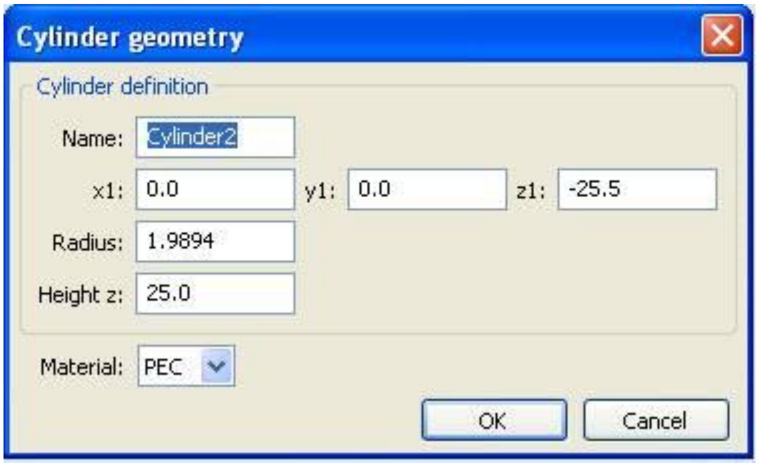


The transversal coordinates are given above in the screen shot. Please check all these settings carefully. If you encounter any mistake, please change the value in the corresponding entry field. You should now assign a meaningful name to the brick by entering e.g. substrate in the *Name* field.

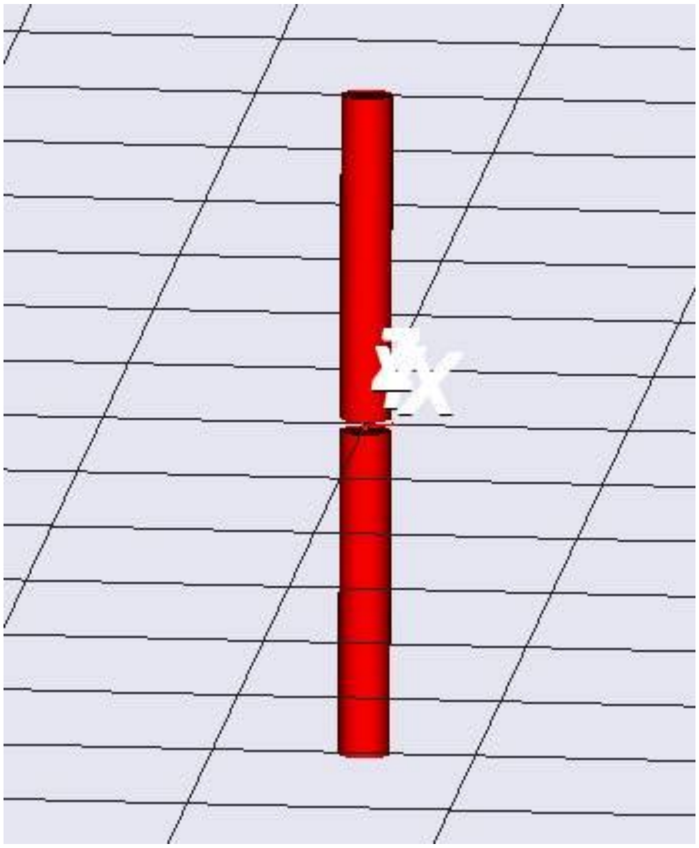
The *Material* setting of the cylinder must be changed to the desired material. Because no material has yet been defined for the cylinder, you should open the layer definition dialog box by selecting PEC from the *Material* dropdown list. Now in the cylinder creation dialog box you can press the *OK* button to finally create the PEC cylinder. Your screen should now look as follows



Since we know that dipole antenna is a straight collinear wire with a small space between them hence design the other part of dipole antenna. Select the cylinder again. Give the appropriate design parameters as shown in screen shot below.

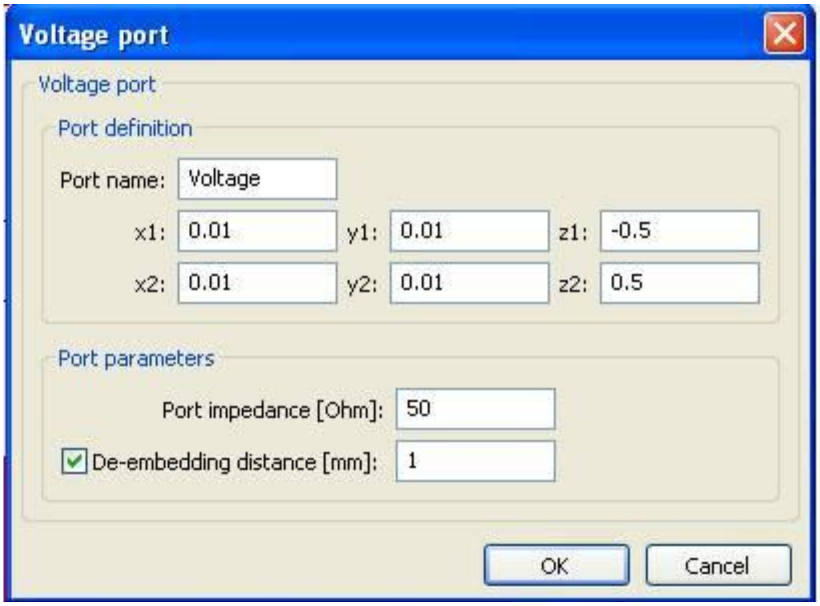


Your screen should now look as follows



Define Ports

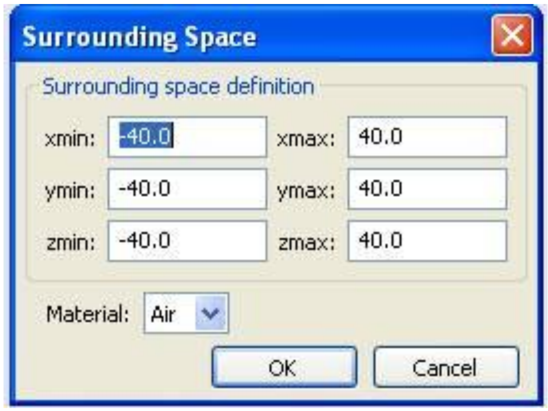
The next step is to add the ports to the dipole antenna for which the S-parameters will later be calculated. Only on port will simulate dipole antenna structure that is connected in the small space between two PEC wires. To define the port, go to excitation and select voltage port. A dialog box will open then in the dialog box give the port name as port1 and then define the coordinates as shown below and press ok to finalize.



Note: dipole antenna is a single port device.

Define Surrounding Space:

For defining the surrounding space go to simulation and click the surrounding space it will open a dialog box as shown in picture below



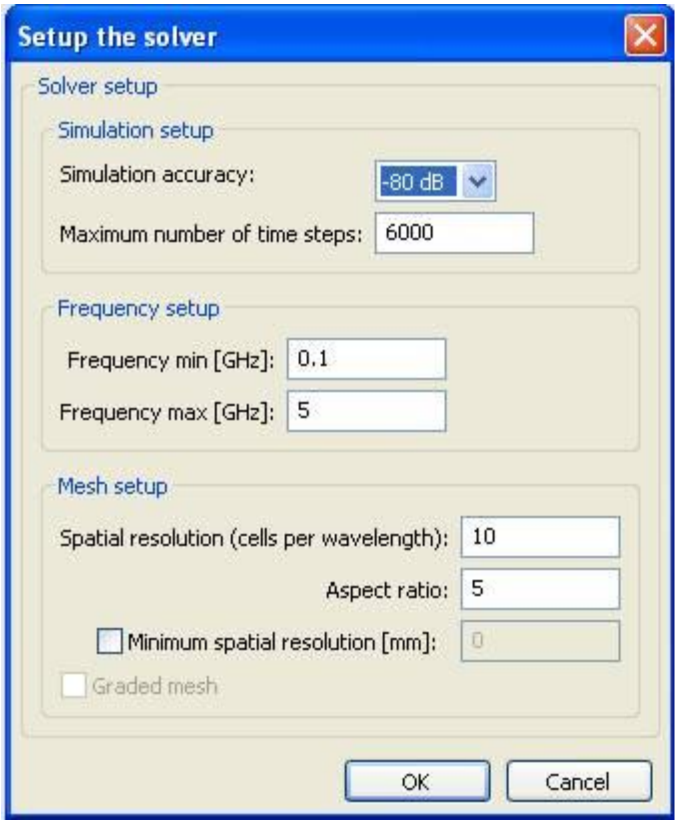
Give the values defined in the screen shot above and choose air as the surrounding material from the material drop down list and press ok for finalizing the condition.

Define the Boundary Conditions

Go to simulation and double click on boundary condition then a boundary condition setup box will open give the boundary conditions as defined in the screen shot below and press ok.

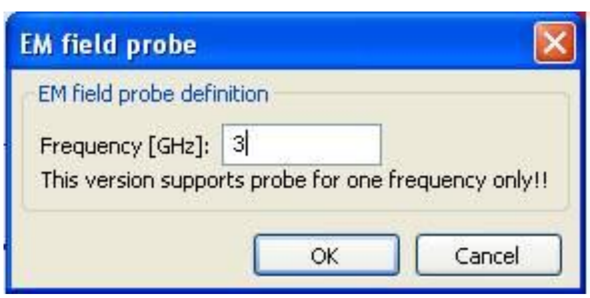
Setup the Solver

The next step is the solver setting, for this go to solver and by pressing setup a dialog will open. In this box simulation accuracy should be -80dB. You can choose maximum number of the time steps between 500 and 10000. Choose 6000 steps. After that define the frequency range for the simulations you can set frequency min as 0.1 GHz and frequency max as 5 GHz hence your frequency range is from 0.1 GHz to 5 GHz. Now define Special resolution as 10, Aspect ratio as 5. For finalizing the setup solver press ok.



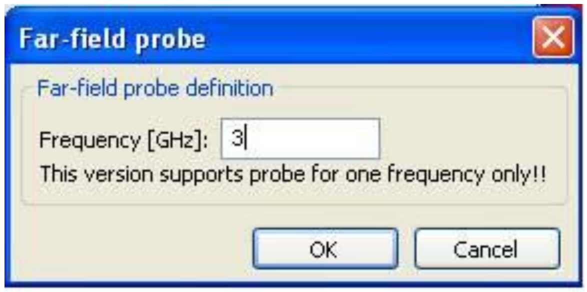
Define the EM Field Visualization

Go to probes and choose EM Field Visualization then an EM Field probe setup box will open, Choose 3 GHz as frequency and press ok.



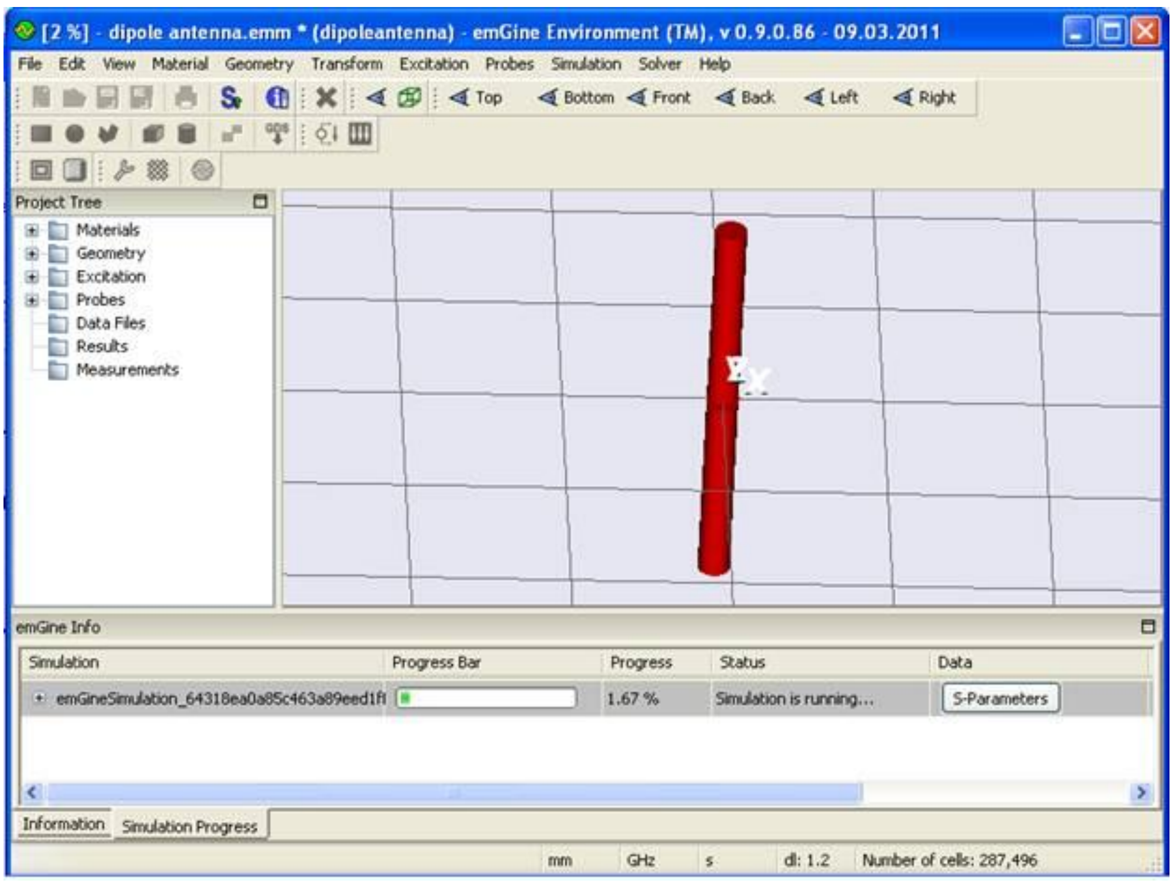
Define the Far-Field

Go to probes and choose Far Field then an Far Field probe setup box will open, Choose 3 GHz as frequency and press ok.



Simulation

Finally to start the simulations go to solver and press *Simulation* button to start the calculation. A progress bar will appear in the status bar, displaying some information about the solver stages.



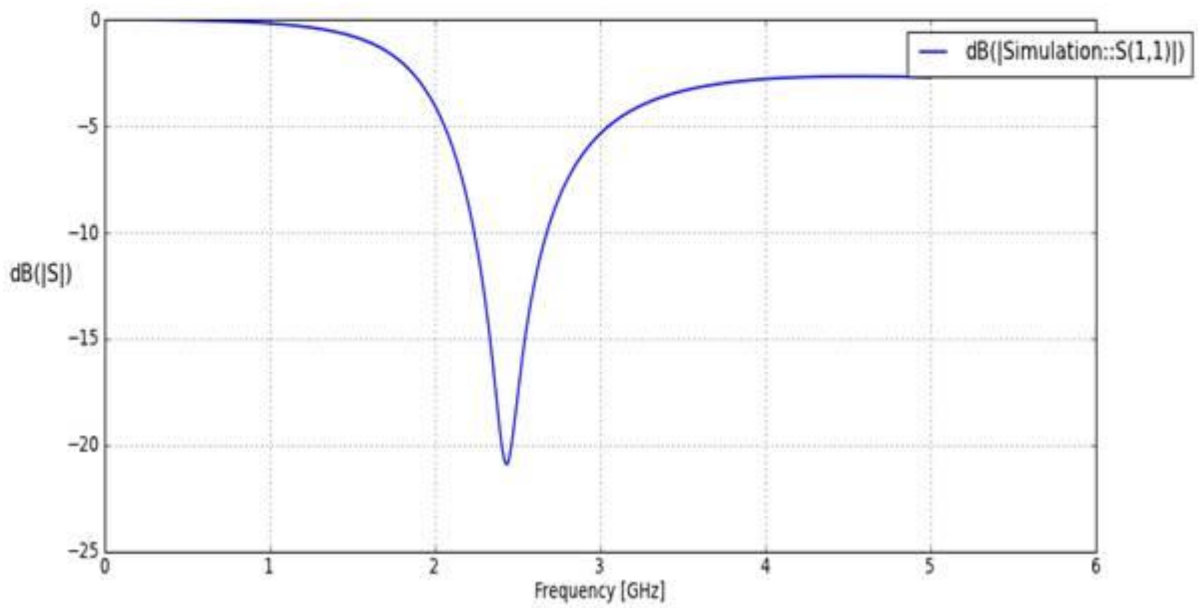
During the simulation, the Message Window will show some details about the performed simulation.

Congratulations, you have simulated the dipole antenna! Let’s review the results.

Results:

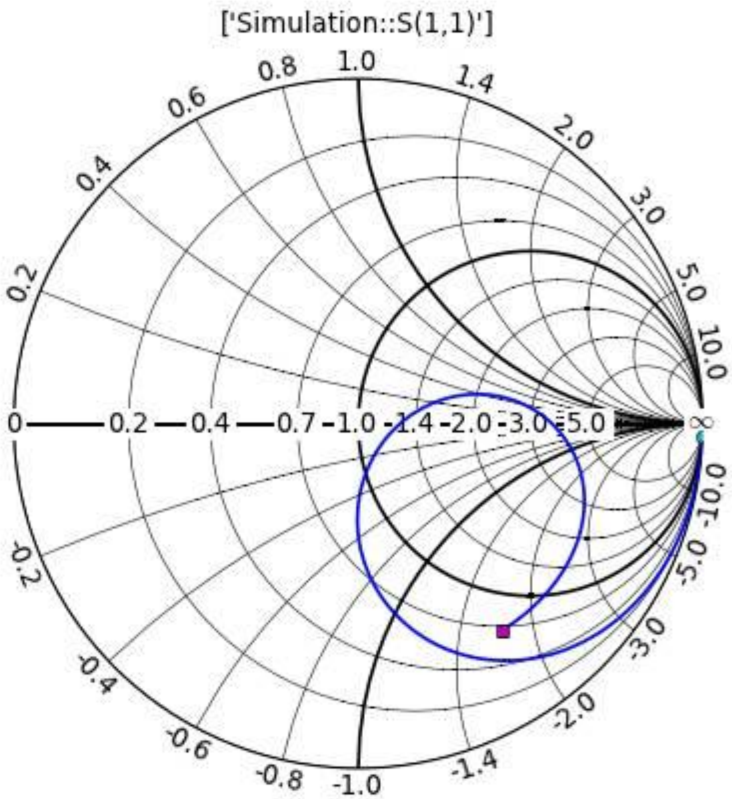
S-Parameters Results

The S-parameters magnitude in dB scale can be plotted by clicking on the *Results: dB* folder



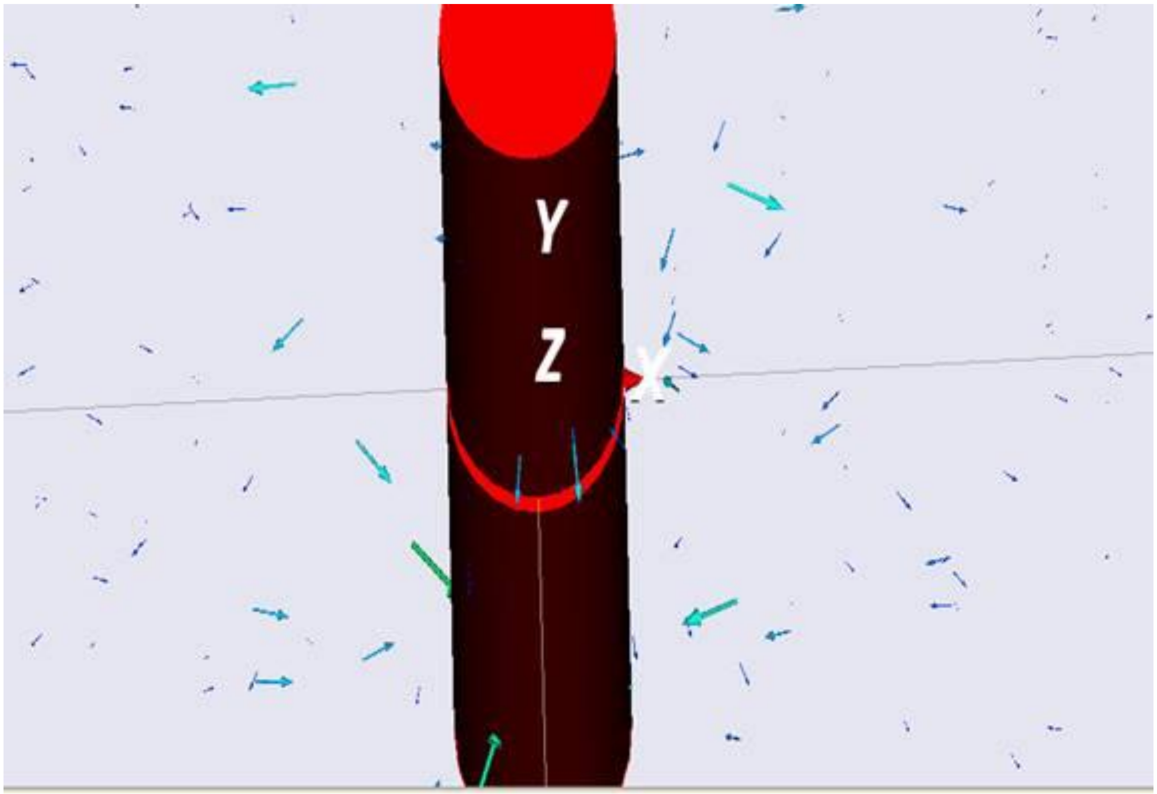
Smith Chart

The smith chart can also be seen from Smith chart folder.



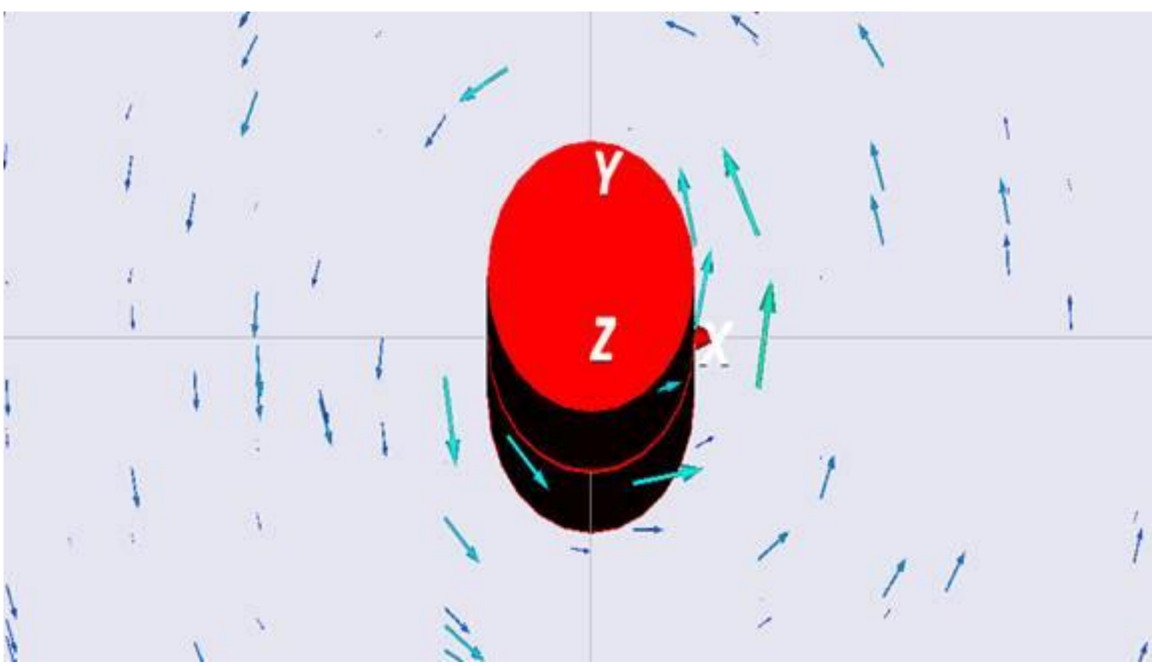
Electric Field

The computed electric field – E-field at 3 GHz – of the dipole antenna



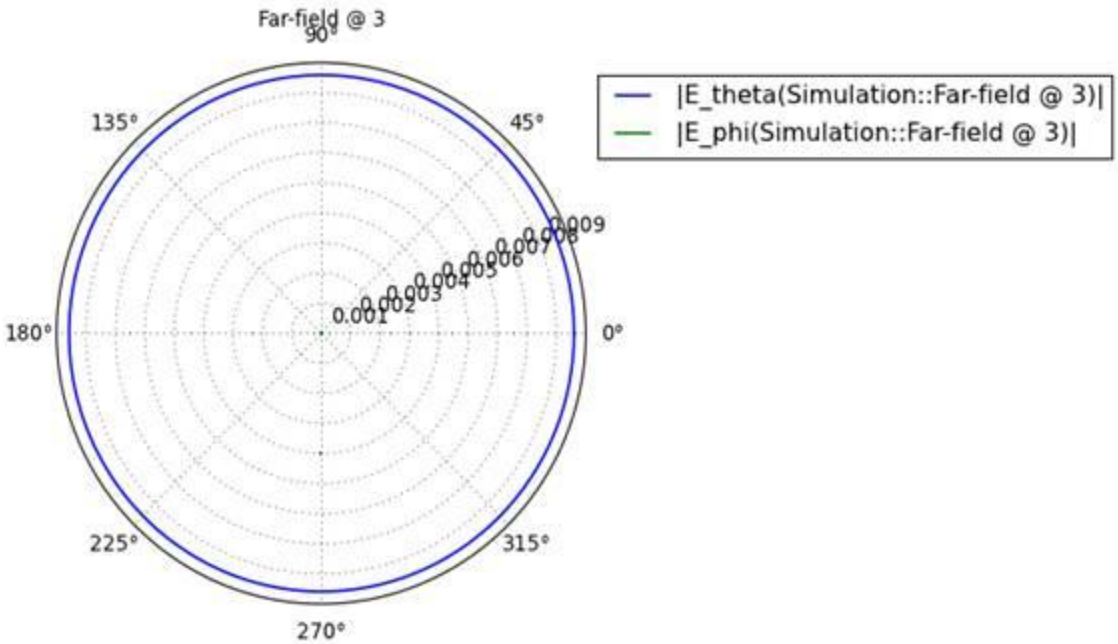
Magnetic Field

The computed magnetic field – H-field at 3 GHz – of the dipole antenna



Far Filed results:

The computed far field at 3 GHz – of the dipole antenna



Precautions:

- Follow instructions carefully.
- EMgine software should be properly installed.