

# Lab 8 Report

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## Background

In this week's lab, we simulate hybrid coupler and rat race coupler in HFSS. Both of these are four ports device. For hybrid coupler, we can get equal power with 90 degree phase shift between output ports. For rat race coupler, it can spilt the input signal into equal power with a phase difference of 180 degree.

## Design

### Task 1. Hybrid Coupler

All the analysis is in David. M. Pozar, "Microwave Engineering, ", Chapter 7.5. Then, we get the hybrid coupler geometry in Figure 1. By using the online microstrip line calculator, we can get all the information of width and  $\lambda/4$  for the 50 ohm and 35.35 ohm transmission lines we use in this design. After using these parameter directly in the HFSS, the results shows the S11 deep point and -3 dB points for S21 and S31 are all in high frequency. Thus, I do the tuning job to increase the length of  $\lambda/4$  to make the central frequency go to 2.5 GHz. The final design parameters are shown in the following table 1.

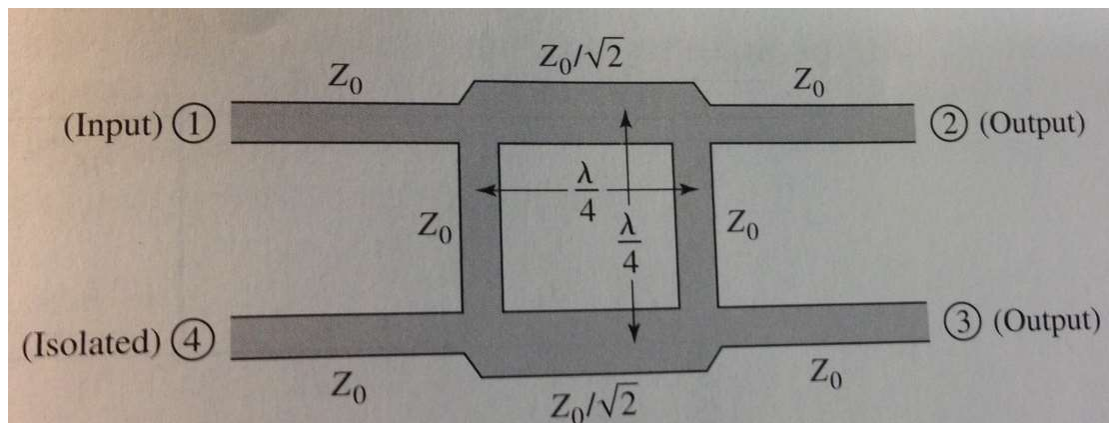


Fig. 1 Hybrid Coupler

Design Parameter:		Hybrid Coupler at 2.5 GHz	
Unit:mm		Unit:mm	
$W_{\text{feed line}}$	3.12	$L_x \text{ coupler}$	20
$W_x \text{ coupler}$	3.12	$L_y \text{ coupler}$	18
$W_y \text{ coupler}$	5.266		

Table. 1 Design Parameters for hybrid coupler

## Task 2. Rat Race Coupler

All the analysis is in David. M. Pozar, "Microwave Engineering, ", Chapter 7.8. Then, we get the rat race coupler geometry in Figure 2. The design parameters are shown in the table 2.

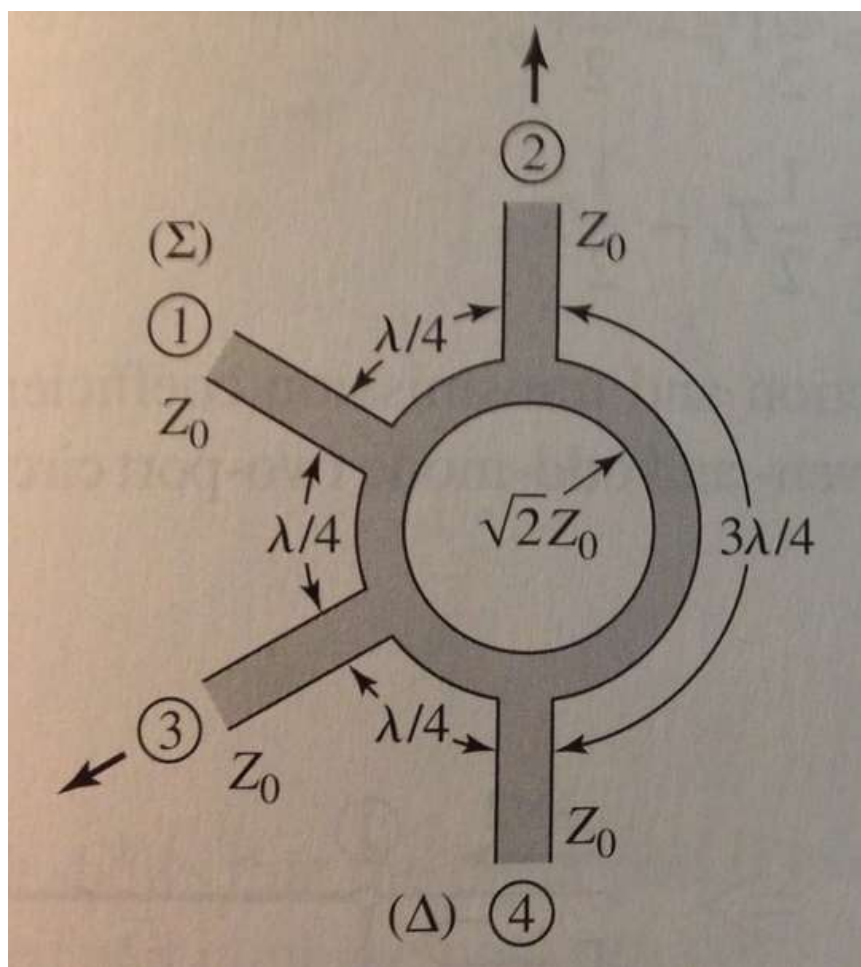


Fig. 2 Rat Race Coupler

Design Parameter:		Rat Race Coupler at 2.5 GHz	
Unit:mm		Unit:mm	
$W_{\text{feed line}}$	3.12	$Cir_{\text{rat race}}$	103.8
$W_{\text{rat race line}}$	1.67		

Table. 2 Design Parameters for hybrid coupler

## Procedure

Putting all the design parameters into HFSS model shown in figure 3.

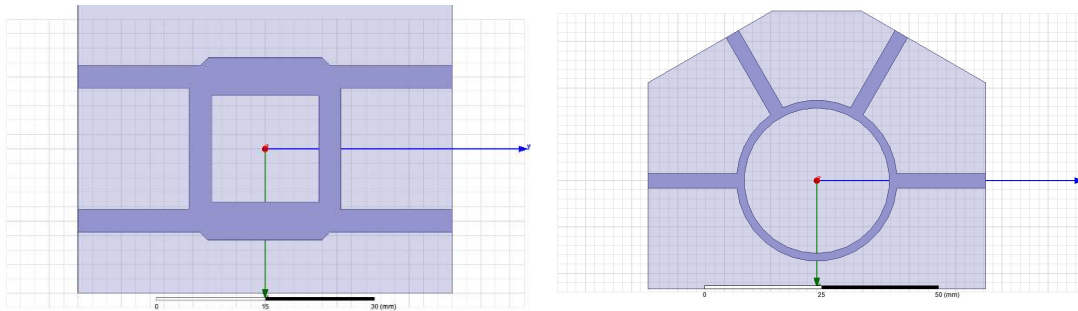


Fig. 3 HFSS model for Hybrid Coupler and Rat Race Coupler

## Results and Discussion

### Task 1. Hybrid Coupler

After the tuning jobs, I get the simulation results which is close to the measurement results. The measurement and simulation results are shown in figure 4 and 5. The phase difference is close to 90 degree at 2.5 GHz. Note that there are some difference between simulation and measurement at high frequency. I think it is caused by simulation error due to that this difference are in the end of the frequency sweep.

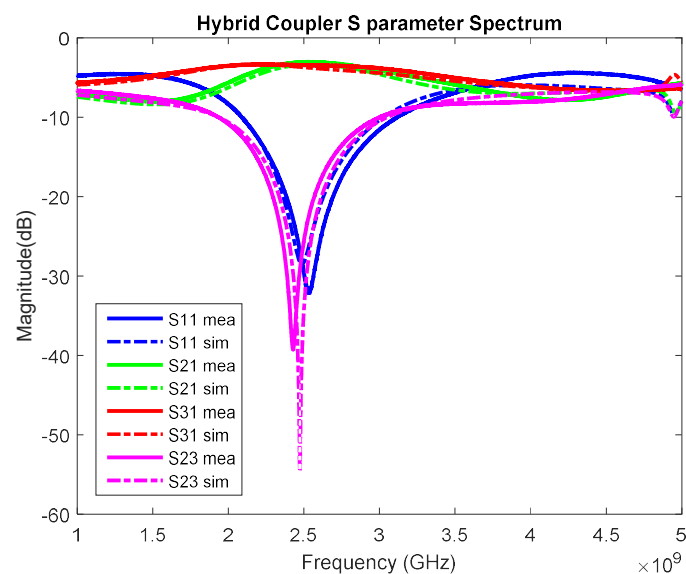


Fig. 4 Hybrid Coupler S parameter Spectrum

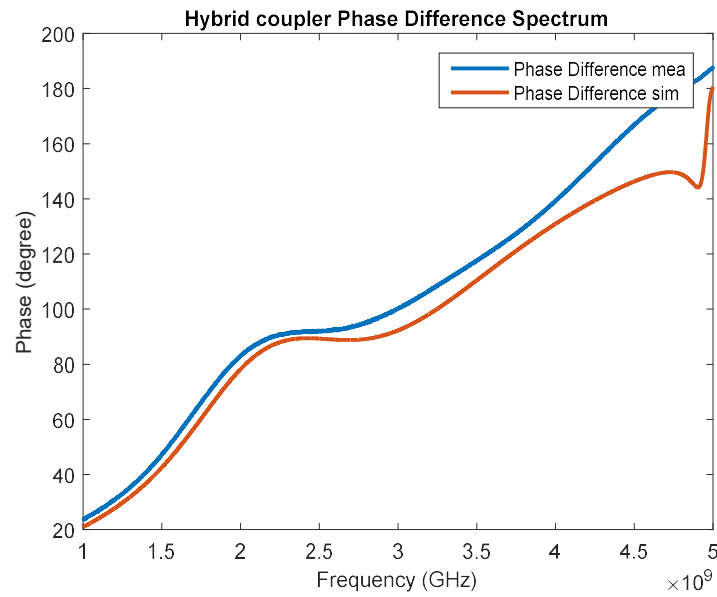


Fig. 4 Hybrid Coupler phase difference

## Task 2. Rat Race Coupler

The simulation results in figure 5 which is close to the measurement results even without tuning.

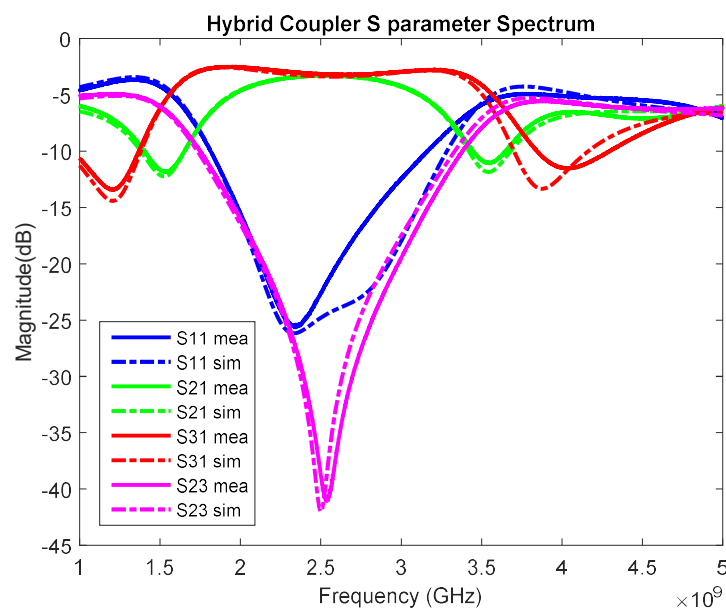


Fig. 5 Rat Race Coupler S parameter Spectrum

## Conclusion

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- Knowing the analytical solution and theory of the circuit can help us to find out which parameter should be modified to get our desire performance.
- This 90 degree hybrid can be a 180 degree coupler in 5 GHz.