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Lab 5

Introduction/Background

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.

In this lab, we used HFSS to design a TRL kit for frequencies between 1 GHz and 5 GHz and a PIN diode switch.

Design

We used an online microstrip calculator to determine the widths and lengths of the transmission lines

We used parameters:

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

The calculator gave us the following values:

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

These required some tweeking to find the exact values needed:

- reflect length, width: 15 mm, 3.12 mm
- thru length, width: 30mm, 3.12 mm
- line length, width: 46.08 mm, 3.12 mm

We used the microstrip line calculator for the PIN diode as well.

- Width of 50 ohm lines = 3.12 mm
- width of 100 ohm choke = 0.72mm
- quarter wavelength = 17.79 mm

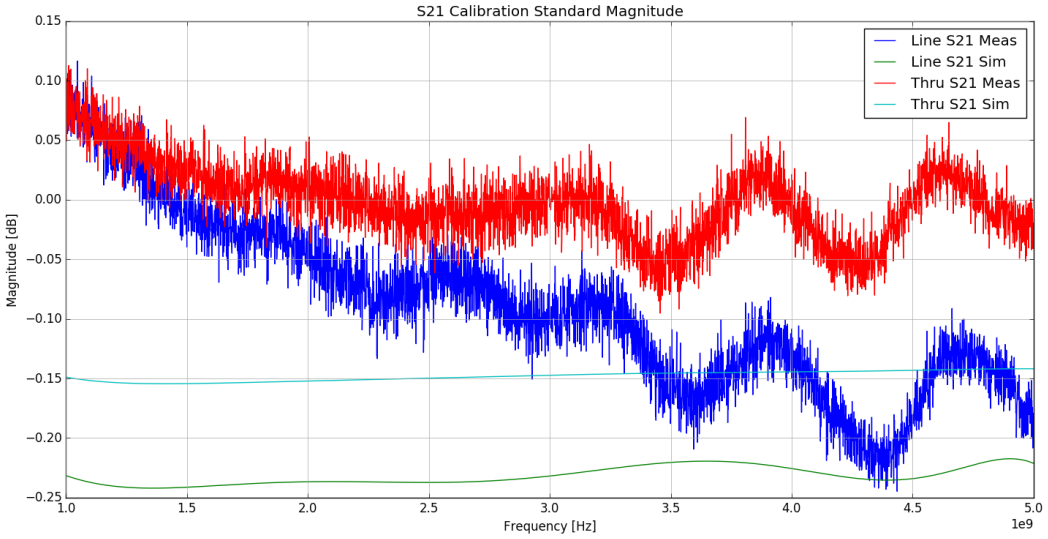
In Lab Procedure

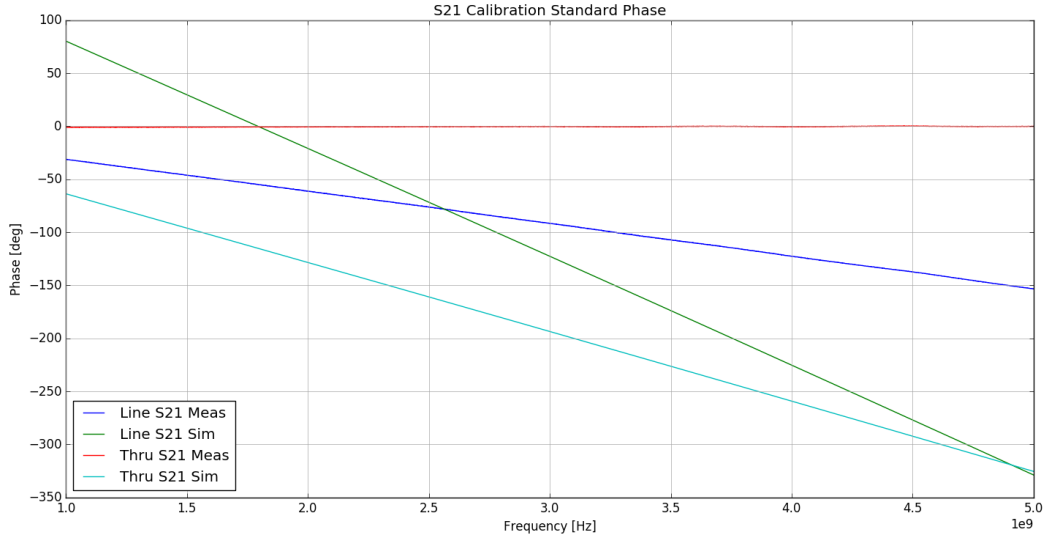
In lab David showed us the calibration of both designs. The TRL kit required solving a third order polynomial with HFSS data and python code. The coefficients that were found were then entered into the network analyzer and calibrated both ports to the reflect, thru, and line.

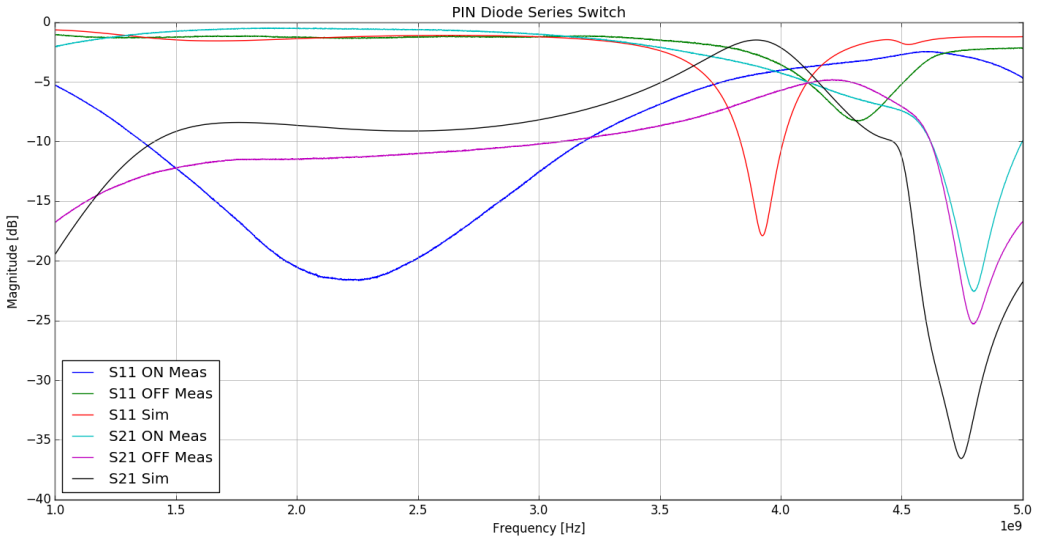
After saving the data in a csv file, David did a similar calibration for the PIN diode for both the on and off stages and then saved this data in a csv file.

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.







Our simulated S21 plot for the PIN diode is fairly similar to the measured S21 plots. The minimums occur at the same frequency, but our magnitude is lower.

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.

Hindsight

On the first attempt, we didn't use the microstrip calculator. When we started using that later on, it made the choice of design changes significantly faster.

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, and discussing my results with David afterwards, helped me understand the meaning of the S parameters much more.