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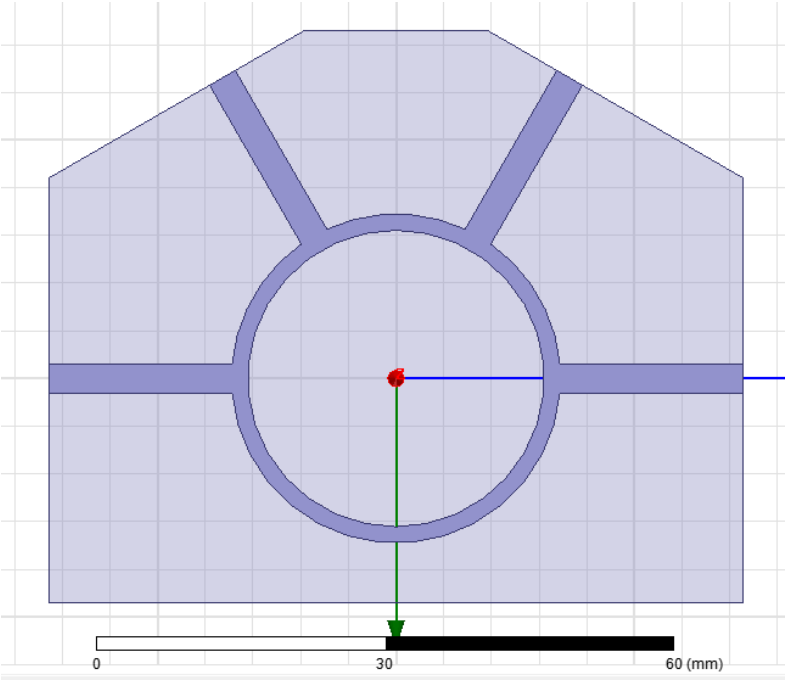
Lab 8

Introduction/Background

This lab introduced us to how different kinds of couplers operate. In lab we focused on the Rat-Race coupler and the Hybrid coupler. It has four ports, each a quarter wavelength from each other, on the top half of the circle (the circles total circumference is 3/2 wavelengths), with the circle having an impedance of $Z0\sqrt{2}$. The Hybrid coupler is a passive device that is often used in radio and telecommunications. It is a directional coupler with the input power divided equally between two output ports.

Design

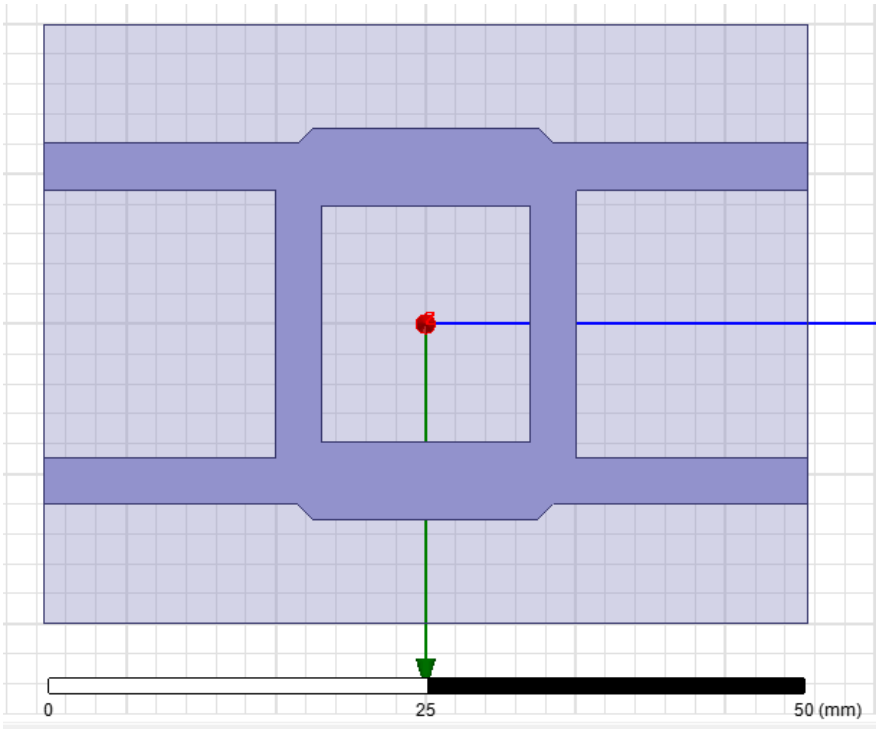
Both couplers were to be made in HFSS before lab. The Hybrid coupler was first and had input ports with 50 ohm characteristic impedance and quarter wavelength line. The two lines perpendicular to the input lines had a width of 3.105 mm and a length of 16.92 mm. The lines connecting port 1 to port 2 and port 3 to port 4 had impedances of $Z02$ with $Z0$=50 ohms, or 35.35 mm, widths of 5.25 mm, and lengths of 16.5 mm. This is known as a quadrature coupler.



Ratrace coupler simulated in HFSS

Name	Value	Unit	Evaluated Value	Type
feed_line_width	3.1	mm	3.1mm	Design
rat_race_line_width	1.7	mm	1.7mm	Design
rat_race_circumf...	103	mm	103mm	Design

Ratrace HFSS parameters



Hybrid coupler simulated in HFSS

Name	Value	Unit	Evaluated Value	Type
feed_line_width	3.1	mm	3.1mm	Design
coupler_x_width	3.1	mm	3.1mm	Design
coupler_y_width	5.2	mm	5.2mm	Design
coupler_x_length	21	mm	21mm	Design
coupler_y_length	17	mm	17mm	Design

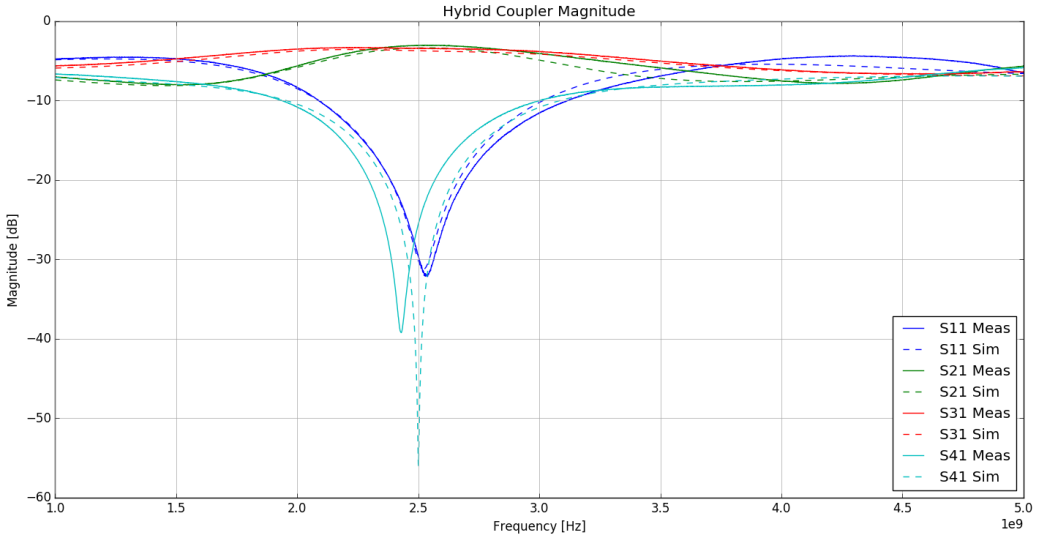
Hybrid coupler HFSS parameters

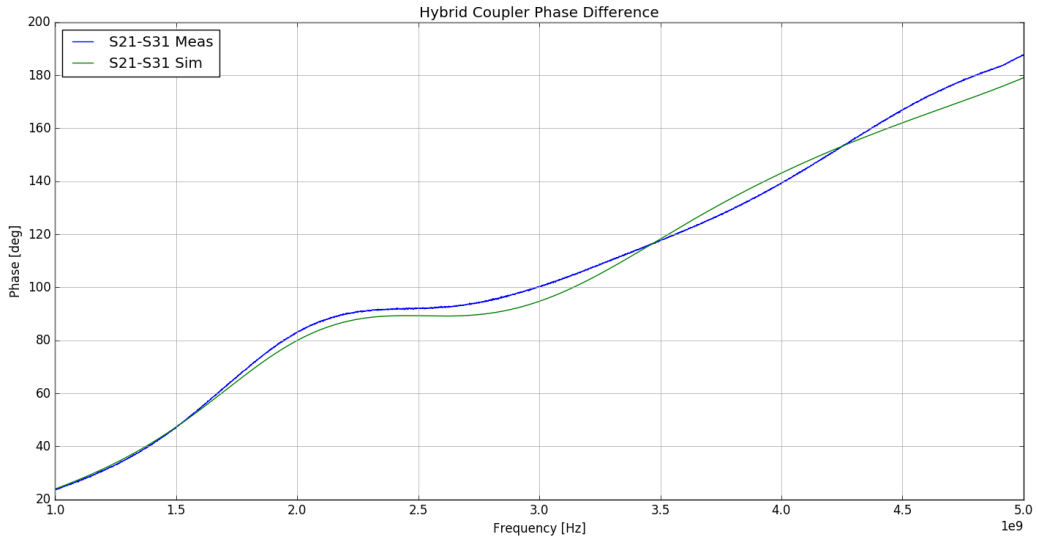
The Rat-Race coupler was designed next. The lengths between the ports were quarter wavelengths, except for the 2 ports farthest away from each other which are separated by three quarter wavelengths. The total circumference is 1.5 wavelengths. The port measurements are like that of the hybrid coupler: 50 ohms, 3.105 mm width, 16.92 mm length. The parts of the circle between ports has impedance $Z0*2$ = 70.7 ohms which translates to a width of 1.648 mm, and length of 17.36 mm.

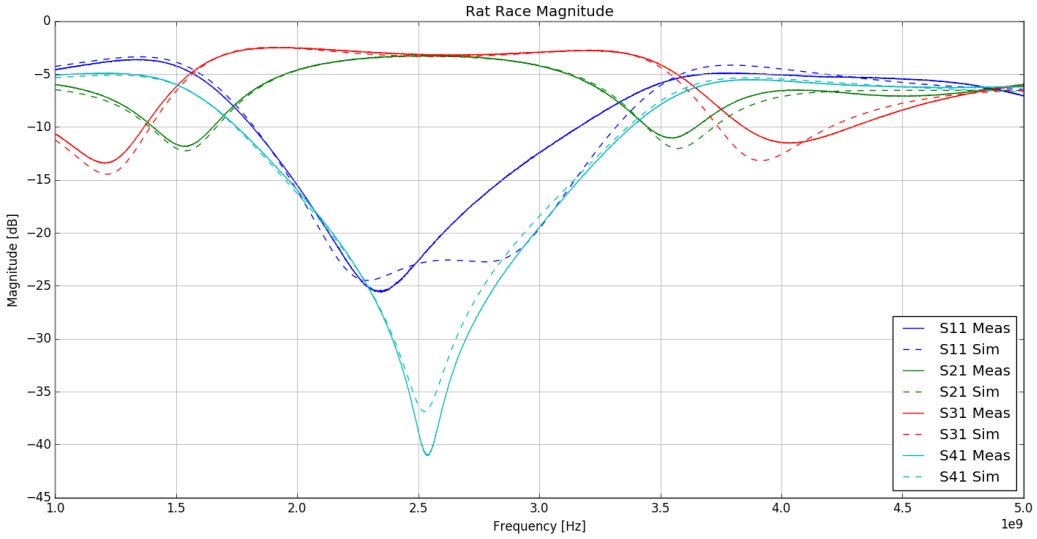
In Lab Procedure

We only had to do the simulations for this lab so there was no in-lab portion.

Results and Discussion


Hybrid Coupler Magnitude
Magnitude [dB]
Frequency [Hz]
1e9
S11 Meas
S11 Sim
S21 Meas
S21 Sim
S31 Meas
S31 Sim
S41 Meas
S41 Sim


Hybrid Coupler Phase Difference
Phase [deg]
Frequency [Hz]
1e9
S21-S31 Meas
S21-S31 Sim



Our hybrid coupler simulation performed very similarly to the measured values. Other than S41, all of our s parameters were nearly identical, and S41 was fairly similar as well. The phase of the hybrid coupler also was very close to the measured values.

Our rate race coupler also performed very similarly to the measured results. S11 = reflect, S12

Conclusion

The main point of this lab was to teach us about the Hybrid and Rat-Race couplers. David took measurements in lab and gave us the results to compare to HFSS. These results were almost the same.

We put matched loads on the ports while measuring S-parameters so that the reflections from other ports don't interfere. It helped to get an accurate measurement at ports across the circuit from each other.

Hindsight

I should have researched more which ports should be showing what characteristics in the plots.

Reflection

The most challenging aspect was dealing with HFSS, since none of us have much experience with the program. The most rewarding was getting our coupler simulations' plots so close to the measured values.