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Lab 6

Introduction/Background

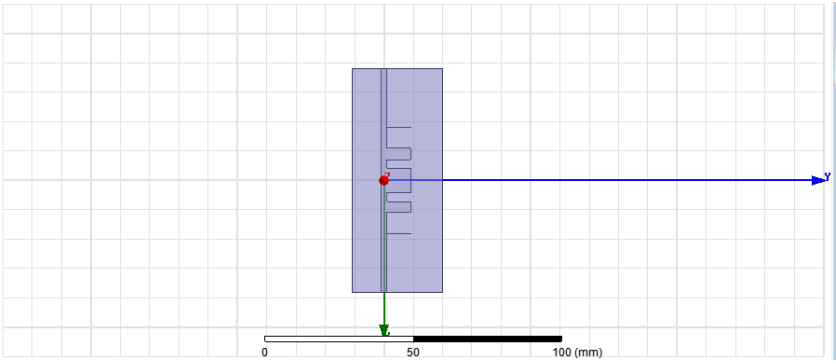
This lab introduced us two types of filters: low-pass and band-stop. Two different low-pass filters were simulated; one was a normal T-line filter while the other was a T-line filter with tapped stubs. We designing the filters in HFSS and then constructed the band stop filter in lab.

Design

There were three different designs for this lab. The first was the low-pass filter with 2.5 GHz cut-off frequency and attenuation of 10 dB at 3.25 GHz. We used the charts and graphs from the lab report, as well as the in class discussion, to determine the coefficients of the different filter components. The lab manual walked through the step by step procedure to using Richard's transformation to getting the line widths for the transmission lines.

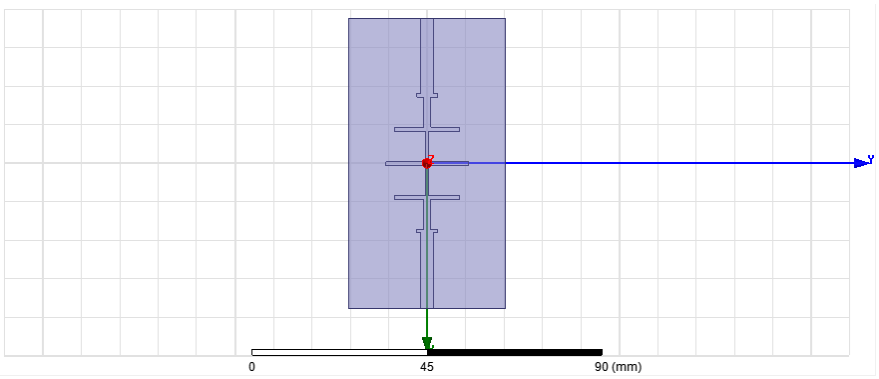
We found the widths and lengths of each line for the normal T-Line LPF to be:

Name	Value	Unit	Evaluated Value	Type
w0	3.117	mm	3.117mm	Design
UE_L	14.744152734312	mm	14.7441527343...	Design
w1	1.479	mm	1.479mm	Design
L1	14.744152734312	mm	14.7441527343...	Design
w2	0.608	mm	0.608mm	Design
L2	14.744152734312	mm	14.7441527343...	Design
w3	3.117	mm	3.117mm	Design
L3	14.744152734312	mm	14.7441527343...	Design
w4	0.608	mm	0.608mm	Design
L4	14.744152734312	mm	14.7441527343...	Design
w5	1.479	mm	1.479mm	Design
L5	14.744152734312	mm	14.7441527343...	Design



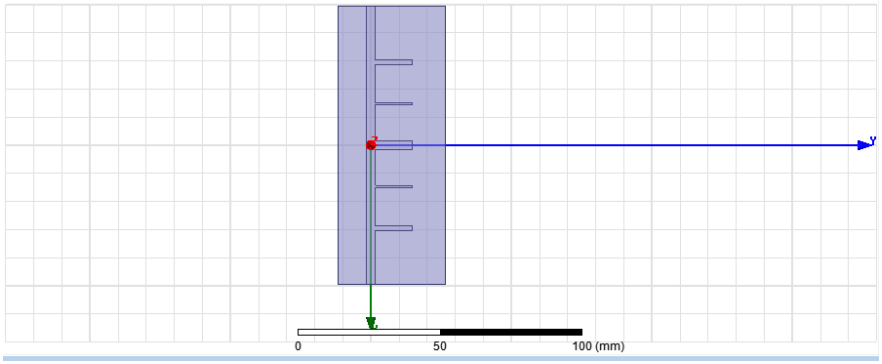
We found the widths and lengths of each line for the tapped stub T-Line LPF to be:

Name	Value	Unit	Evaluated Value	Type
w0	3.1298828125	mm	3.1298828125...	Design
wUE1	0.5408935546875	mm	0.54089355468...	Design
wUE2	0.5408935546875	mm	0.54089355468...	Design
wUE3	1.7607421875	mm	1.7607421875...	Design
wUE4	1.7607421875	mm	1.7607421875...	Design
UE_L1	8.8	mm	8.8mm	Design
UE_L2	8.8	mm	8.8mm	Design
UE_L3	8.8	mm	8.8mm	Design
UE_L4	8.8	mm	8.8mm	Design
w1	1	mm	1mm	Design
L1	2.788	mm	2.788mm	Design
w2	1	mm	1mm	Design
L2	8.53	mm	8.53mm	Design
w3	1	mm	1mm	Design
L3	10.841	mm	10.841mm	Design
w4	1	mm	1mm	Design
L4	8.53	mm	8.53mm	Design
w5	1	mm	1mm	Design
L5	2.788	mm	2.788mm	Design



We found the widths and lengths of each line for the tapped stub T-Line LPF to be:

Name	Value	Unit	Evaluated Value	Type
w0	1.7607421875	mm	1.7607421875...	Design
wUE1	1.7607421875	mm	1.7607421875...	Design
wUE2	1.7607421875	mm	1.7607421875...	Design
wUE3	1.7607421875	mm	1.7607421875...	Design
wUE4	1.7607421875	mm	1.7607421875...	Design
w1	0.085628509521484	mm	0.08562850952...	Design
L1	9.07817737369	mm	9.07817737369...	Design
w2	3.62890625	mm	3.62890625mm	Design
L2	9.07817737369	mm	9.07817737369...	Design
w3	8.39794921875	mm	8.39794921875...	Design
L3	9.07817737369	mm	9.07817737369...	Design
w4	3.962890625	mm	3.962890625mm	Design
L4	9.07817737369	mm	9.07817737369...	Design
w5	0.085628509521484	mm	0.08562850952...	Design
L5	9.07817737369	mm	9.07817737369...	Design
UE_L1	9.07817737369	mm	9.07817737369...	Design
UE_L2	9.07817737369	mm	9.07817737369...	Design
UE_L3	9.07817737369	mm	9.07817737369...	Design
UE_L4	9.07817737369	mm	9.07817737369...	Design



In Lab Procedure

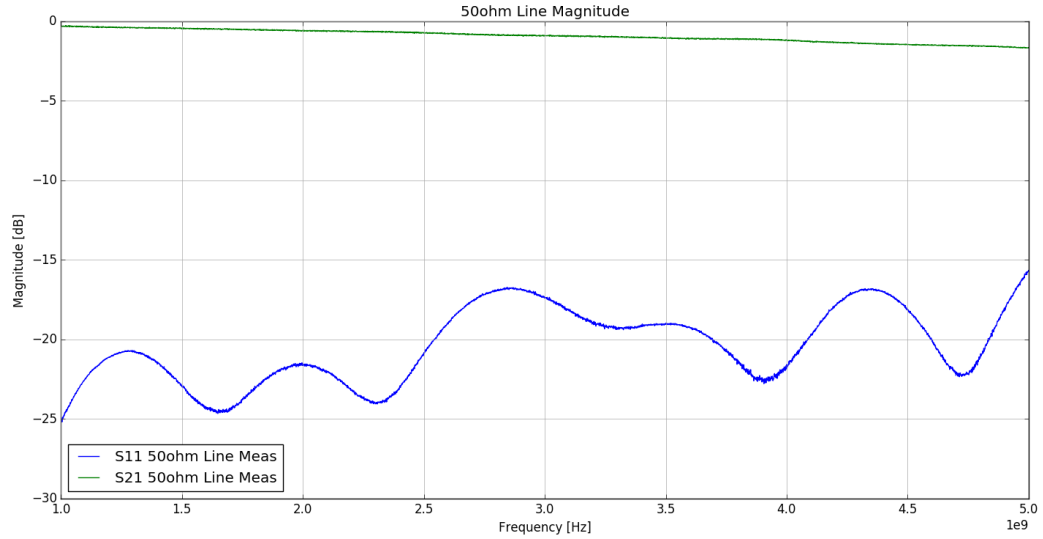
In lab we cut t-lines out of copper tape and attached them to a substrate in order to construct a band stop filter.

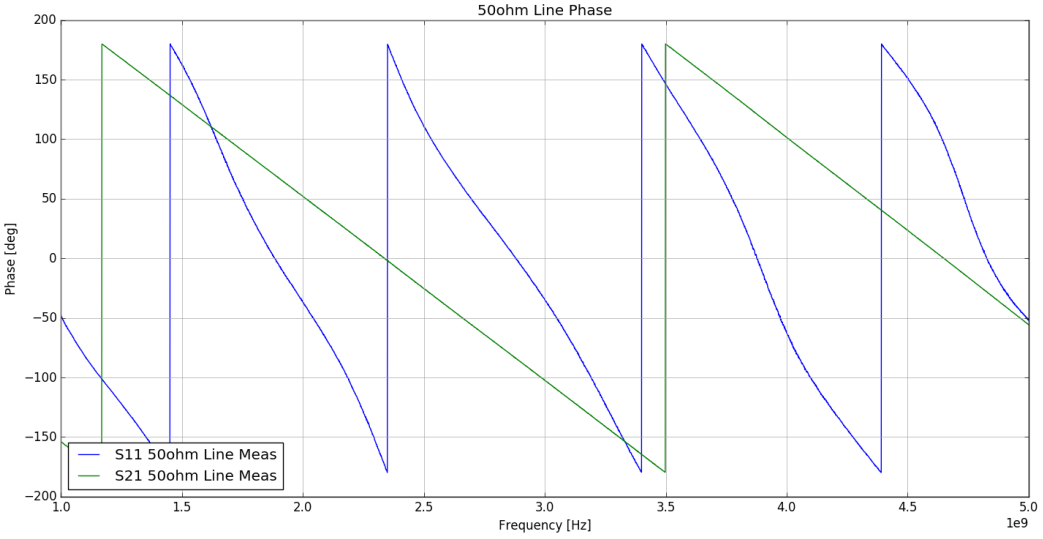
- 50 ohm lines were 3.11 mm wide

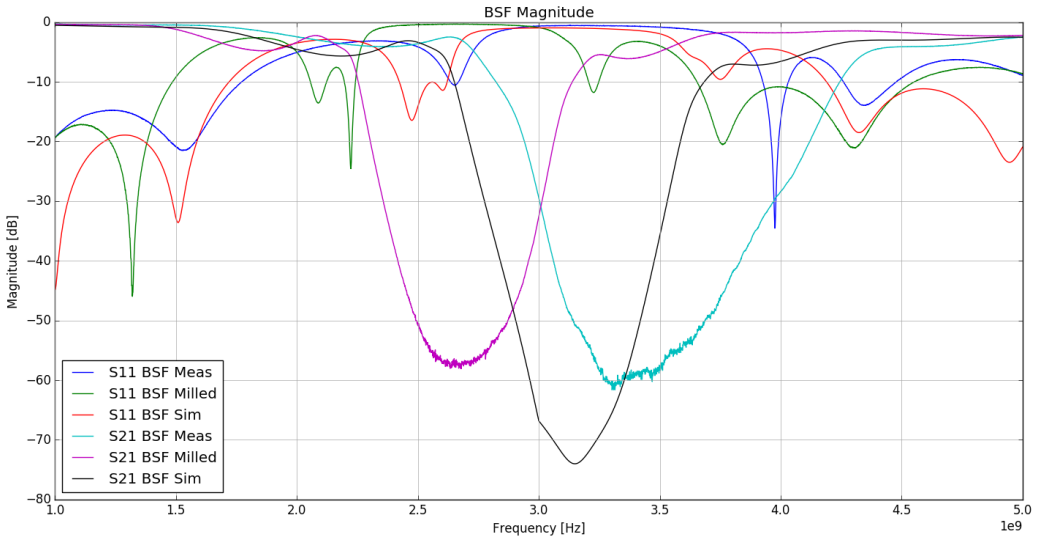
- 75 ohm lines were 1.478 mm wide
- 104 ohm lines were 0.667 mm wide
- Each stub was 14.75 mm long
- The space between each stub was a quarter wavelength or about 16.88 mm

Once the stubs were glued and soldered into place, David measured the cutoff frequency using the network analyzer.

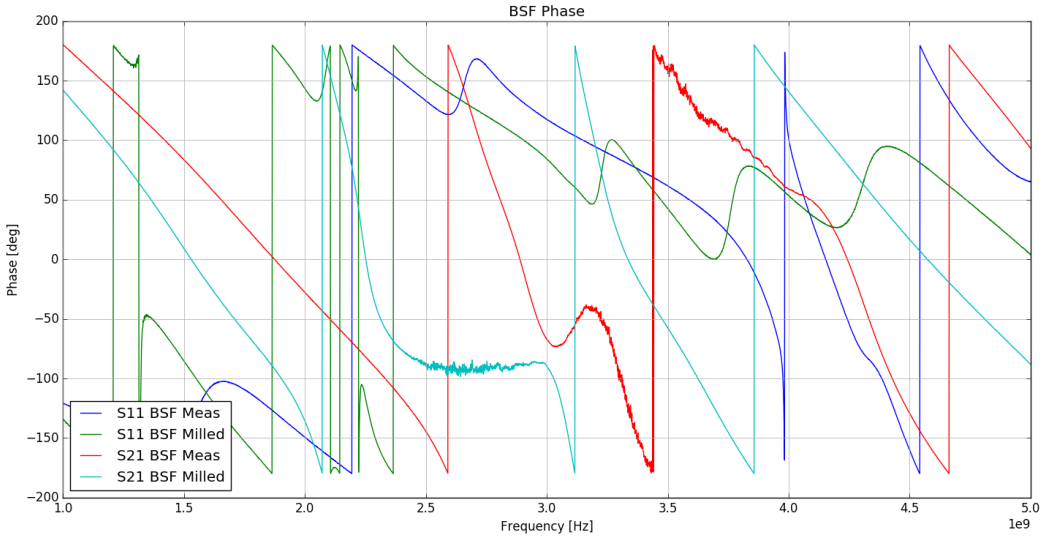
Results and Discussion

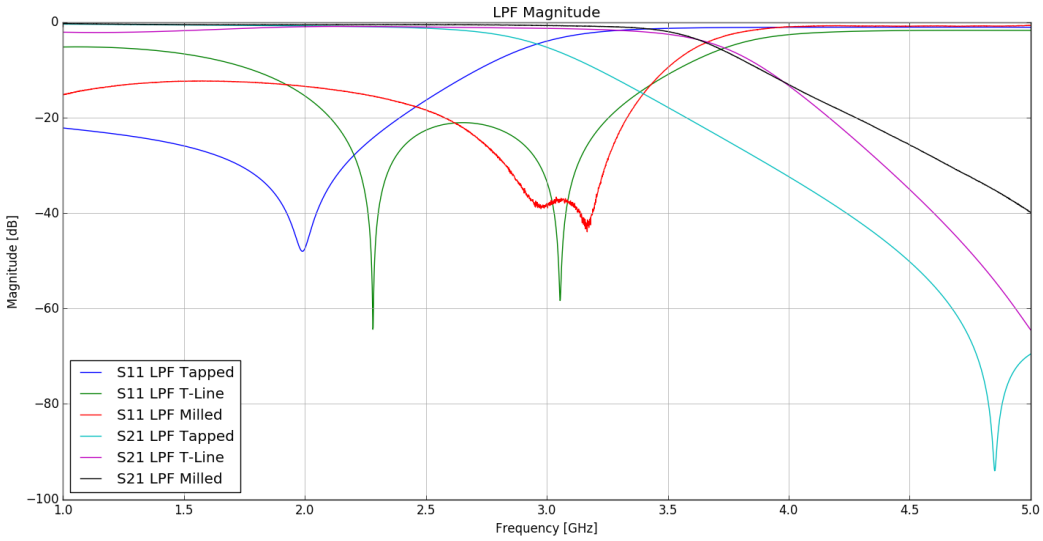




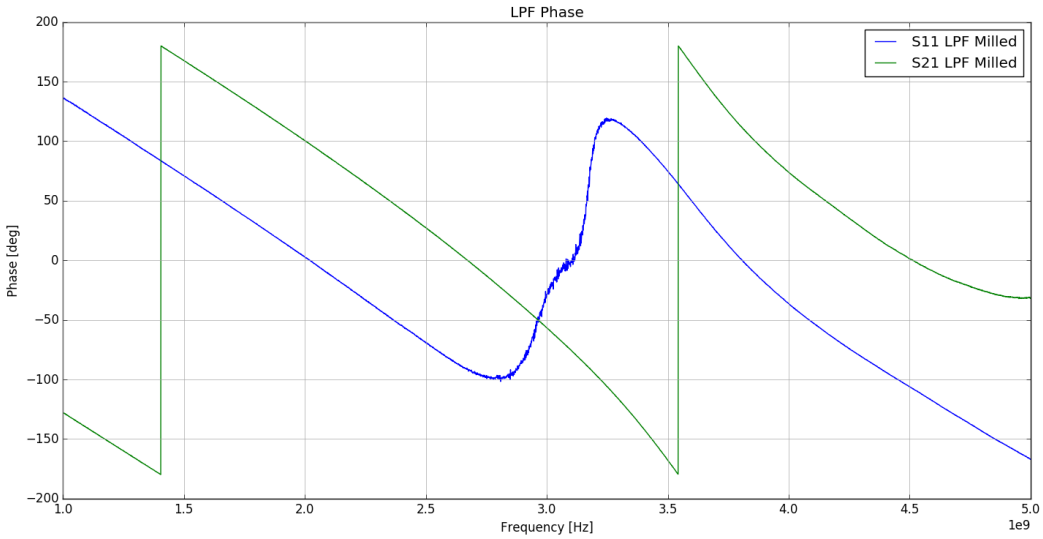


We can see the differences between the BSF plots in the above magnitude plot, specifically in the S21 plots. The milled BSF has the band stop centered around roughly 2.7 GHz, whereas our simulation is centered around 3.2 GHz. If we were to lengthen our lines somewhat, we might be able to tune our BSF's center frequency closer to the milled filter.





By examining the S21 plots of the different filters, we can see that the T-Line LPF performs very similar to the milled LPF, whereas the tapped stub LPF's cut off frequency is a bit lower than the milled LPF.



Conclusion

The main point of this lab was to teach us about designing different types of filters. We got hands on experience in building one (albeit out of copper tape, which ended up being a somewhat error prone method of constructing a t-line filter) and experience in designing and simulating three. This activity helped cement the concepts learned in class.

Hindsight

The first time we laid down the copper tape on the substrate, we didn't think to make sure the lines were are as close to perpendicular to the feed line as possible. This caused us to have to remove and carefully reapply the copper tape in order to make the filter perform better. This and difficulty using the hot air gun slowed down the construction process.

Reflection

The most challenging portion of the lab was attempting to cut out the lines perfectly with an accuracy of 10ths or hundredths of a mm. The most rewarding portion of the lab was that it helped me understand the in class material better and also helped me understand how different components of the filter affect the performance of the filter.