Lab 7 Report

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Background

In this week's lab, we go through the process to design the phase shifter, fabricate phase shifter by copper taper on FR4 substrate and simulate 2 way Wilkinson power divider in HFSS. This phase shifter is two port device. By controlling the signal on different paths we design, we get the desire phase difference on the output port.

The Wilkinson power divider is a three port device- when the signal enter to input port, we can get the equal amplitude and equal phase in the output ports in our design frequency. The most important thing is this device is with high isolation between its output ports.

Design

Task 1. Phase shifter

By inserting two section of transmission line with different length, one quarter guided wavelength and one half guided wavelength to get 90 and 180 degree phase difference in output port. The schematic diagram is shown in figure 1. Note: CR1 and CR2 in this design are both RF switch.

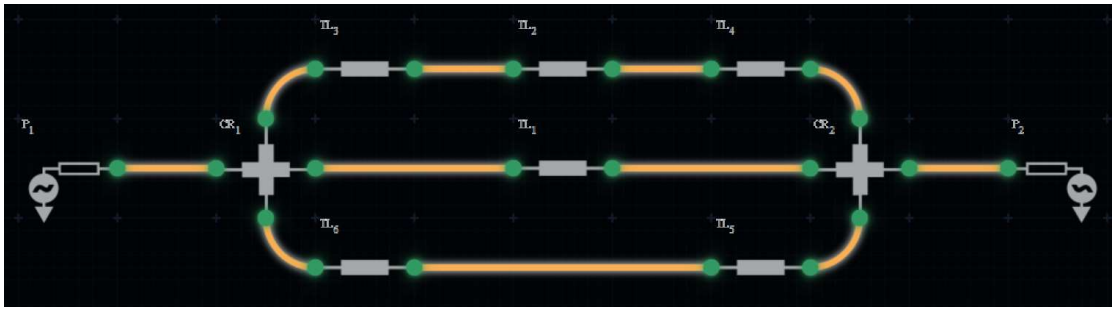

Fig. 1 Phase shifter

By using the online microstrip line calculator, we can get the width and lamda for the 50 ohm transmission line we use in this design. The design parameters are shown in the following table.

Design Parameter:		Phase shifter			at 3 GHz
Unit:lamda		Unit:lamda		Unit:lamda	
Length $_{TL2}$	0.5	Length $_{TL3}$	0.25	Length $_{TL4}$	0.25
Length $_{TL1}$	0.5				
Length $_{TL5}$	0.5	Length $_{TL6}$	0.25		
50 Ohm Microstrip line					
W	3.1 mm	h	1.57 mm	ε_r	4.1

Table. 1 Design Parameters for Phase shifter

Task 2. Wilkinson Power Divider

After doing the even mode and odd mode analysis, we can get the impedance and length information for this device. After putting lamda/4=17.3 mm in to HFSS model, the isolation between port 2 and port 3 is bad in low frequency. I think the main problem is the shape is still not so smooth and the discontinuity in the junction making some parasitic component change the electrical length. I increase the transmission line length to 23 mm to optimize the isolation performance in low frequency. The schematic diagram is shown in figure 2. The design parameters are shown in the following table.

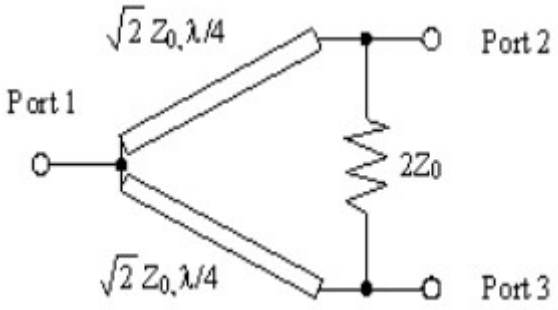

Fig. 2 Wilkinson Power Divider

Design Parameter:		Wilkinson Power Divider			at 2.5 GHz
W $_{feedline}$	3.12 mm	h	1.57 mm	ε_r	4.1
W $_{QWline}$	1.67 mm	Length $_{QW}$	23 mm	Risistor	100 Ohm

Table. 2 Design Parameters for Phase shifter

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Procedure

Task 1. Phase shifter

We make a 50 ohm through line and measure S21 amplitude and phase. Then, adding the quarter and half wavelength on other path and measure S21 amplitude and phase, respectively. We can observe the phase difference is approaching to 90 degree and 180 degree.

Task 2. Wilkinson Power Divider

Measurement and simulation.

Results and Discussion

Task 1. Phase shifter

The measurement results is shown in figure 3. The phase difference is not 90 degree or 180 degree as estimate. The magnitude is not the same, too.

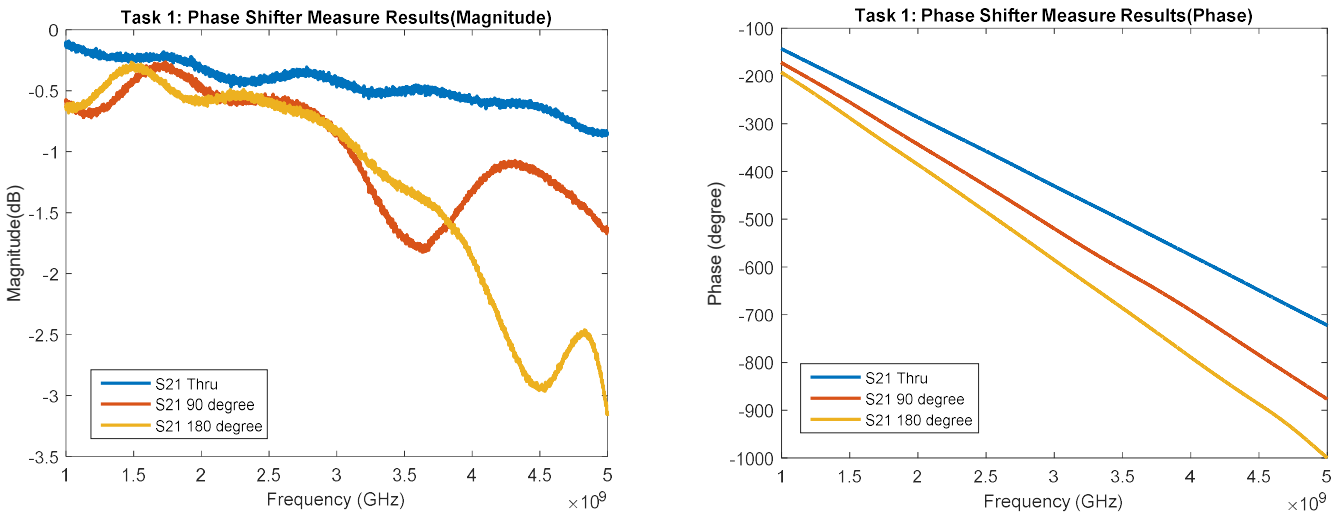

Fig. 3 Phase shift measure results

I believe this difference between theory and measurement is caused by the fabrication error and this difference is tolerable. 1 mm transmission line is equal to 6.4 degree phase shift in 3 GHz. We left some gap for soldering and the gap is a small

capacitance in this frequency which can be modeled as an extra length. The re-use SMA connector is an issue, too. Heat can change the dielectric constant permanently. And the calibration kit is not made by “our connectors”.

Task 2. Wilkinson Power Divider

After some tuning jobs, I get the simulation results which is close to the measurement results. The measurement and simulation results are shown in figure 4. S21 and S31 is pretty close to -3dB. The isolation is pretty close to measurement results, too. I also simulate the situation that this Wilkinson is without 100 ohm resistance. It results is in figure 5. It just a T junction spilt the equal power and the isolation is bad.

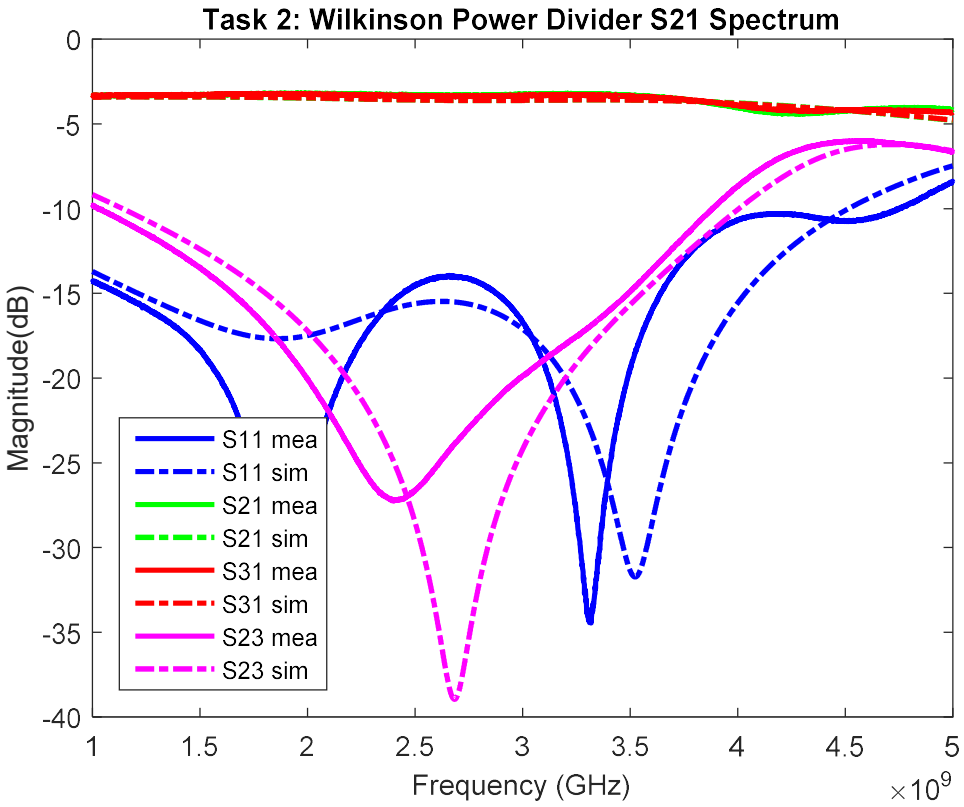

Fig. 4 Wilkinson Power Divider simulation and measure results

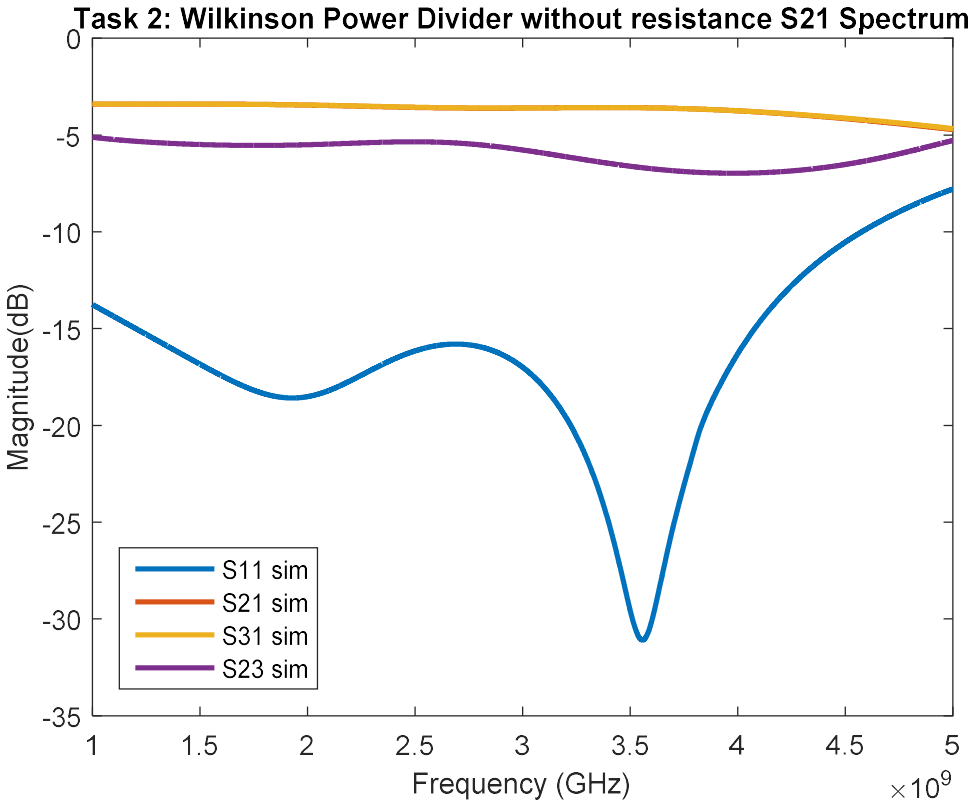

Fig. 5 Wilkinson Power Divider without resistance simulation results

Conclusion

- Unwrapped Phase function in network analyzer sometimes go wrong, we have to test our circuit characteristic to find out what happen.
- Even though we get the analytical solution to design the Wilkinson power divider, when we implement it in different shape, we still have to do tuning job.
- If the space is not an issue, Wilkinson power divider is the better choice than the T junction.