Lab 5

Introduction/Background

In this lab I worked with Matias Kalaswad and Matthew Walck. This includes pre-lab materials such as parameter calculations and HFSS simulations, as well as post-lab deliverables such as lab reports and plots.

This lab introduced us to the TRL calibration kit and the PIN diode switch with two short circuit choke lines. The TRL kit was designed to calibrate for the frequencies between 1 GHz to 5 GHz. The diode switch is a current-controlled resistor; it can also be described as a semiconductor diode in which a highly resistive intrinsic region is put in between a P-type and N-type region.

Design

To design the TRL kit we used a free online microstrip calculator. Our parameters were as follows:

- h = 1.575 mm
- er = 4.1
- f = 3 GHz
- Z0 = 50 ohm

The calculator allowed us to find the following values:

- Deembed: 15 mm
- reflect length, width: 15 mm, 3.17 mm
- thru length, width: 30mm, 3.17 mm
- line length, width: 44.07 mm, 3.17 mm

Our first attempt at inputting these values into HFSS was not successful. We consulted with David on whether or not our graphs looked correct and he explained that they were not showing the proper frequency and that we should tweek our values. Once we made some corrections our graphs can be seen in the Results and Discussion section.

The design of the PIN diode was like that of the TRL kit in that we utilized the online microstrip calculator. Given the width of the 50 ohm line as 3.105mm we obtained the following values:

- width of 100 ohm choke = 0.72mm
- quarter wavelength = 17.79 mm

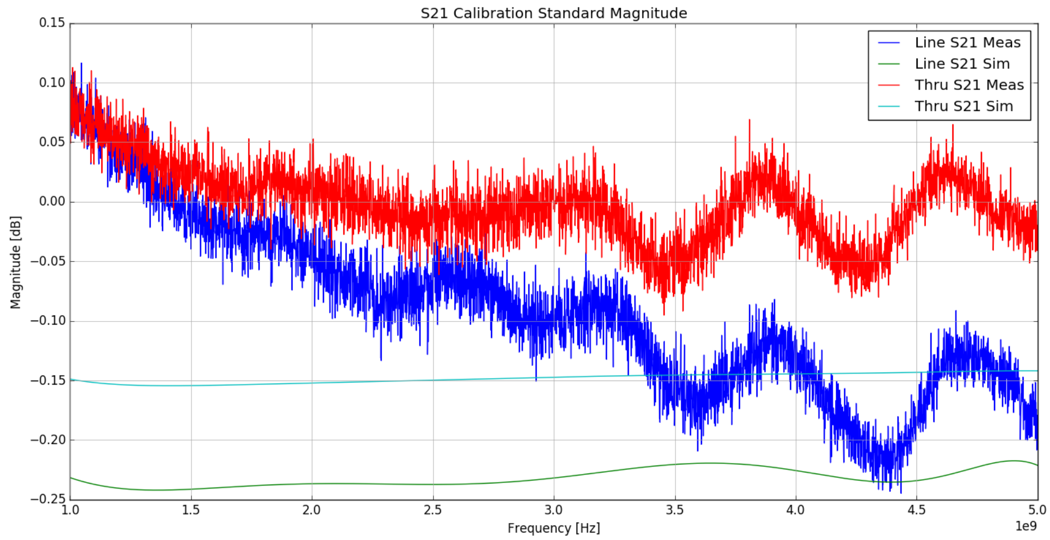
In Lab Procedure

In lab David showed us the calibration of both designs. The TRL kit required solving a third order polynomial with HFSS data and python code. The coefficients that were found were then entered into the network analyzer and calibrated both ports to the reflect, thru, and line.

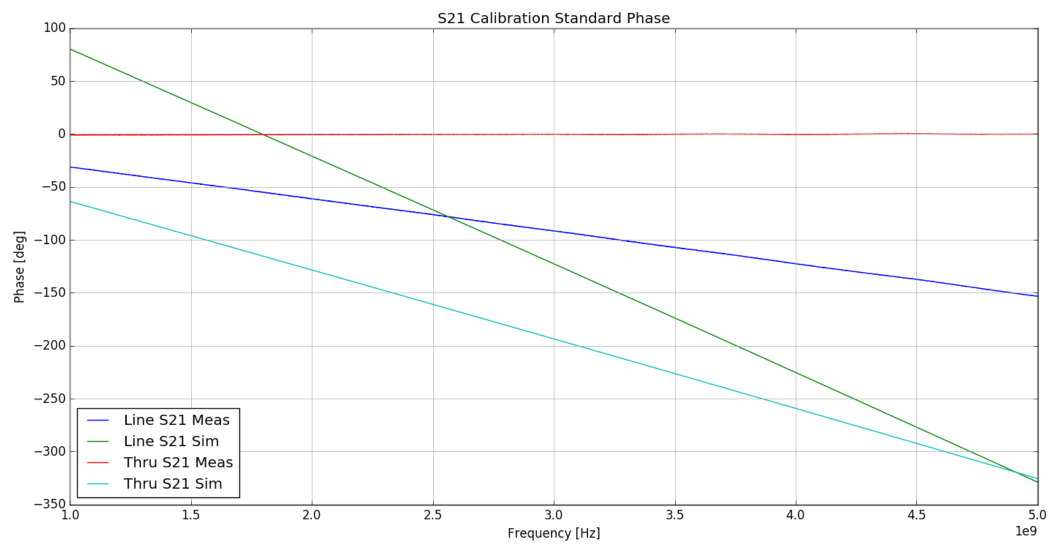
After saving the data in a csv file, David did a similar calibration for the PIN diode for both the on and off stages and then saved this data in a csv file.

Results and Discussion

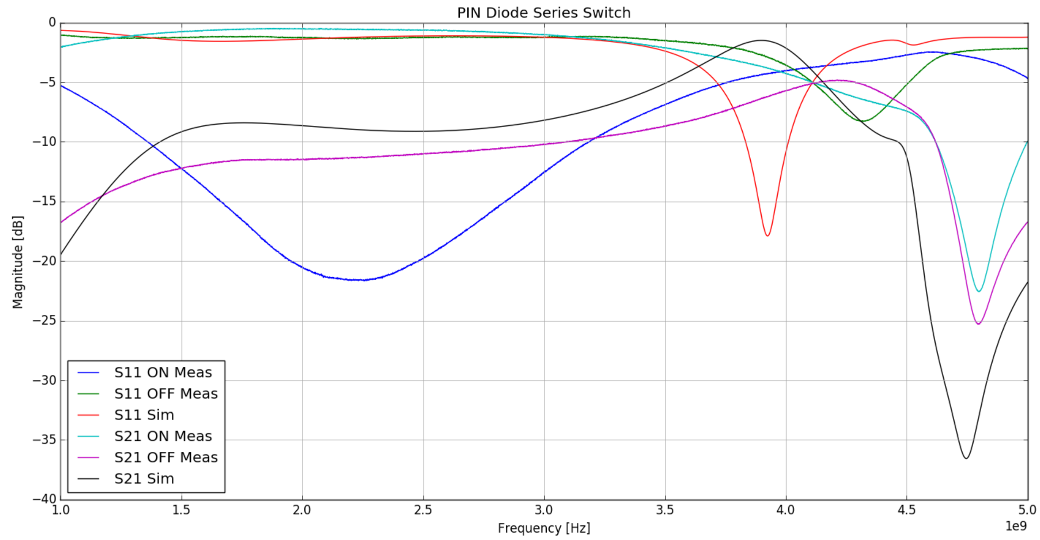
In the graphs below, S_{NM} represents the graph where the circuit is being measured at gate N while gate M is being excited. S_{21} was the parameter that we were most interested in. This is where gate 1 is excited while we measure at gate 2.



S21 Calibration Standard Magnitude
Magnitude [dB]
Frequency [Hz]
1e9
Line S21 Meas
Line S21 Sim
Thru S21 Meas
Thru S21 Sim



S21 Calibration Standard Phase
Phase [deg]
Frequency [Hz]
1e9
Line S21 Meas
Line S21 Sim
Thru S21 Meas
Thru S21 Sim



Conclusion

The main points of this lab were calculating the lengths and widths of the reflect, thru, and line; as well as calibrating the PIN diode. Some unexpected challenges that had to be overcome during the design step included altering values in the HFSS schematic until the graphs showed the intended values.

Hindsight

I wish I had known earlier in the design procedure about the online calculator. It was very easy and quick to use. I also wish I had had more background on how to use HFSS but it makes slightly more sense now and we were able to produce the necessary graphs with David's help.

Reflection

The most challenging part of this lab was figuring out how to use HFSS since we have never had any previous experience with it.

This lab was extremely interesting and I enjoyed doing the calculations to find the reflect, thru and line lengths. This lab was really helpful in explaining the meaning of the S parameters and what they can show us when graphed properly.