Engineering ElectroMagnetism
Experiment - 4

To simulate, and analyze a Microstrip transmission line.

Submitted to: Prof. Ashwani Sharma

Submitted BY:

Group No.-11

Parth Joshi-2018eeb1170

Preetesh Verma-2018eeb1171

Puneet Bansal-2018eeb1172

Ritesh Chaudhari -2018eeb1174

Objective :
To simulate, and analyze a Microstrip transmission line.

Component/Software :
Ansoft HFSS Software.

Introduction :

Microstrip is a type of electrical transmission line which can be fabricated using **printed circuit board technology**, and is used as transmission line for microwave frequency signals. It consists of a conducting strip separated from a ground plane by a dielectric layer known as the **substrate**.

Microstrip line may be used as an interconnect (for transporting signals) or for realizing microwave passive components such as antennas, couplers, filters, power dividers etc., the entire device existing as the pattern of metallization on the substrate.

Microstrip line base components are thus much less expensive than traditional waveguide technology based, as well as being far lighter and more compact. The disadvantages of microstrip compared with waveguide are the generally lower power handling capacity, and higher losses. Also, unlike waveguide, microstrip is not enclosed, and is therefore susceptible to cross-talk and unintentional radiation. For low cost microstrip devices, one may employ an ordinary FR-4 (standard PCB) substrate.

About HFSS :

HFSS stands for **High Frequency Structure Simulator**. As its name implies this software is a structure simulator mainly employed for simulation of high frequency electromagnetic phenomenon. It can carry out analysis of the structures for circuit, antenna and scattering applications.
The usable frequency may range from a few MHz to hundred of GHz.
HFSS carries out computer based analysis of 3-D structures using **Finite**

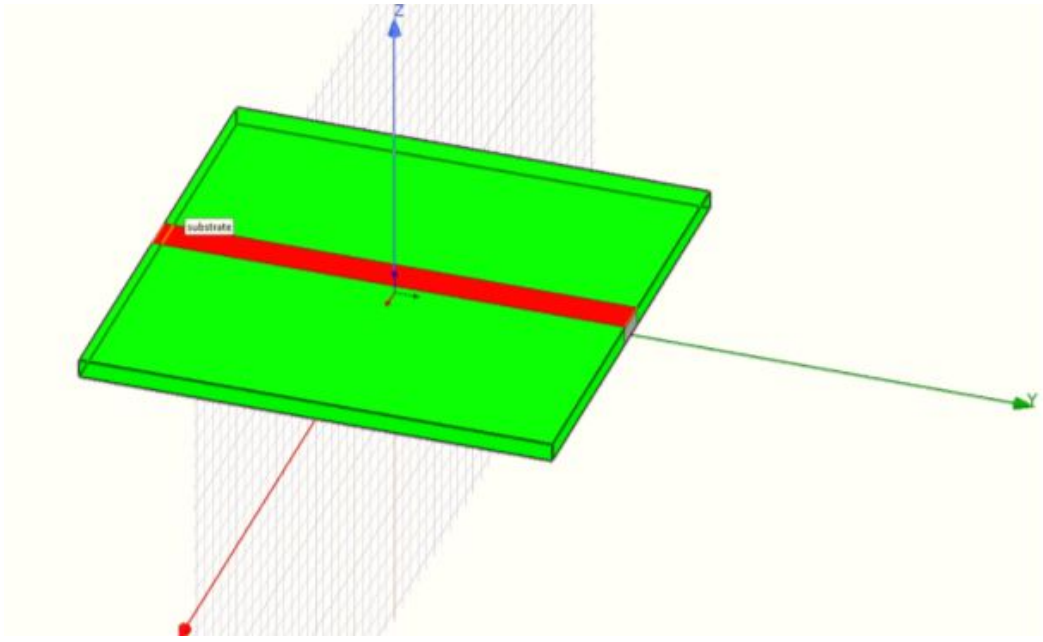
Element Method (FEM). For this, the given geometry is divided (discretized) into a large number of connected tetrahedrons. Maxwell's equations are satisfied over each and every tetrahedron resulting in a large sized matrix equation, sometimes more than a few hundred. Solution of this matrix equation provides the field/current distribution on the geometry/structure. These distributions provide the parameters of interest such as S-matrix, radiation pattern or RCS

Procedure :

1. First, A substrate of Dimension = 40mm×40mm× 1.6mm is made in the HFSS software whose material is FR4(ϵr=4.4).

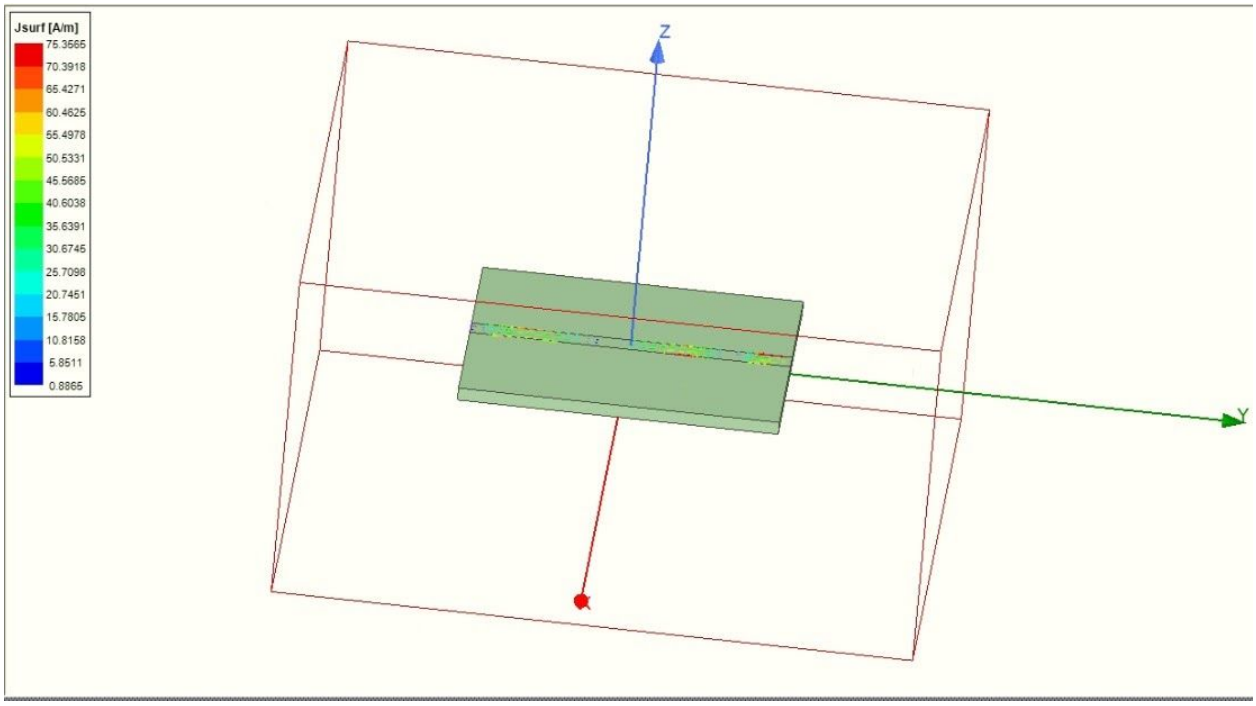
2. Then using a microstrip line calculator, we calculated the microstrip line length which is 3.059mm.

3. Now a strip is made in the substrate and then we assigned the finite conducting boundary to the strip by selecting the material of the strip as copper. Here is the model image:



4. Excitation is assigned to the microstrip line using a lumped model function. To port 1 excitation is given in upward to downward direction while to port 1 excitation direction is downward to upward.

5. A region is created around the substrate by using the “create open region” option by putting a frequency of 5 GHz and boundary defined as a radiating boundary.



6. Now we clicked on “create analysis setup” and “add frequency sweep” by adjusting the frequency range from 1GHz to 10 GHz, and entered maximum passes as 20 and maximum delta to 0.02.

7. Finally, The project is saved.

8. Then, The model is Validated and then analyzed.

9. Now, we checked if the model is converged or not. Convergence shows whether the error is less than 0.02 or not.

10. Now, we analyzed the model using various plots.

Given

ϵ_r=4.4 (FR4 epoxy)
Dimension of substrate = 40mm×40mm× 1.6mm
Zo=50ohm
Frequency=50GHz
Using a microstrip line calculator, Width of microstrip Line = 3.059mm
Height of microstrip Line=1.6mm
Length of microstrip Line=40mm
Conductor Material:Cu
Loss Tangent:0.02

Simulation:-

1. Materials for various elements of transmission line:-

Dielectric Substrate	FR-4 Epoxy Substrate
Microstrip	Copper
Ground	Copper

2. Both ports 1 and 2 were given lumped type excitation with impedance of 50 ohms
    a. Port 1 was given excitation from ground to strip
    b. Port 2 was given excitation from strip to ground
3. Analysis setup and frequence swap:-

No. of Passes	20
Max Delta S	0.02

Frequency	5 GHz
Frequency Sweep Start	1 GHz
Frequency Sweep End	10 GHz
Sweep Type	Fast

Model analysis and plots:-

1. To check convergence with no of passes

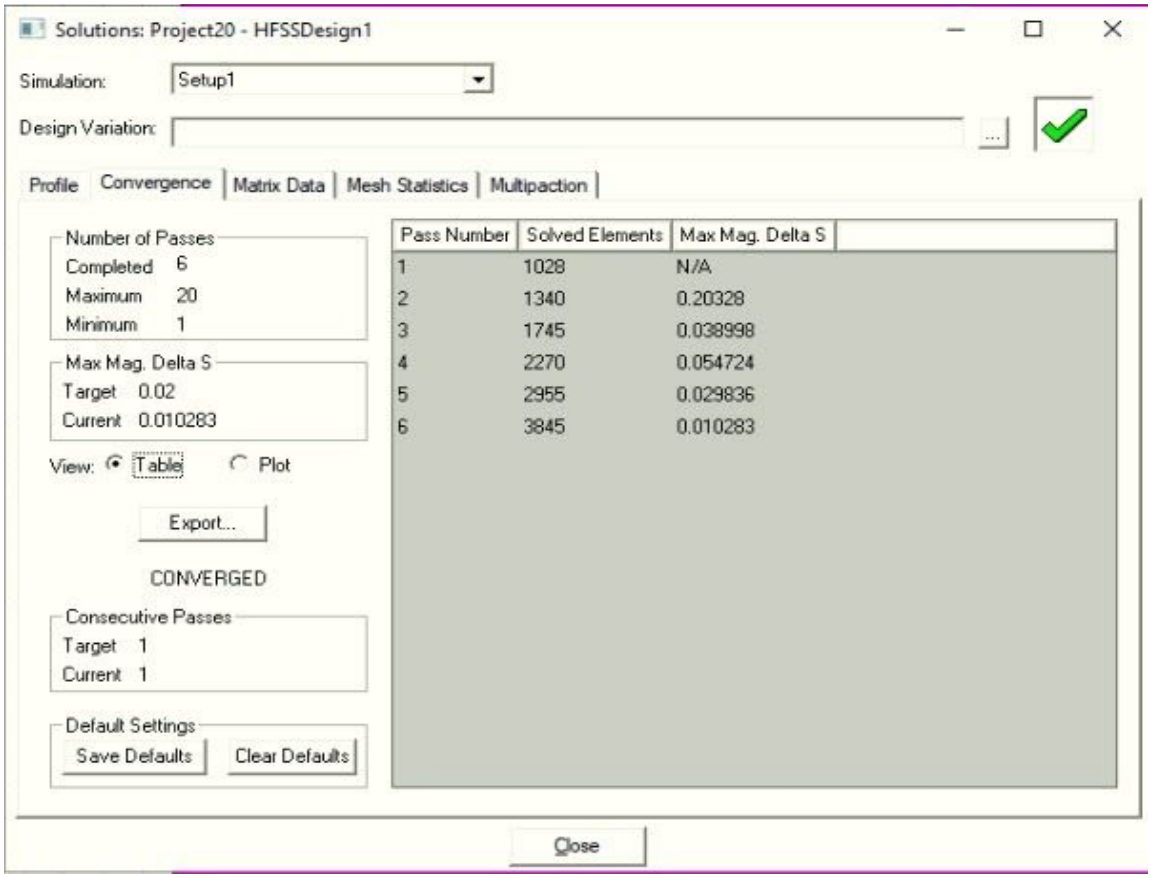


Fig 1. It shows delta S with no of passes

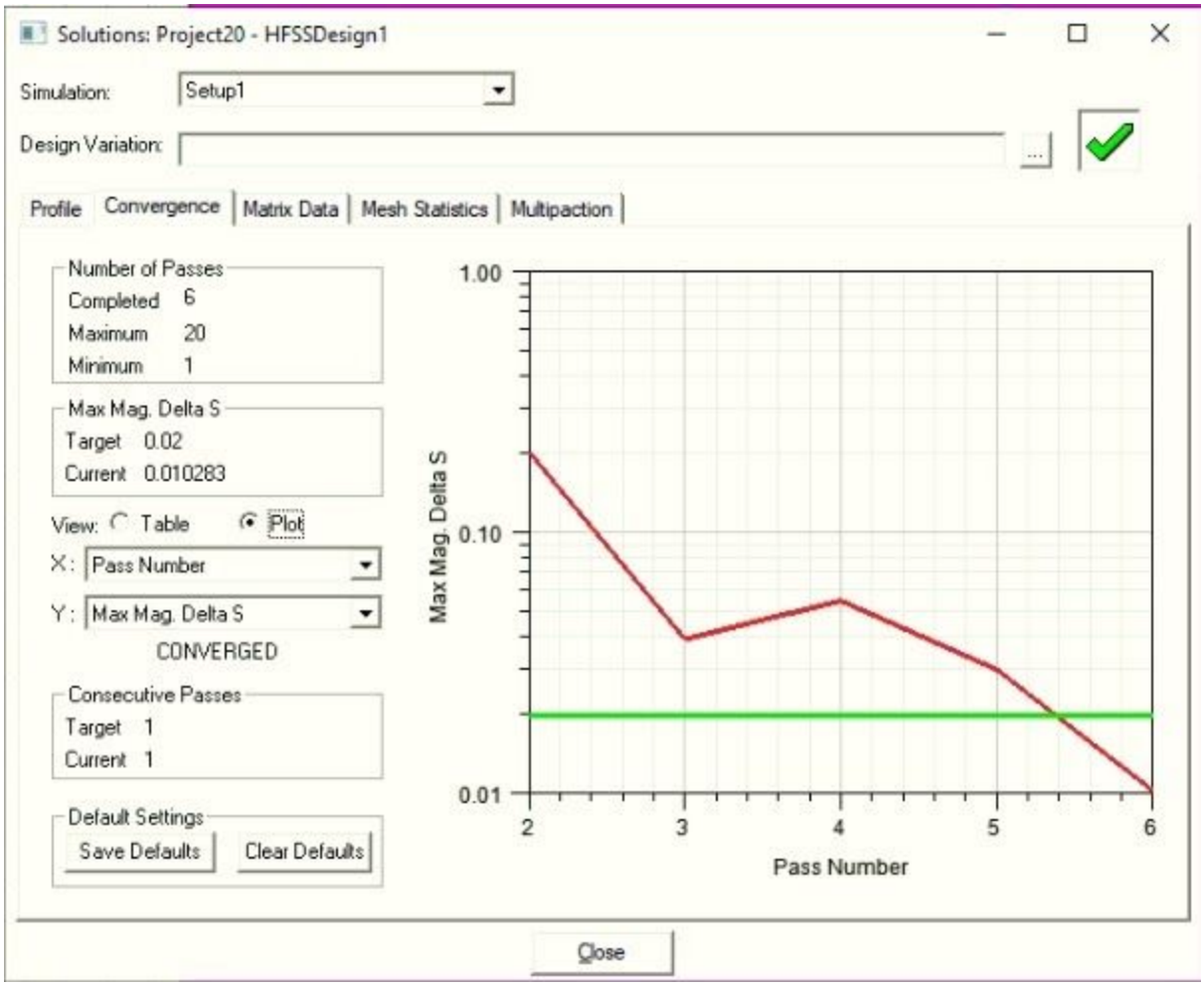


Fig 2. It shows max delta S(in magnitude with respect to no of passes completed)

Both figure1 and 2 show that just after 6 passes we achieved our error under the allowed limit of 0.02%.

2. S- parameter plot

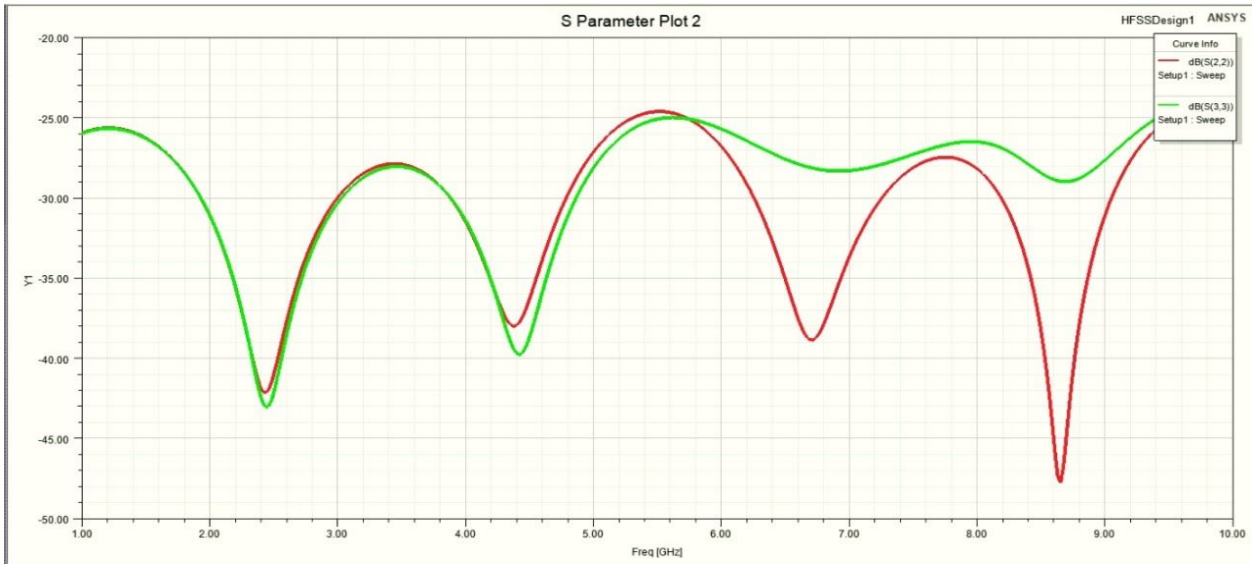
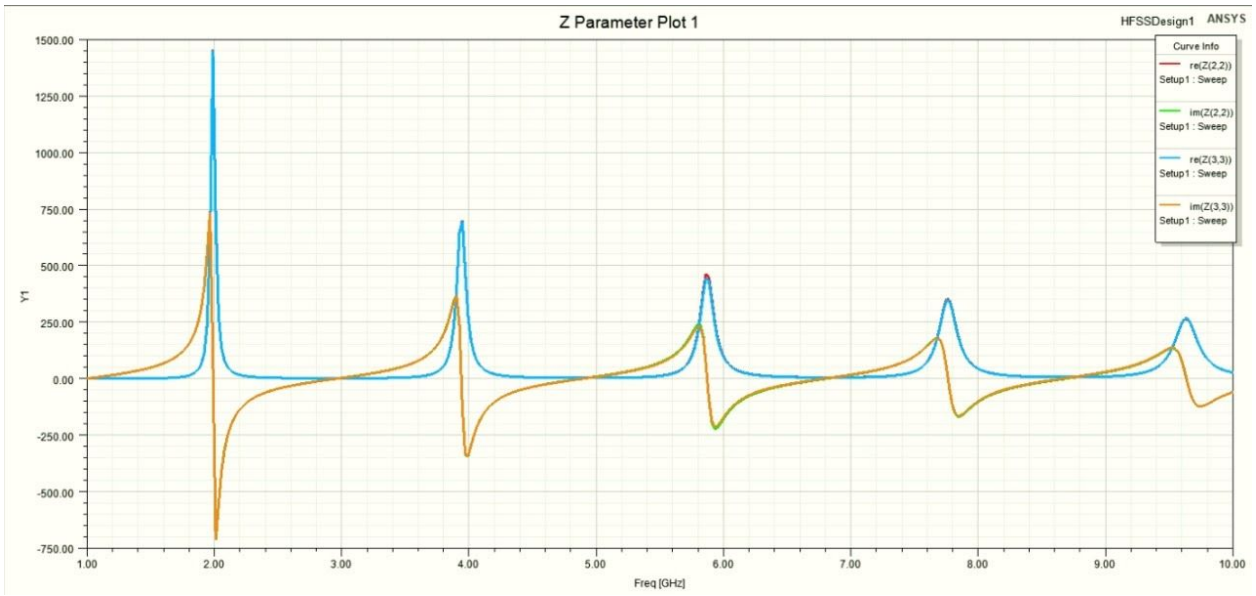


Fig 3. Plot of input(S(2,2)) and output(S(3,3)) port voltage reflection coefficient with frequency.

In general if the S parameter plot is below -10dB it is matched. In our case it is below -25dB which shows matched and better design.

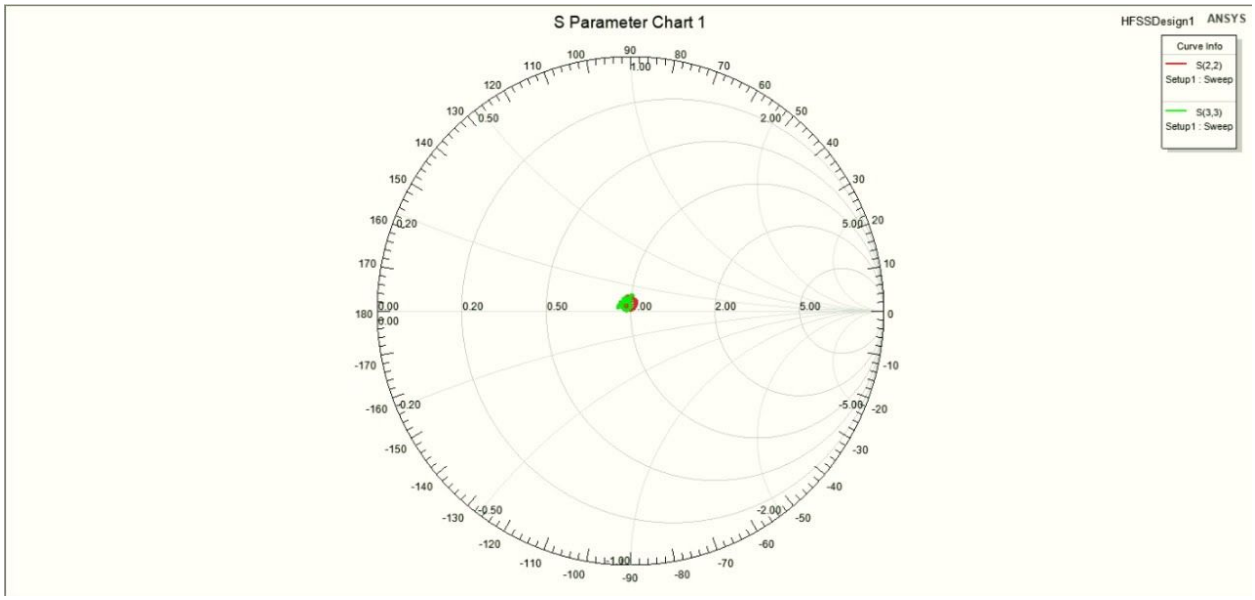
3. Z- parameter plot

Z - Parameter Plot for Real & Imaginary parts of Open circuit input impedance = Z(2,2) & Open circuit output impedance = Z(3,3)



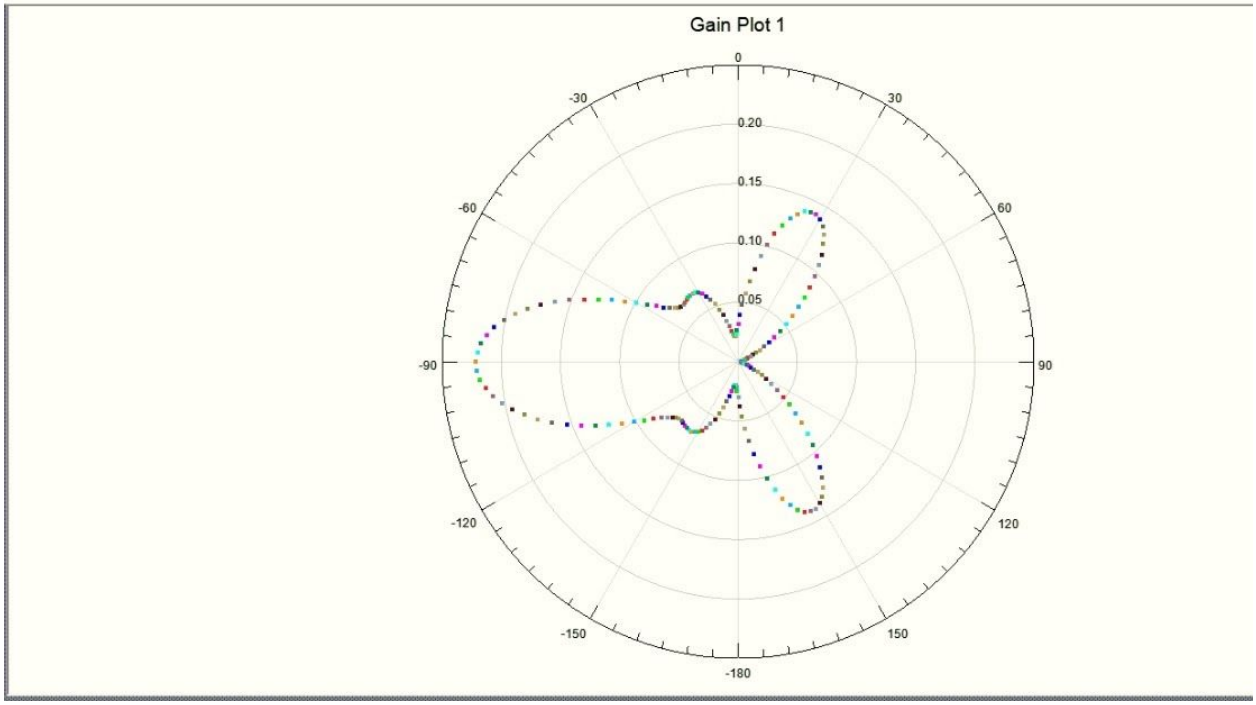
4. Smith chart plot

Smith Chart for Input port voltage reflection coefficient = S(2,2) & Output port voltage reflection coefficient = S(3,3)



This smith plot also shows that the design is perfectly matched.

5. 3D Polar Far Field Plot for theta = 90Deg



Azimuthal Plane Plot for Far Field Radiation Pattern.

6. Field overlay for surface current density of micro strip