Testing the Available Filters in the Lab

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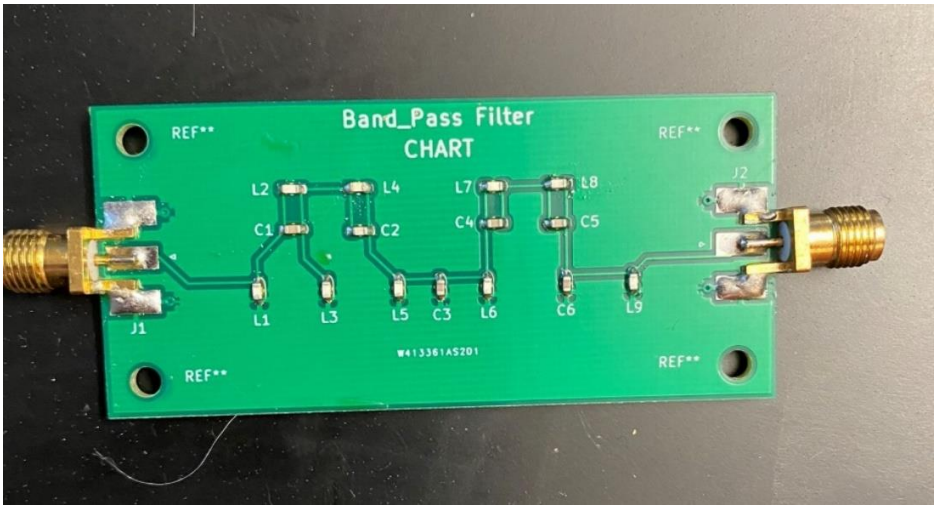
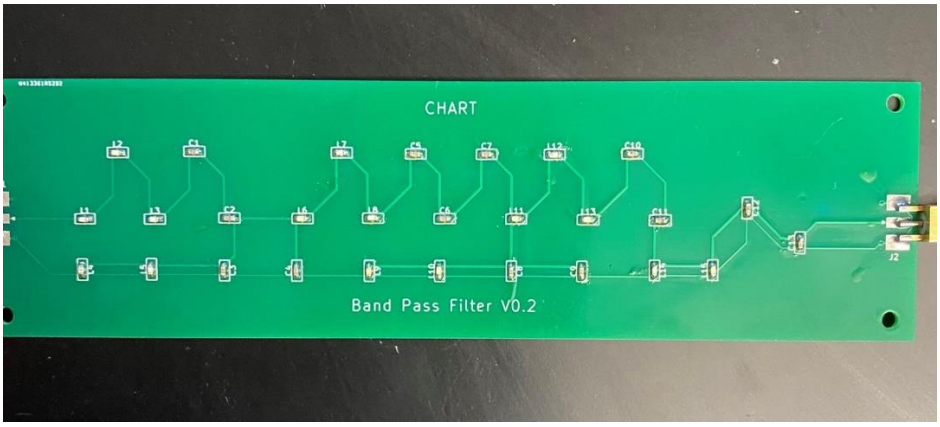
Materials Needed

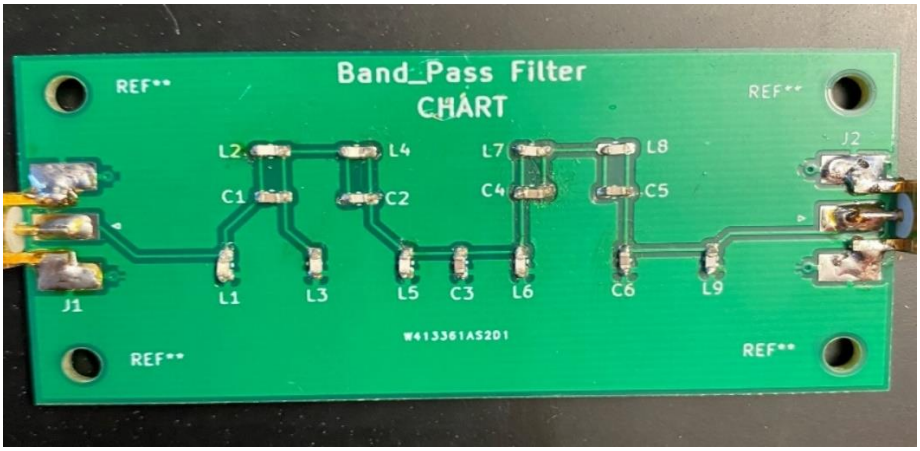
- Copper Mountain Technologies VNA and cables
- Laptop
- Torque wrenches (One TW-N and one TW-S)
- 7 filters labelled 2, 2b, 4, 0, blue, mini, atten
    - Filter 2 (bpf_2): One of the filters from version 1 of what Nahum built



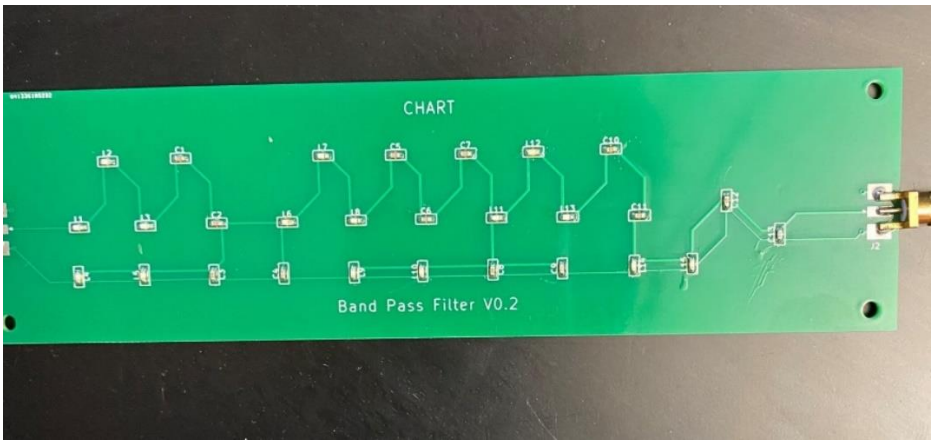
    - Filter 2b (bpf_2b): One of the filters from version 2 of what Nahum built



- Filter 4 (bpf_4): One of the filters from version 1 of what Nahum built



- Filter 0 (bpf_0): One of the filters from version 2 of what Nahum built

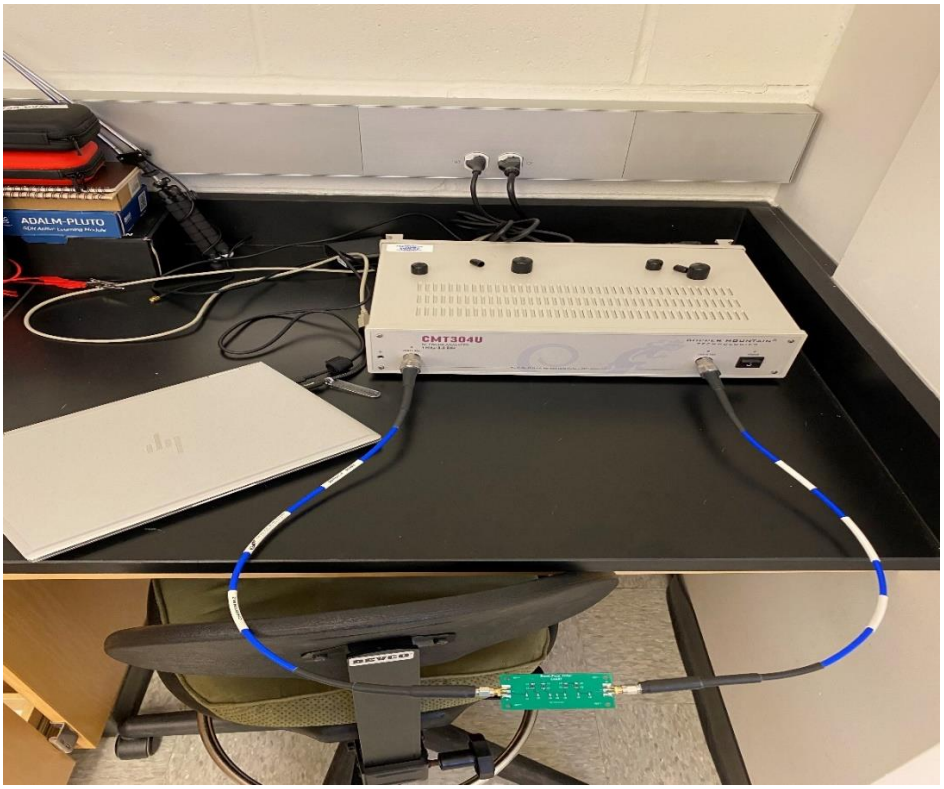


- Blue Filter (bpf_blue): Filter that was provided with the VNA University Kit
- https://coppermountaintech.com/university-kit/

- Mini Filter (bpf_mini):
- https://www.minicircuits.com/pdfs/VBFZ-1400-S+.pdf

- Nooelec Filter (atten):
- https://www.nooelec.com/store/sawbird-h1-barebones.html

Setup



- I made sure to attach the cables in the same way each time with the lower serial number in Port 1 and the higher number in Port 2
- Because the filters hung off the bench a little, I waited to take the data until it was still/stopped moving so the data stayed constant
- To calibrate the VNA, I used the SMA 2.1 calibration kit that came with the system. First, I connected Port 1 to the Open and Short ends of the kit and then did the same for Port 2. Then, I connected both ports to the Thru ends of the kit at the same time. After the initial calibration, I was able to save the file so I could recall it for future tests.

Tests to be Performed

I connected each filter to the VNA and ran all four traces (S11, S21, S12, S22)

The frequency range for all data taken was between 1 MHz and 3.2 GHz

Each result was exported to Microsoft Excel, where I created graphs for each trace

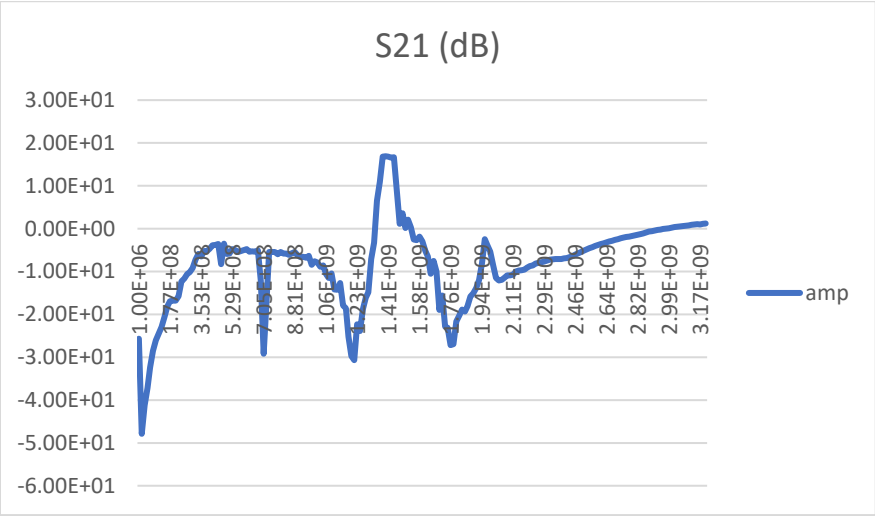
Observations

Data were collected June 2, 2022.

The filters that were not professionally made do not give the desired results. There are too many peaks in the data for any of them to be truly effective

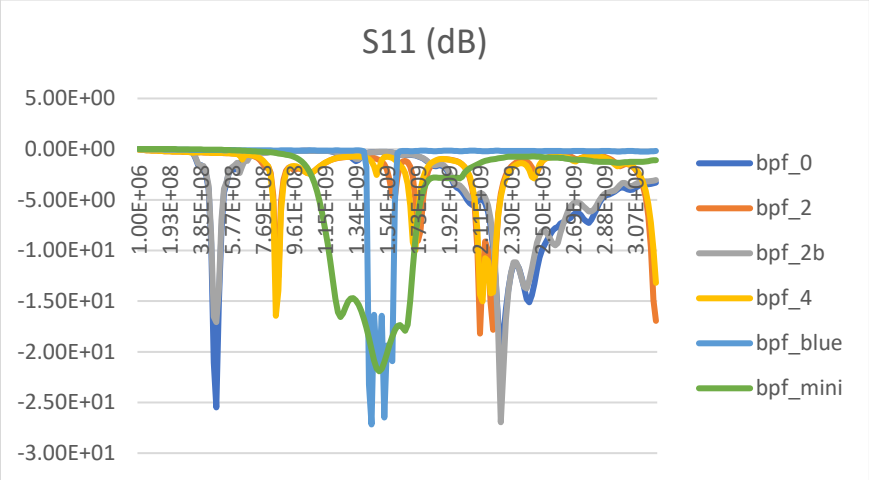
When exporting the data, I saved it in the form of dB/angle

Because the nooelec filter (atten) is also an amplifier, the initial data was observed to be saturated (as shown on the graph below). To combat this, we added 40 dB of attenuation before the filter. From this point on, the data collected from the nooelec filter was taken with the addition of attenuators.

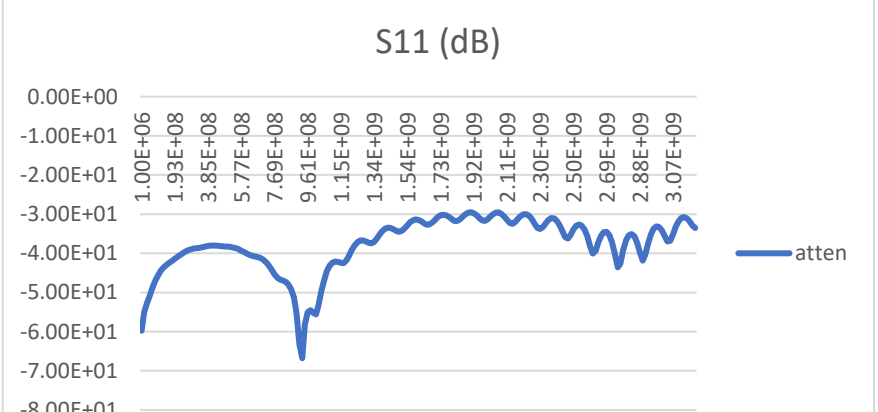


Results

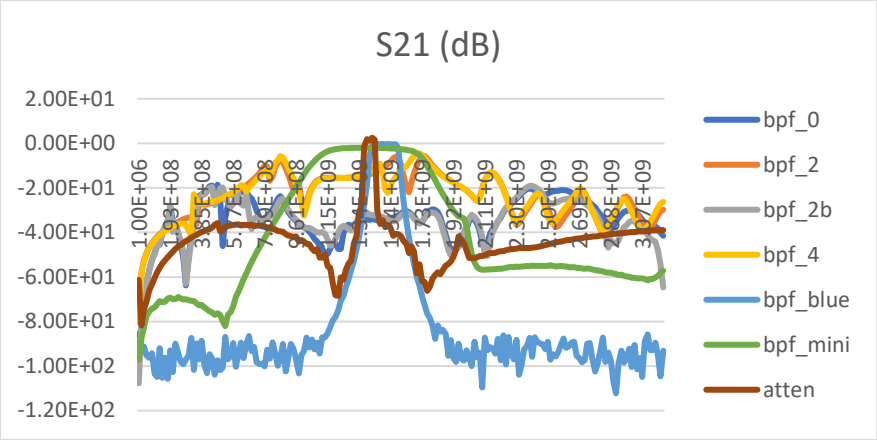
S11 is the signal going from Port 1 of the VNA, to the filter, and back to Port 1.



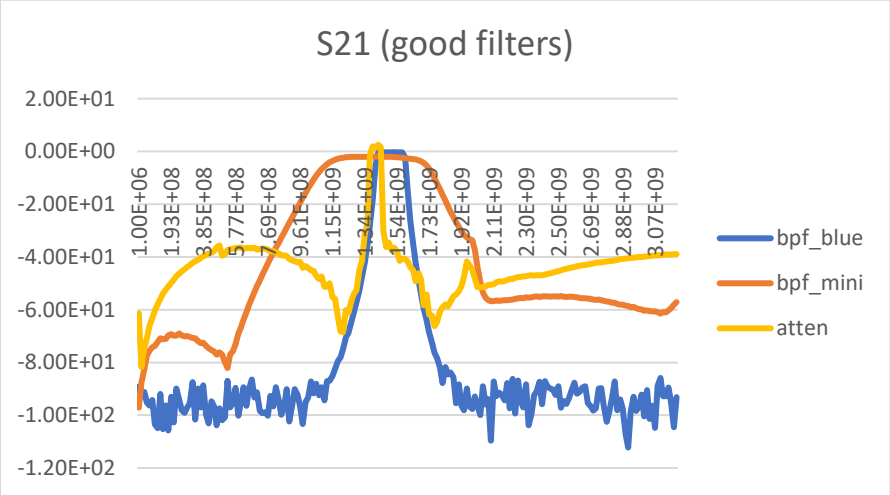
Note: I put the atten filter in its own graph for S11 because the y-axis made the lines for the other filters too small to see properly



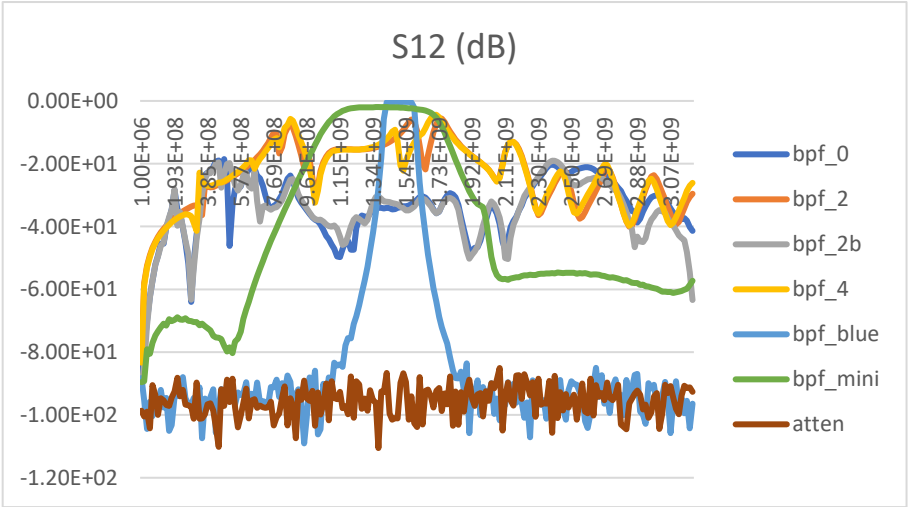
S21 is the signal going from Port 1 of the VNA, through the filter, and into Port 2.



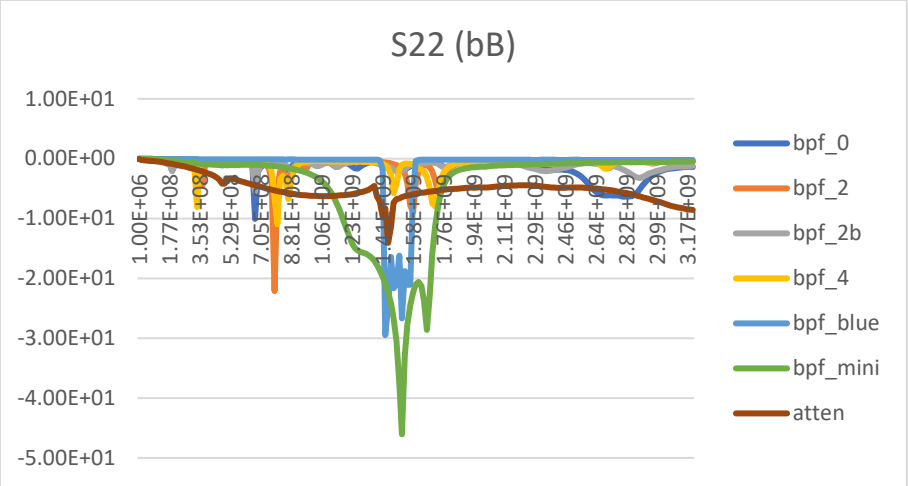
This is the S21 graph for the filters that worked the best to give a better view of what the data is supposed to look like.



S12 is the signal going from Port 2 of the VNA, through the filter, and into Port 1.



S22 is the signal going from Port 2 of the VNA, to the filter, and back to Port 2.



Conclusion

The nooelec filter that required power and attenuation is the best option for taking CHART data. It's the cheapest option that outputs acceptable data. The only other viable option would be the mini circuits filter because the blue filter that comes with the VNA kit is too expensive for this project. The side lobes of the mini circuits filter are lower at -97.1 dB and -82.1 dB compared to the nooelec's side lobes of -81.7 dB and -68.5 dB. This would be more desirable because more unnecessary information is filtered out when taking data. However, the bandwidth of the nooelec filter is the narrowest with its 3 dB bandwidth at 80 MHz and its 10 dB bandwidth at 96 MHz, while the mini circuits filter's 3 dB bandwidth is 608 MHz, and its 10 dB bandwidth is 752 MHz. This narrow bandwidth (and built-in amplifiers) is what gives the nooelec filter the edge as the most preferred option for CHART field tests.

Future Work

I am still learning how to use python, which is why the graphs were constructed in Microsoft Excel.