EE203L: Engineering Electromagnetics

Roll: EE22B056

Name: Piyush Gupta

Assignment 1

Design of a 90° Hybrid Coupler

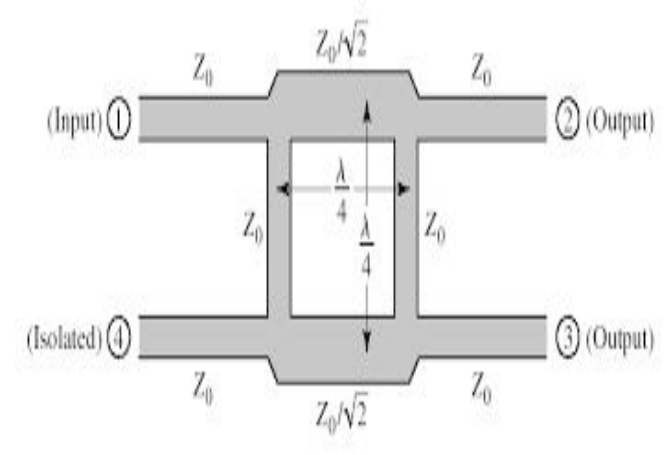
Scattering Matrix at Design Frequency

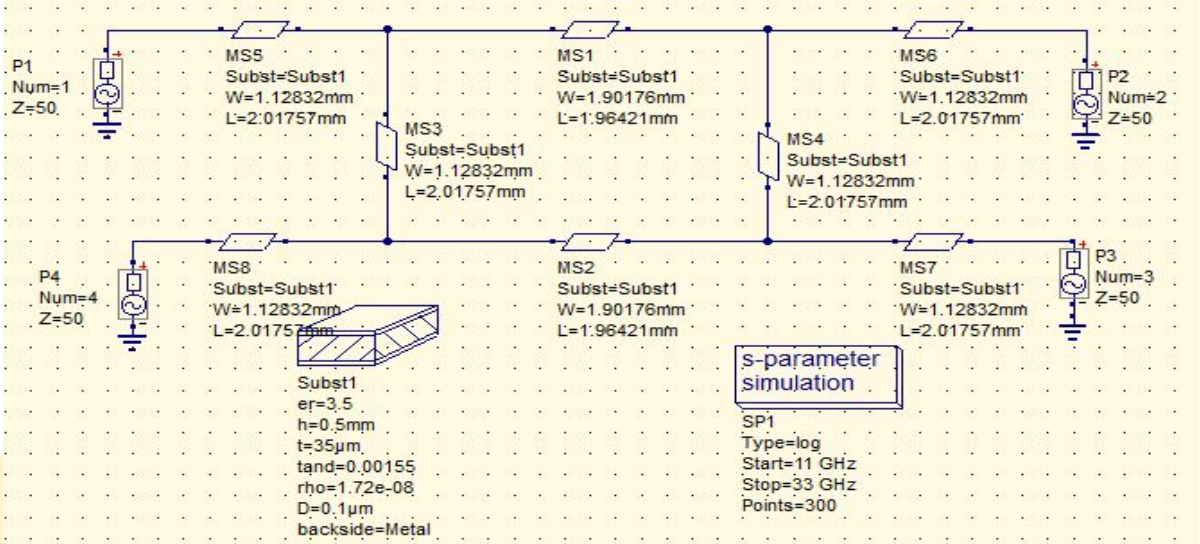
0.0036	0.697	0.704	0.0082
0.697	0.0036	0.0082	0.704
0.704	0.0082	0.0036	0.697
0.0082	0.704	0.697	0.0036

Summary

Design Frequency:	22 GHz
Insertion Loss:	3.135dB
Coupling:	3.048dB
Isolation:	41.72dB
Directivity:	38.67dB
Bandwidth:	11GHz

Design/Simulation Schematics





Comments/Remarks

To design this,the standard substrate RF-35 is chosen.From the data Sheet given,

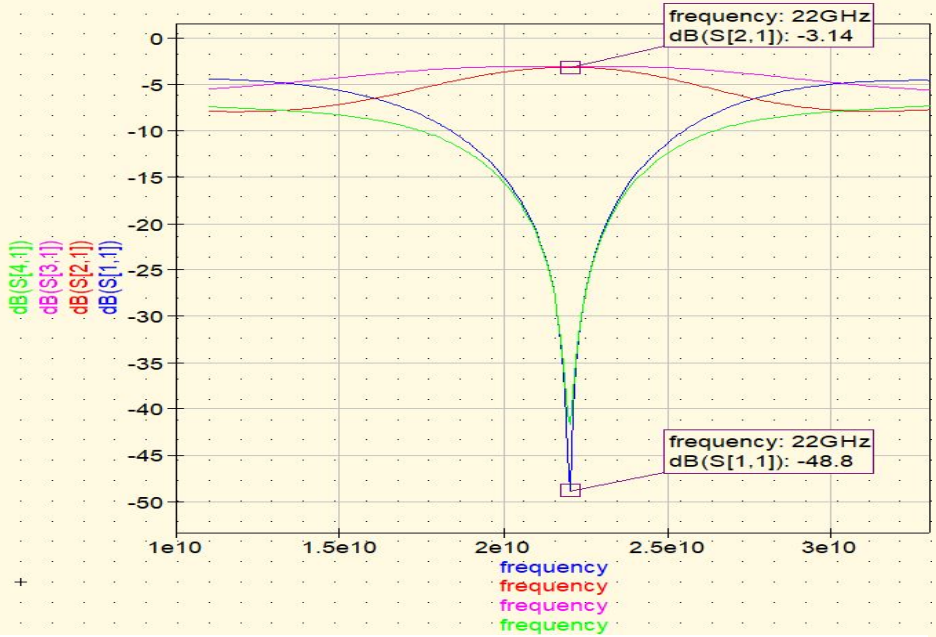
Dielectric Constant=3.50 **Loss Tangent=0.000155 @22Ghz**

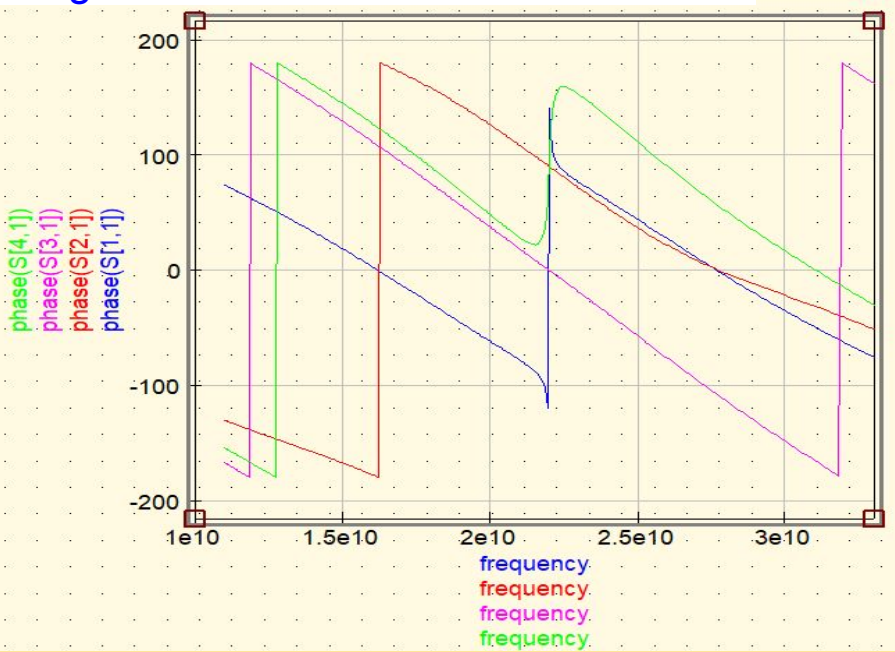
Thickness of dielectric(h)=0.5 mm **Thickness of c(t)=35 um**

$S_{11}, S_{21}, S_{31}, S_{41}$ Magnitude Plot in dB

$S_{11}, S_{21}, S_{31}, S_{41}$ Phase Plot in Degree

As my frequency is 22GHz ,the design frequency range should be from 11GHz to 33GHz.

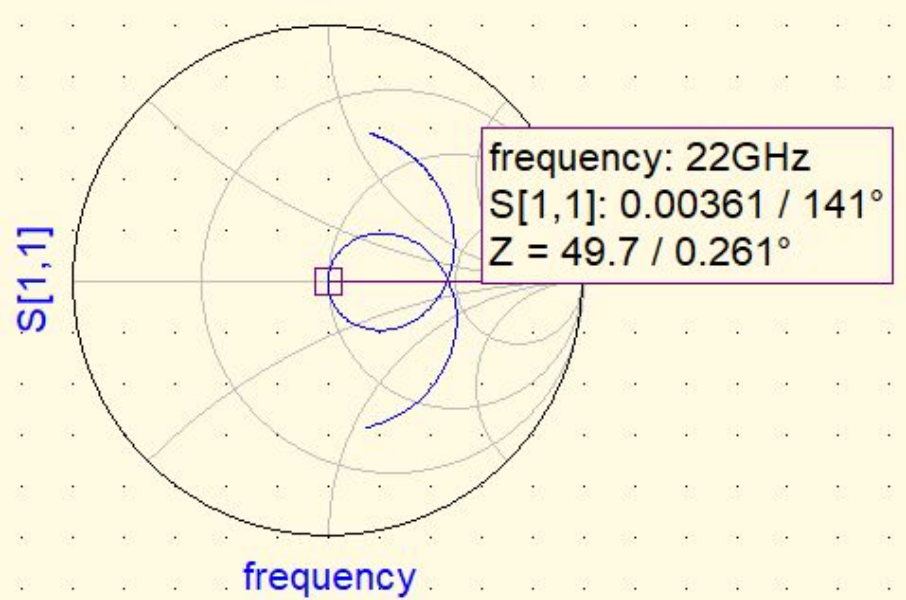




Comments/Remarks

We obtain nearly perfect power division of 3.14dB at port 2 and 3, and perfect isolation and return loss at port 4 and 1,respectively,at the design frequency 22GHz. All these quantities,however degrade quickly as the frequency departs 22GHz.

S_{11} Plot in Smith-Chart



Put a marker on the S_{11} trace and find out the input impedance at your design frequency.

Each point on smith chart represents a unique impedance normalised to the characteristic impedance Zo of transmission line. After locating the point on smith chart which corresponds to S11,we read the input impedance directly from the chart,we get Zin=49.7|0.261 ohms.The input impedance characterizes how a device interacts with the signals applied at its input port

Comments/Remarks

As Zin is approximately equal to Zo,we can say that the port is almost matched .As they are equal,even the reflection coefficient will be Zero

S parameter in tabular format

0.00361 / 141°	0.697 / 89.5°	0.704 / -0.472°	0.00826 / 105°
0.697 / 89.5°	0.00361 / 141°	0.00826 / 105°	0.704 / -0.472°
0.704 / -0.472°	0.00826 / 105°	0.00361 / 141°	0.697 / 89.5°
0.00826 / 105°	0.704 / -0.472°	0.697 / 89.5°	0.00361 / 141°

Comment on the matching of the circuit.

Commonly,a reflection Coefficient below 10dB (which corresponds to approximately 0.1 in magnitude) is considered well matched in many applications.Here S11=0.00361 which is less than 0.1. So it is considered to be matched.

Decide the type of design based on the properties of the S-matrix.

As S11=S22=S33=S44 and S21=S12,S23=S32..etc so it is symmetric and reciprocal.And it also satisfies the lossless conditions so it is lossless and matched.Therefore our application is symmetric,reciprocal,matched and lossless.Such a device is often referred to as a Magic Hybrid

Conclusion/ Comments/ Remarks

Remarks: So,based on the S11=0.00361 value,port 1 is almost perfectly matched.

Comments: The coupling,Isolation,Directivity values must satisfy the equation I=C+D ,i.e,(41.72=3.048+38.67d) .Here,this equation is satisfied.

Conclusion: The design and simulation of the 90 degree hybrid coupler using QUCS Studio have yielded valuable insights into its performance characteristics and practical considerations. Through thorough evaluation of insertion loss, return loss, isolation, Directivity, and Coupling , we have demonstrated the effectiveness of the designed coupler in achieving the desired functionality.