**DAYALBAGH EDUCATIONAL INSTITUTE,
DAYALBAGH, AGRA**

Manual

Experiment 1

Design and Characterization of Strip Line

Experiment 1

Objective:

To design the Strip Line at 1.5 GHz

1. Calculate the length and width of Strip line at 1.5 GHz

To simulate the Strip Line

1. Specify the Strip Line parameter
2. Define the geometric modal
3. Define the material data and boundary conditions
4. Run the simulation
5. Analyze the simulation results.

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Requirement:

1. Computer facility
2. EMgine Simulation Software

Theory:

Stripline is a transverse electromagnetic (TEM) transmission line that was invented in the 1950s by Robert M. Barrett of the Air Force Cambridge Research Centre. Strip lines are essentially modification of the two wire lines and coaxial lines. These are basically planar transmission lines that are widely used at frequencies from 100 MHz to 100 GHz. Figure 1 shows the cross-sectional view of the strip line structure.

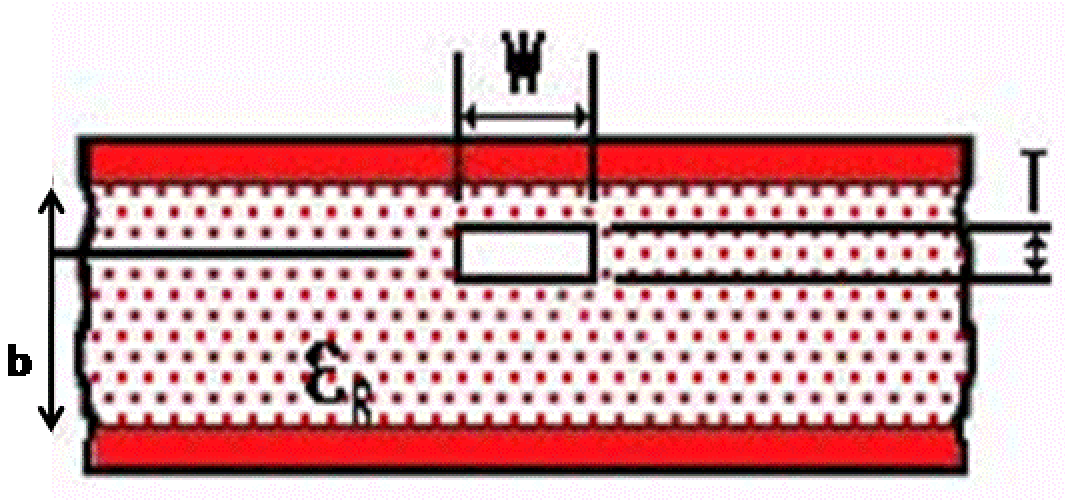

Fig 1: Strip line transmission Line

As seen in fig1, a strip line consist of a central thin conducting strip of width *w* which is greater than its thickness *t*, placed inside the low loss dielectric (ε_r) substrate of thickness b between two wide ground plates. Usually the thickness of the metallic central conductor and the metallic ground plane are the same. The dominant mode for the strip line is a TEM mode shown in fig 2, and the field are confined within the transmission line with no radiation losses. The width of the ground planes is at least five times greater than the spacing between the plates there by avoiding any vertical side walls at the two transverse end. There are practically no fringing fields after a certain distance from the edge of the center conductor. For $b \leq \lambda/2$, there will be no propagation in the transverse direction.

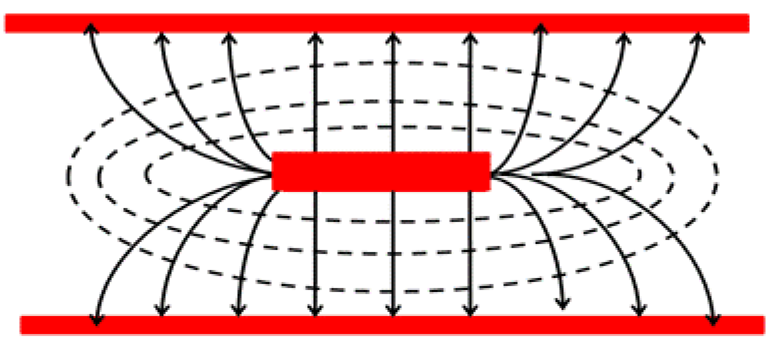

Fig 2: TEM mode of strip line

However, there are certain disadvantage of strip lines is that the circuit is not accessible during development for adjustment and tuning and also it is difficult to mount discrete and active components (like transistors, diodes, chip resistor, circulators, chip capacitors etc.)

An expression for characteristic impedance (Z_0) of the strip line is:

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln \left[\frac{1.9\ (b)}{0.8\ W + T}\right]$$

Width of the strip line can be calculated by:

$$\frac{W}{b} = \frac{30\ \pi}{\sqrt{\varepsilon_r}.Z_0} - 0.441$$

And the wavelength of the electromagnetic signal on the strip line is given by:

$$\lambda_g = \frac{c}{\sqrt{\varepsilon_r}\ f}$$

Formula Used:

To design the Strip Line, we have to calculate the guided wavelength which is equal to length of the slot line.

Procedure is given as following:

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Example: Calculate the wavelength (length) of slot line at 1.5 GHz .

Given Parameters:

Frequency f = 1.5 GHz

Substrate Thickness b = 1.1 mm

Strip line thickness t = 0.02 mm

Substrate Permittivity ε_r = 5.5

Characteristic Impedance Z_0 = 50 Ω

Speed of light c = 3×10^8

Calculate the width W

$$\frac{W}{b} = \frac{30\,\pi}{\sqrt{5.5} \times 50} - 0.441$$

$$\frac{W}{b} = 0.3626$$

W= 0.398 mm

Calculate the value of Z_0

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln\left[\frac{1.9\,(b)}{0.8\,W + T}\right]$$

$$Z_0 = \frac{60}{\sqrt{5.5}}\, ln\left[\frac{1.9 \times 1.1}{0.8 \times \ .398 + 0.02}\right]$$

$$Z_0 = 46.57\ \Omega$$

This value is close to 50Ω but generally we consider 50 Ω as the characteristic impedance hence we consider Z_o = 50 Ω at the place of Z_o = 46.57 Ω

Calculate the value of guided wavelength λ_g which is equal to the length of strip line

$$\lambda_g = \frac{c}{\sqrt{\varepsilon_r}\, f}$$

$$\lambda_g = \frac{3 \times 10^8}{\sqrt{5.5} \times 1.5 \times 10^9}$$

$\lambda_g = .08528\, m\, or\, 85.28\, mm$

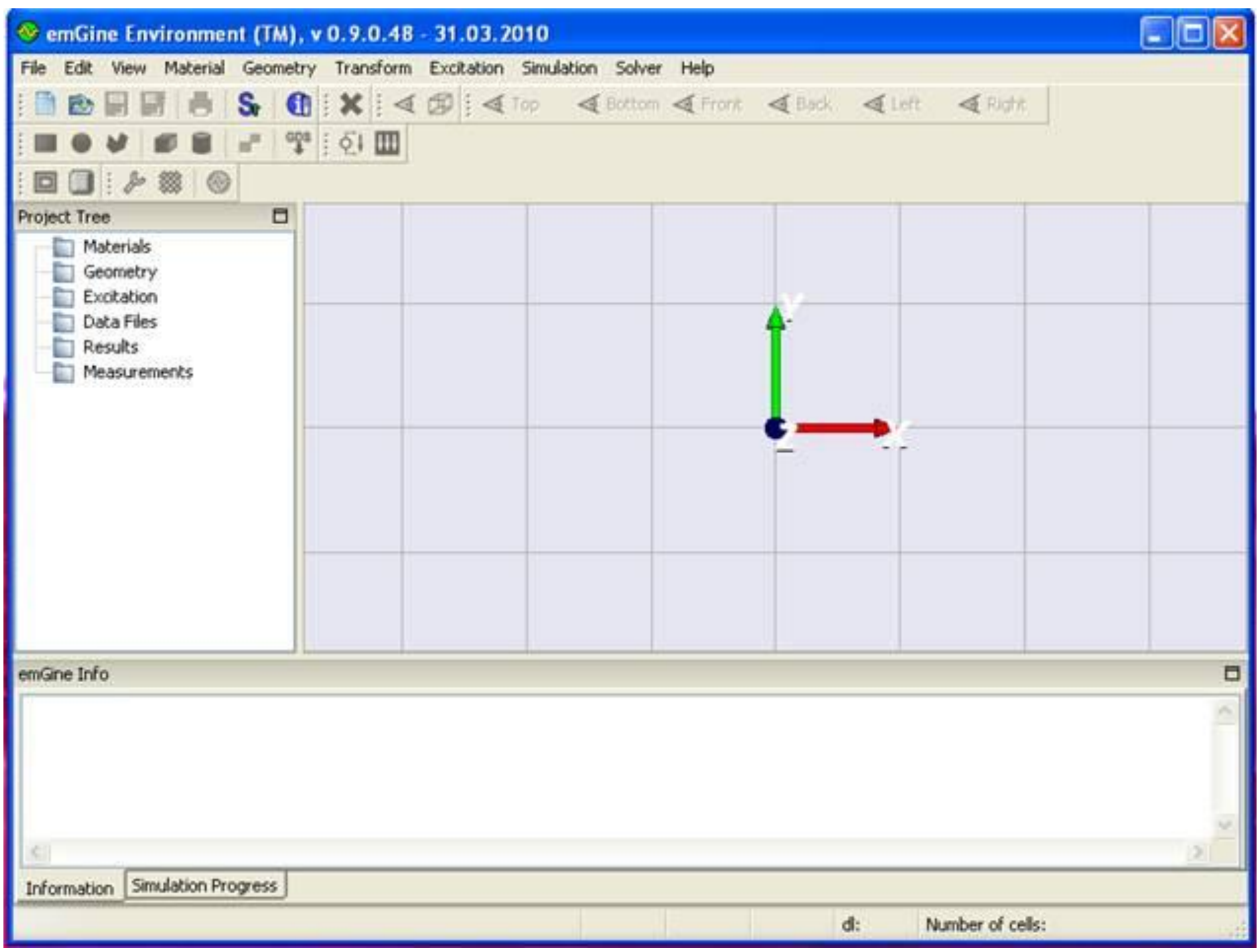
Simulation Procedure:

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 Strip line. The following explanations on how to model and analyze this device can be applied to other planar devices, as well.

Geometric Construction Steps

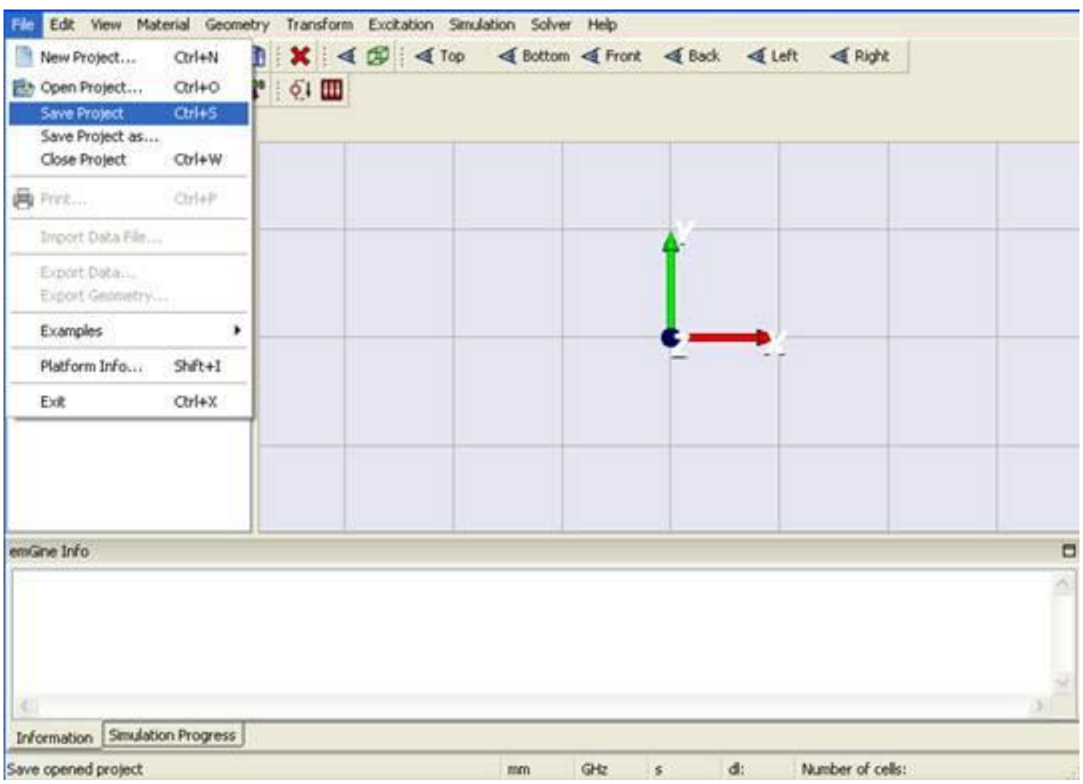
This tutorial will take you step by step through the construction of your model, and relevant screen shots will be provided so that you can double-check your entries along the way. Download the given link of emGine Environment. Go to emGine in the program file and double click to open the simulator.



Select a Template

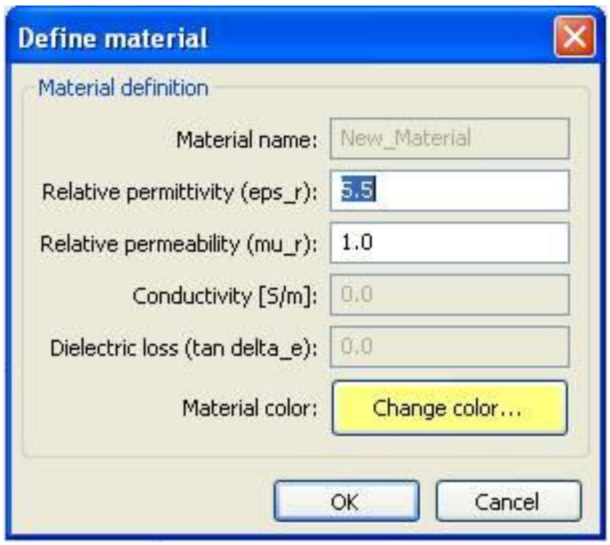
Once you have started emGin, go to file and click on new project a dialog box will open to give the appropriate name for the new project. You should set the units in mm, GHz and s and press ok.

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



Set the Working Planes Properties

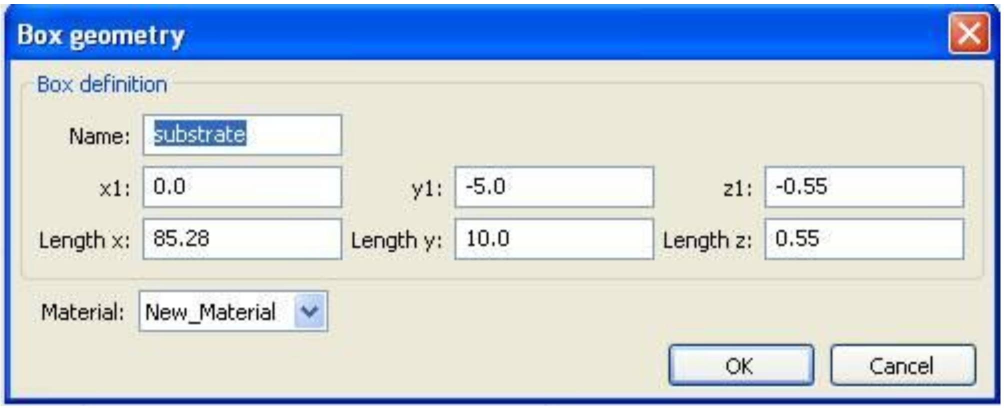
The next step is usually to set the material properties. In this dialog box you should define a new *Material name* (e.g. New_Mtarial). Afterwards, specify the material properties in the *Epsilon* and *Mue* fields. Here, you only need to change the dielectric constant *Epsilon* to 5.5. Finally, choose a color for the material by pressing the *Change* color button. Your dialog box should now look similar to the picture below before you press the *OK* button.



Draw the Substrate Brick

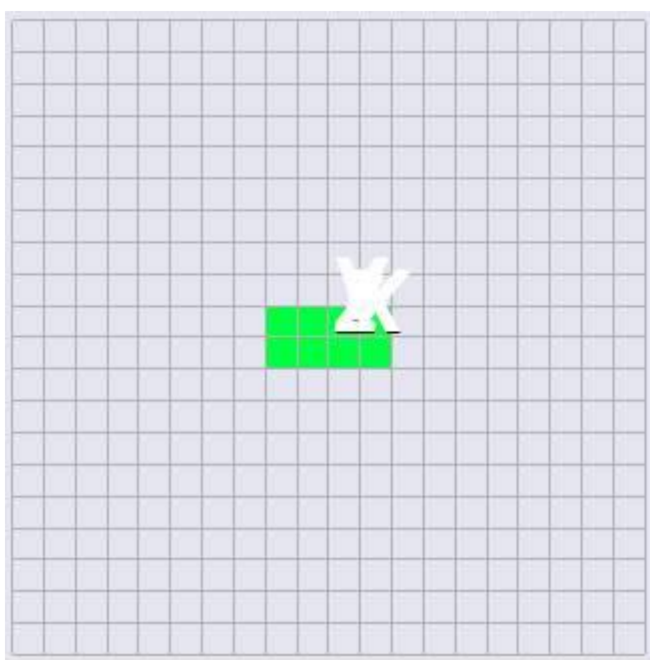
The first construction step for modeling a planar structure is usually to define the substrate layer. This can be easily achieved by creating a brick made of the substrates material. Please activate the brick creation mode (*Geometry* - *Box*).

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



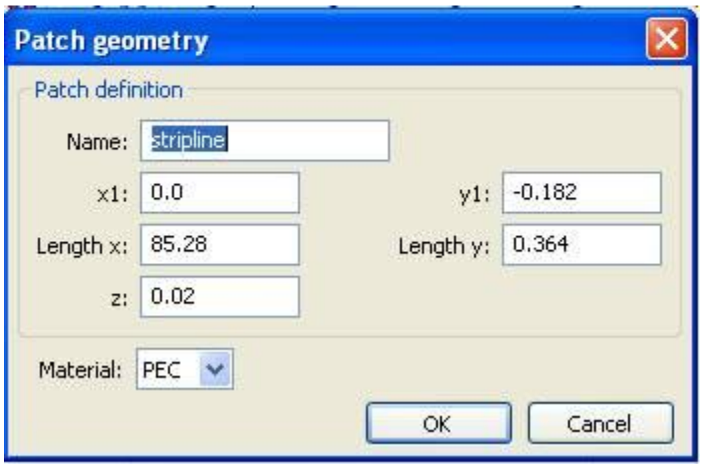
In this example, you should enter a substrate block. The transversal coordinates can thus be described by X 1= 0, Y1 = -5, Z1 = -0.55 for the first corner and give the calculated length X = 85.28, Y = 10, Z = 0.55 for creating the brick, assuming that the brick is modeled symmetrically to the origin. 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 brick must be changed to the desired substrate material. Because no material has yet been defined for the substrate, you should open the layer definition dialog box by selecting New_Material from the *Material* dropdown list. Now in the brick creation dialog box you can also press the *OK* button to finally create the substrate brick. Your screen should now look as follows

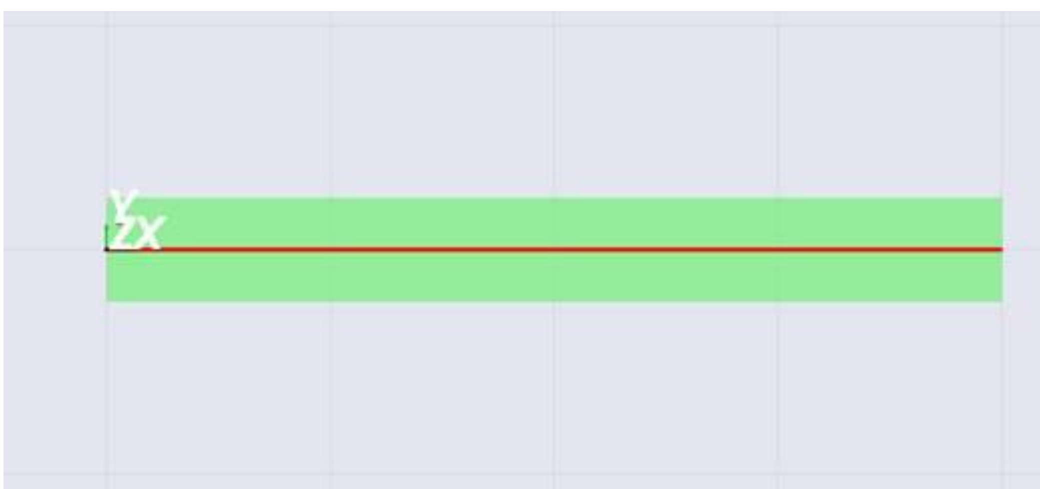


Model the Strip line

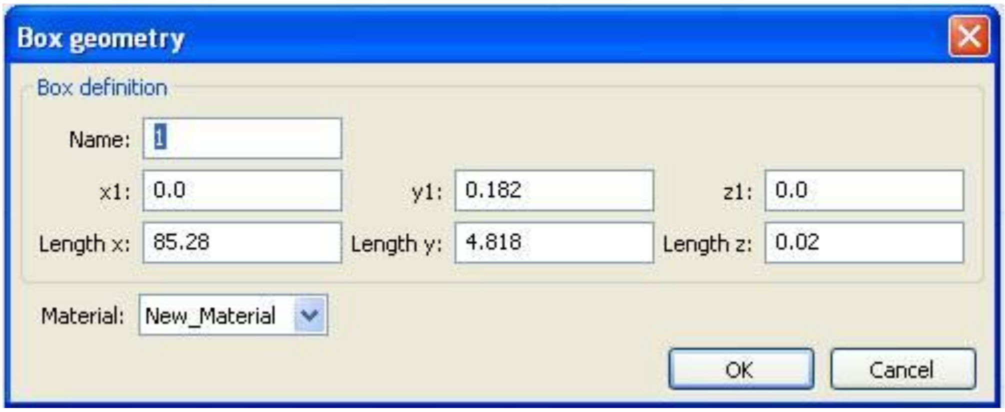
The next step is to model the Strip line. Therefore, you should design two patch of PEC material on the top of the substrate. For the dimensions of strip line, the transversal coordinates can thus be described by X1 = 0, Y1 = -0.182, Z = 0.02 for the first corner and give the actual length as length X = 85.28, length Y = 0.364. You should now assign a meaningful name to the brick by entering e.g. stripline in the *Name* field.

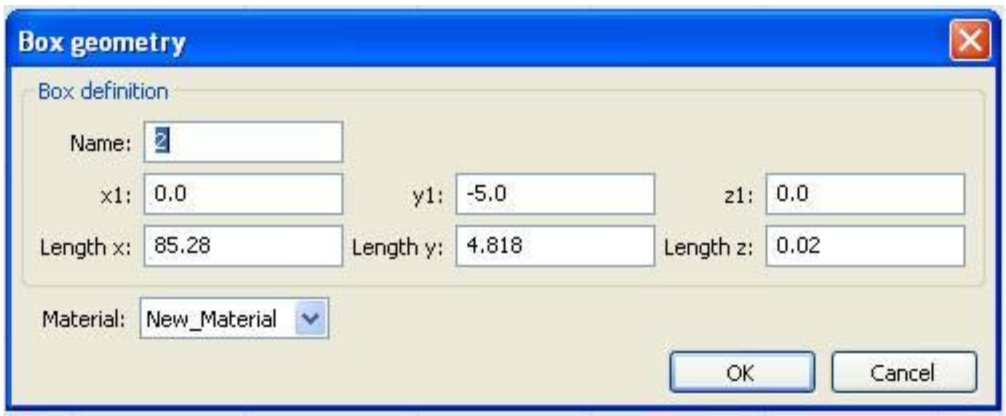


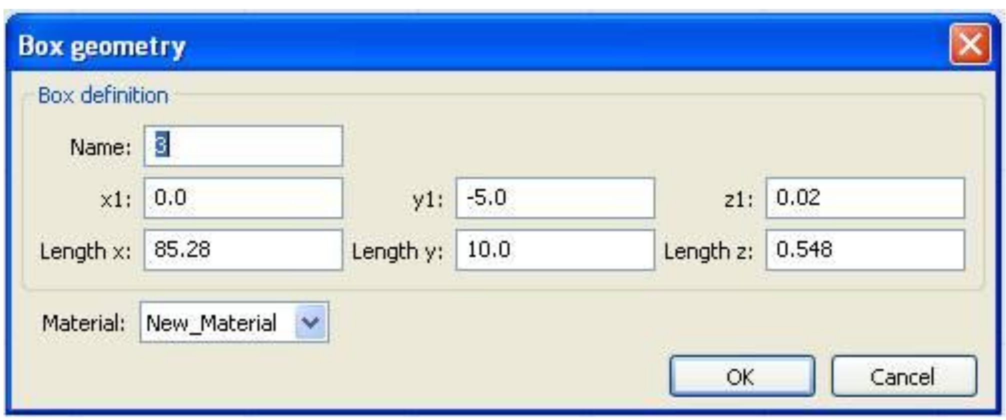
You should select the PEC as the material for PEC plane1 from the material drop down list and in the brick creation dialog box you can also press the *OK* button to finally create the PEC plane 1. Your screen should now look as follows



Again do the same process for creating a substrate because this stripline is sandwiched between two substrate of same dielectric material. For this purpose again go to geometry select box and in the dialog box give the transversal coordinates as given in the screen shot below. Now assign a meaningful name to the brick.



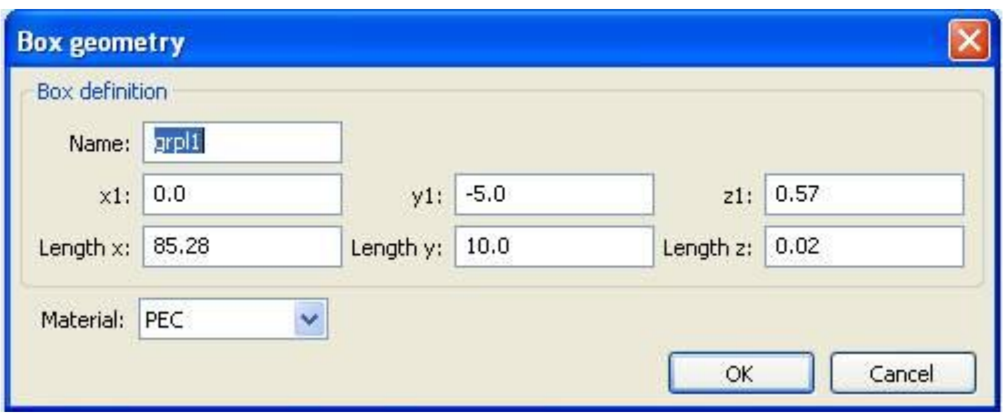


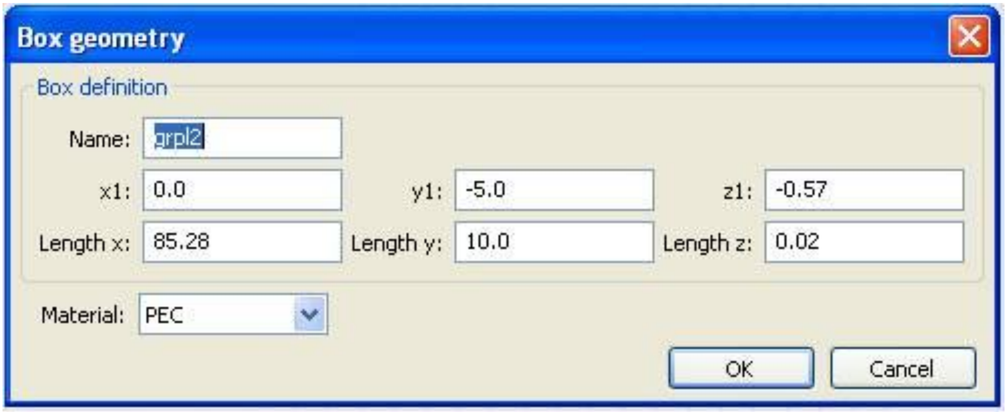


Now select the New_Material as the material for substrate from the material drop down list and in the brick creation dialog box you can also press the *OK* button to finally create the substrate. Your screen should now look as follows

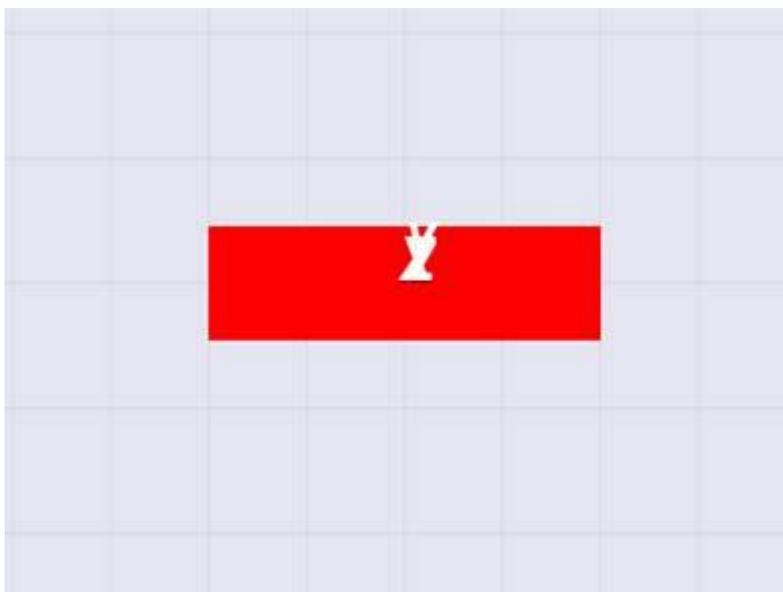
Model the metallic ground plane

The next step is to model the ground plane above and below substrate. Therefore, you should again do the same process. For this purpose again go to geometry select box and in the dialog box give the transversal coordinates as given in the screen shot below. Now assign a meaningful name to the brick. You should now assign a meaningful name to the brick by entering e.g. ground plane1 and 2 in the *Name* field.



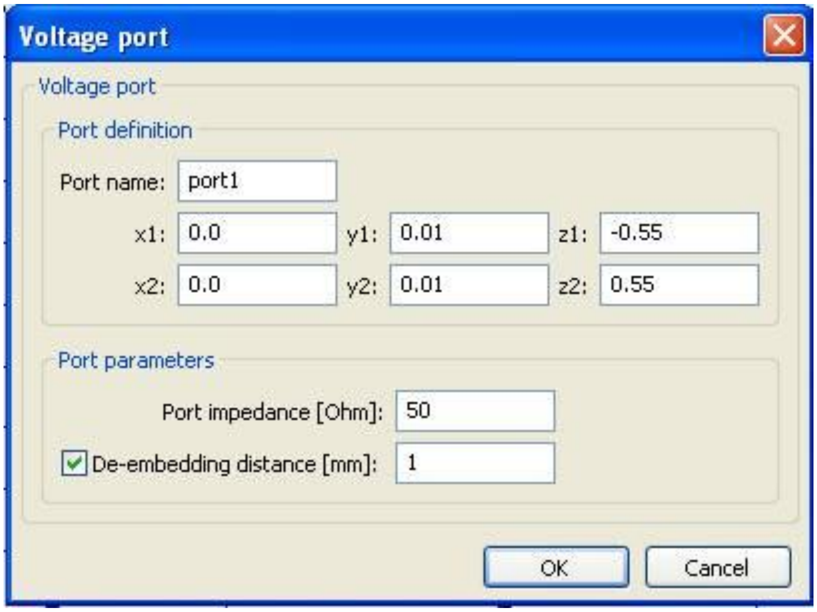


The *Material* setting of the brick must be changed to the desired ground plane. Because no material has yet been defined for the ground plane, you should select PEC as the material for ground plane from the material drop down list and in the brick creation dialog box press the *OK* button to finally create the ground plane. Your screen should now look as follows

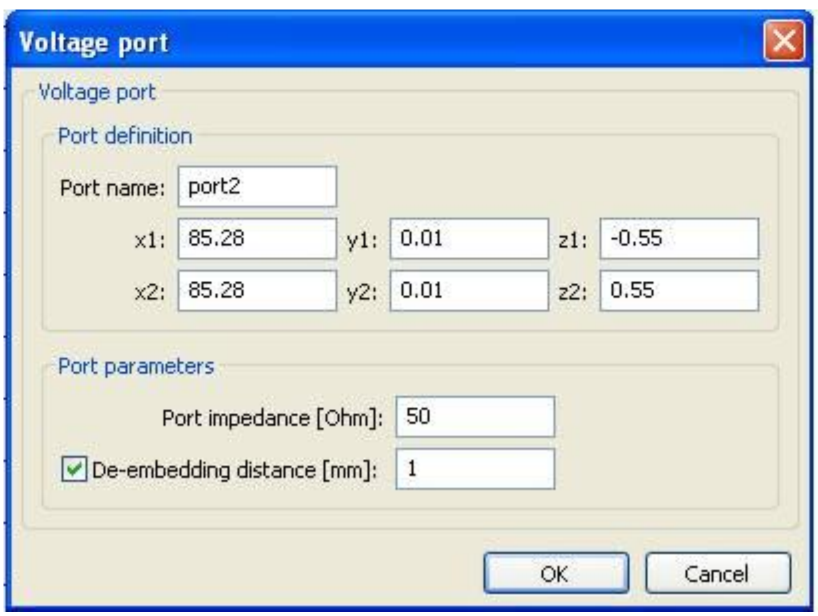


Define Ports

The next step is to add the voltage ports to the strip line device for which the S-parameters will later be calculated. Each port will simulate strip line structure that is connected to the structure at the ports plane. Plane wave ports are the most accurate way to calculate the S-parameters of any microwave device and should thus be used here. To define the port 1 go to excitation and then choose voltage port, it will open a dialog box, give the port name and appropriate dimension to define the exact port. You can define port as shown in picture below

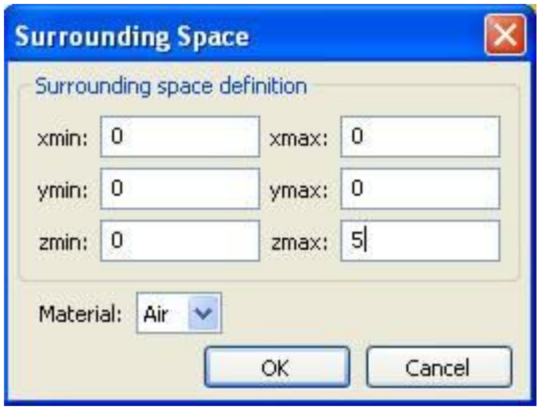


Similarly for defining port 2 give the port name as port 2 and define the coordinates as shown below and then for finalizing the port press ok.



Define Surrounding Space:

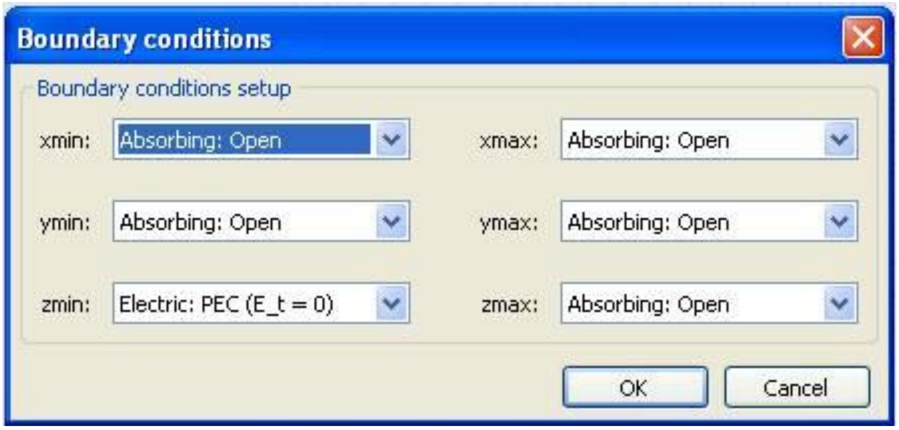
For defining the surrounding space go to simulation and click the surrounding space it will open a dialog box as shown in picture below



Give zmax as 5 and define air as the surrounding material from the material drop down list and press ok for finalizing the condition.

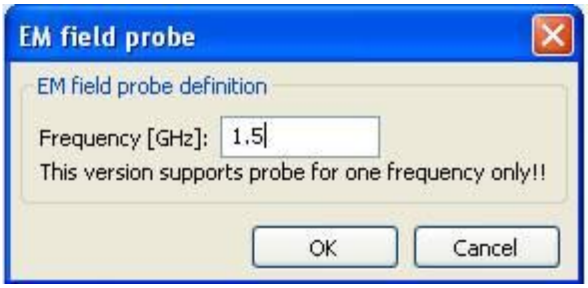
Define the Boundary Conditions

Go to simulation and double click on boundary condition then a boundary condition setup box will open give the boundary conditions according to structure and press ok.



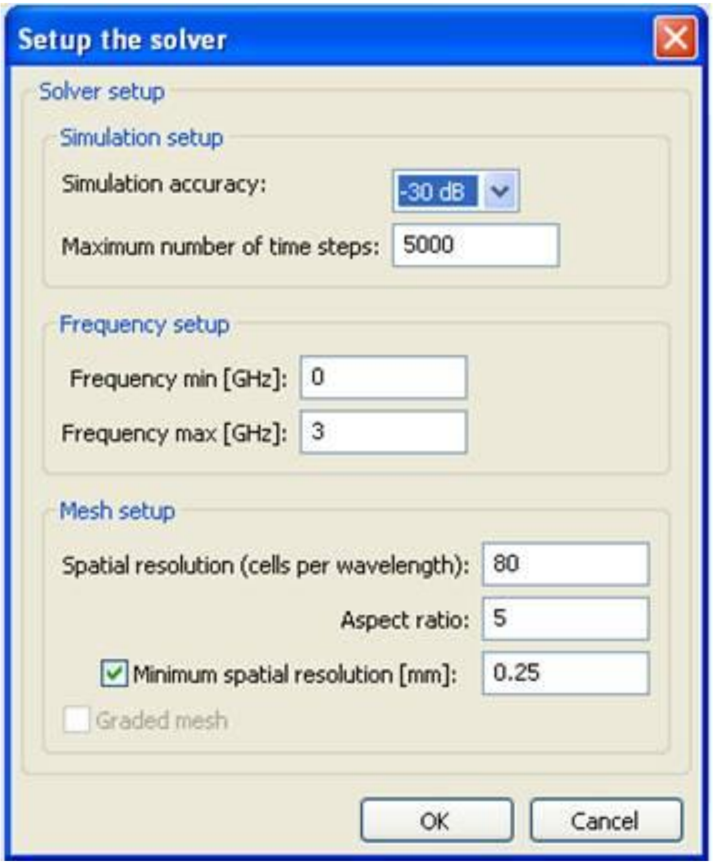
Define the EM Field Visualization

Go to probes and choose EM Field Visualization then an EM Field probe setup box will open. Choose 1.5 GHz as frequency and press ok.



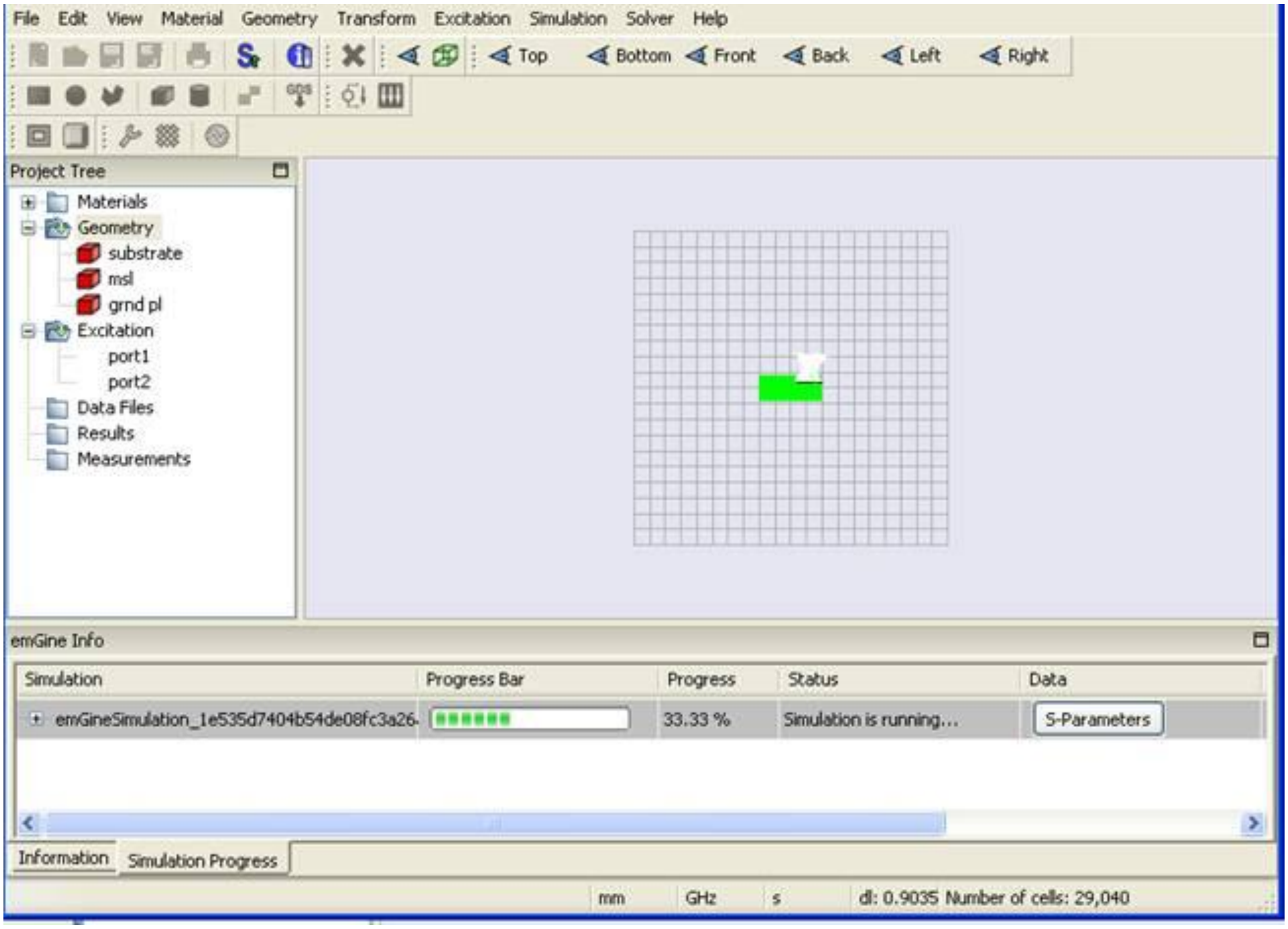
Setup the Solver

The next step is solver setting for this go to sovler and by pressing setup a dialog will open. In this box simulation accuracy should be -30dB. You can choose maximum number of the time steps between 500 and 5000. Choose 5000 steps. After that define the frequency range for the simulations you can set frequency min as 0 GHz and frequency max as 3 GHz, hence your frequency range is from 0 GHz to 3 GHz. Now define Special resolution as 80, Aspect ratio as 5. For finalizing the setup solver 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.



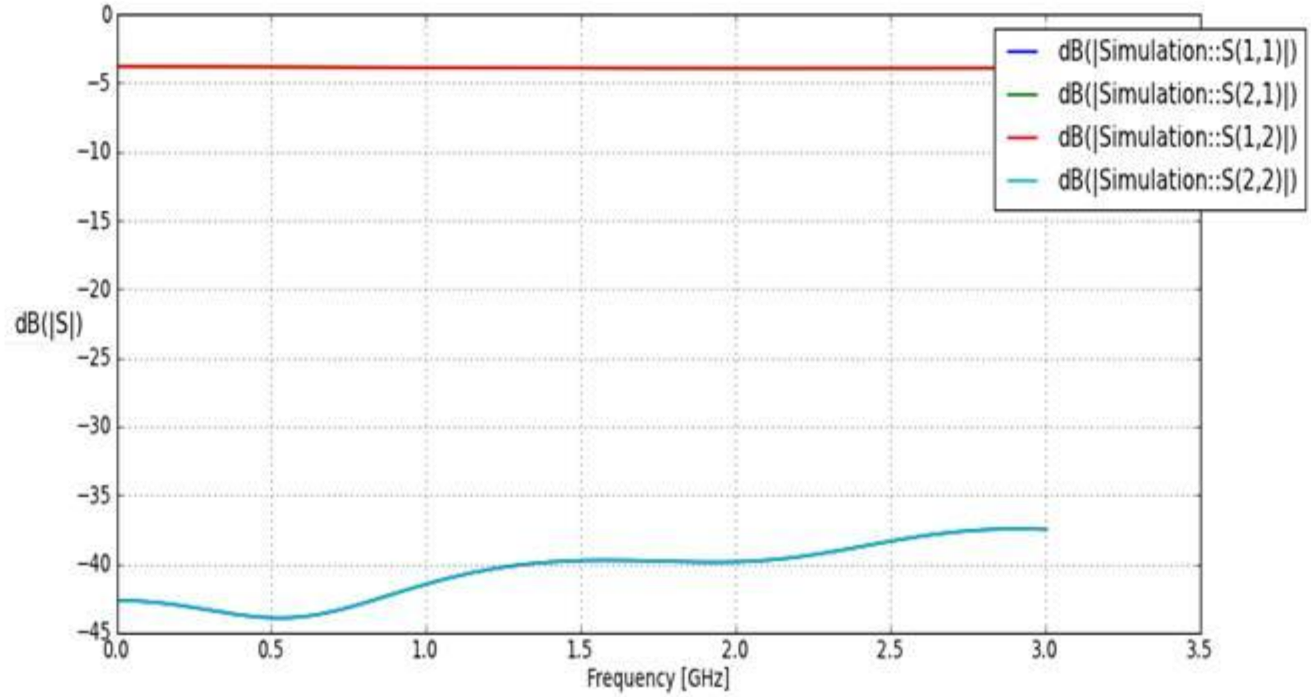
During the simulation, the Message Window will show some details about the performed simulation.

Congratulations, you have simulated the strip line! Let's review the results.

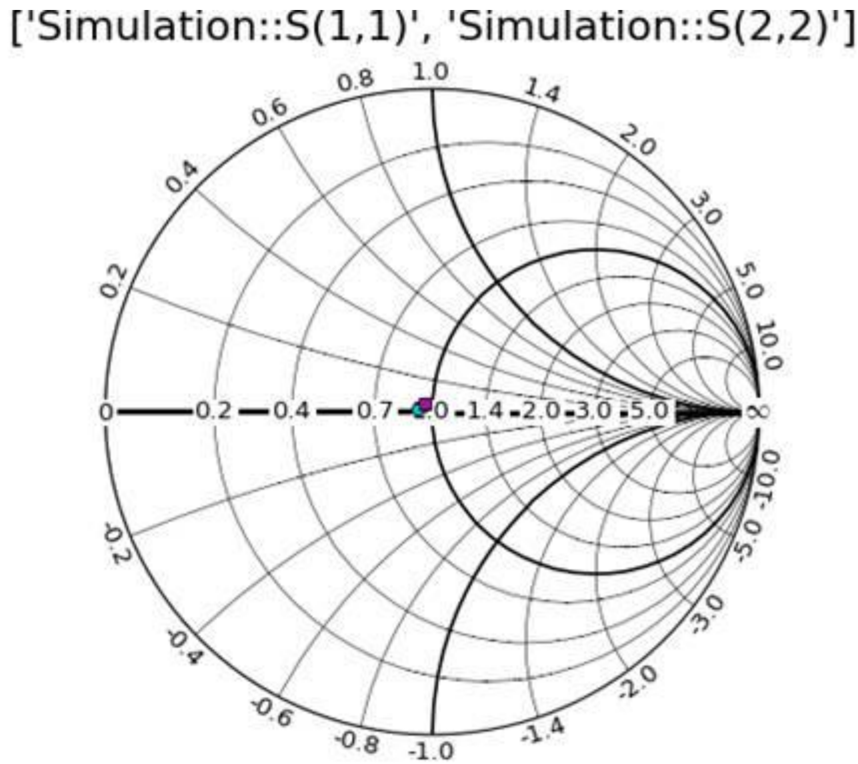
Results:

S-Parameters Results

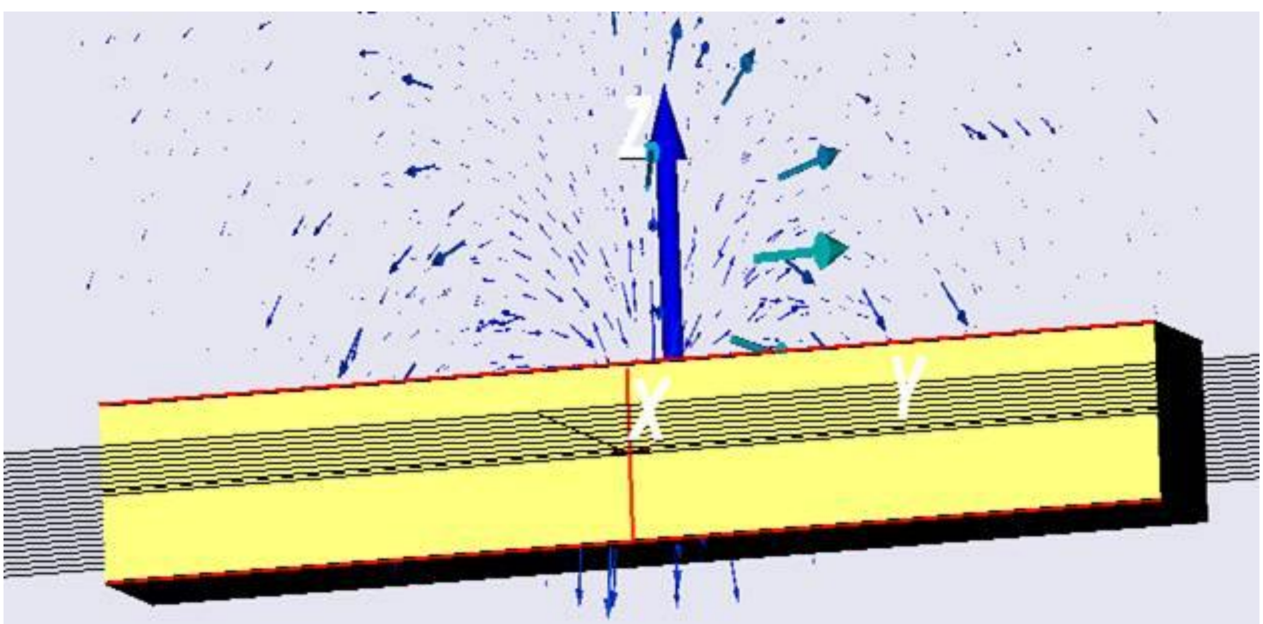
The S-parameters magnitude in dB scale can be plotted by clicking on the *Results: dB* folder



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



The computed electric field – E-field at 1.5 GHz – of the Strip line



Precautions:

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