ECE534

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Final Project

LPF Design

The purpose of the final project was to design a second order LPF using an RC Pi model. In designing sucha model, the objective of the project was to pass signals below 100MHz and reject higher frequency components, ideally with a 40dB/dec drop. Additionally, both a circuit model and 3D model were developed to observe the behavior of the LPF circuit. The ideal LPF circuit design can be found in Fig 1 where a 10 Ohm resistor was used in conjunction with two 22pF capacitors to form a Pi filter circuit. However, in order to meet the desired pass band specification, the ideal circuit was modified as per Fig 4.

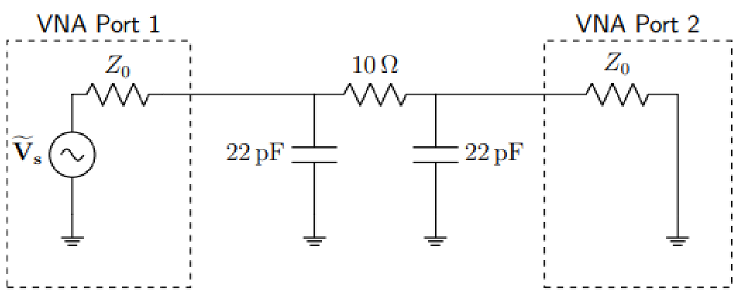

FIGURE 1. Ideal π-filter circuit with VNA ports connected

The circuit was built on a double sided 25mmx25mm copper board sandwiched between a 1.5cm FR408 dielectric. The bottom copper plane acted as a reference gnd whereas the top plane allowed for signal traces to be routed. Upon first milling, the signal traces were etched into the copper to span 24mm with a 1mm gap in the center for the resistor with a trace width of 2.8mm to produce an impedance of 50 ohms. The trace width was selected through a digikey calculator that determined the equivalent width that yieled a 50 ohm resistance. Two 22pF capacitors were placed on either side of the 10 ohm resistor, followed by a 50 ohm transmission line spanning 22.6mm to GND. The transmission line was connected to the gnd plane via soldering a barge wire directly from the signal trace to the bottom copper. Additionally, the copper pour outside the traces was not peeled off and therfore led to the results yielding parasitic effects. The results of the first mill can be found in Fig 2.

In order to improve the performance of the board the 22.6mm length of 50 ohm transmission line at the capacitors was shortened to 3.62mm and 4.68mm manually. Ideally both trace should be milled to be the same length in the future but as this was a modification to the existing board the precision of the cuts were limited. Furthermore, the floating copper was stripped to clean up the signal further, yielding the results in Fig 3. According to the plot, the filter is able to pass up to a

100MHz, indicated by the -3.17dB drop at this frequency. However, the filter only seems to drop down to 40dB per half a decade. In comparison to the model, this 40dB per decade drop should be met, however because the copper pour was manually stripped rather than drilled off, this may have effected the results potentially.

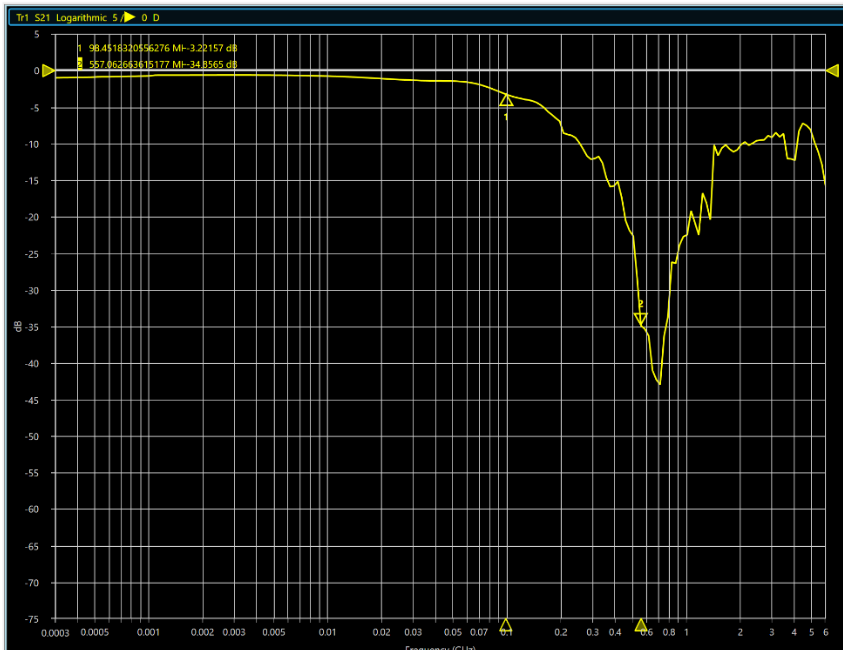

Fig 2. First mill VNA output for LPF

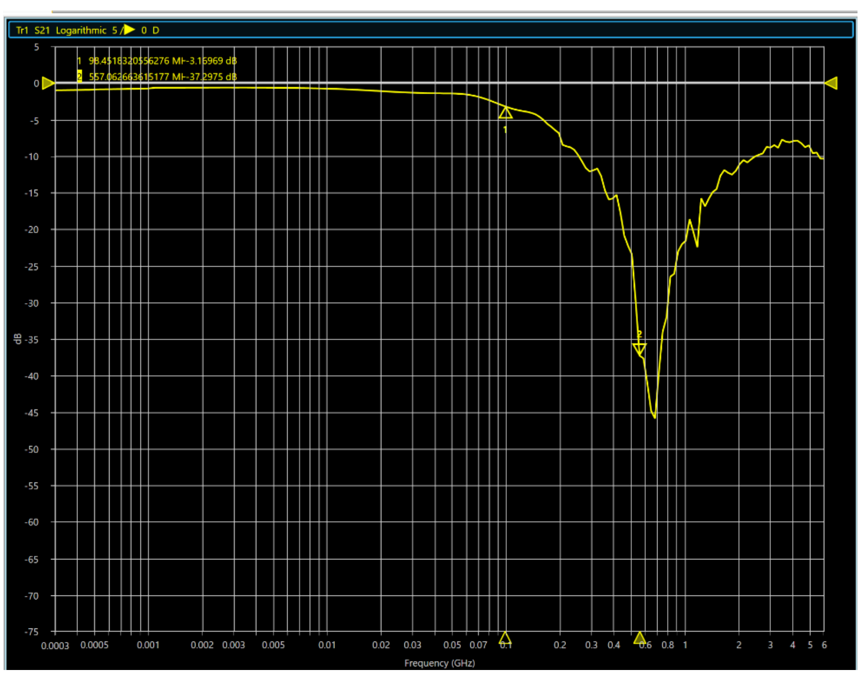

Fig 3. Second mill VNA output for LPF

Fig 4. Constructed LPF Design

In order to model the project, the circuit built was first constructed as per Fig 5. When simulated, the results can be found in Fig 6, where at 100MHz the signal drops to -3dB, and further demonstrates a 40dB/dec drop between 100MHz and 1GHz.

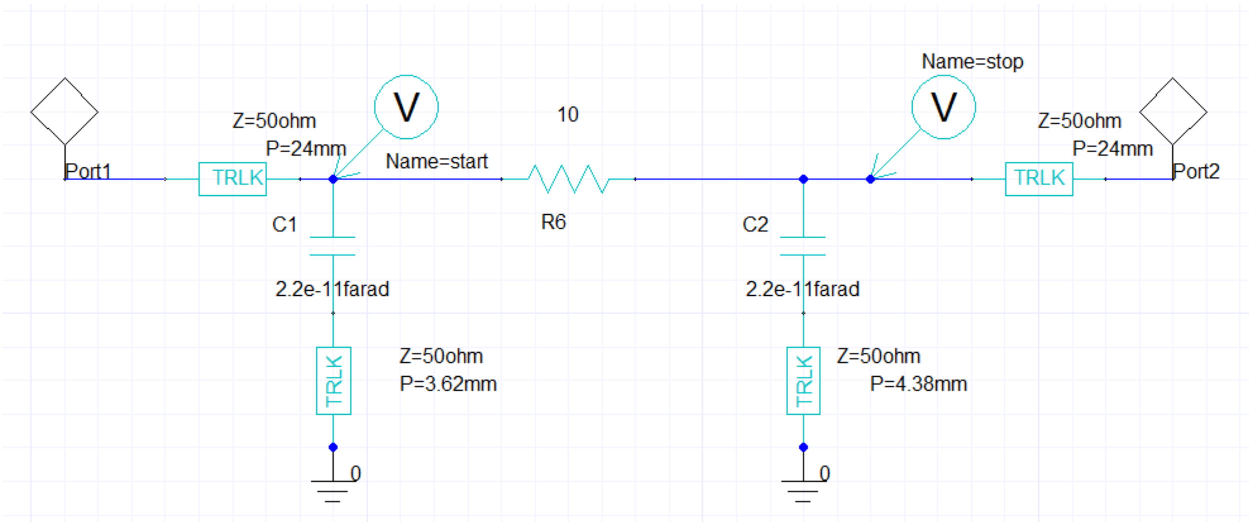

Fig 5. LPF circuit model

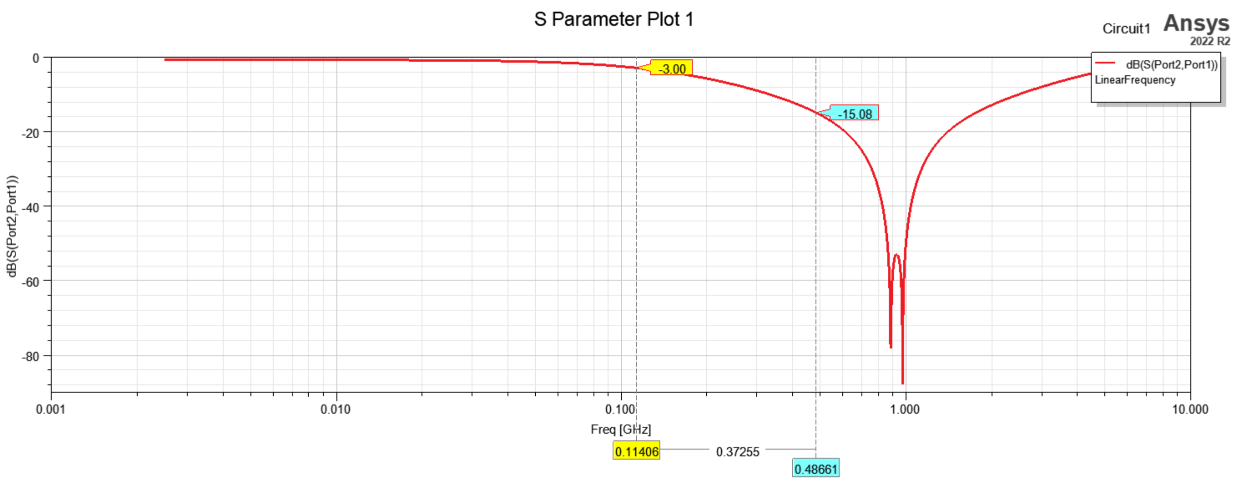

Fig 6. LPF S param output

Moreover, a 3D model was created for the LPF as found in Fig 7, where all components were modeled as RLC boundary conditions. Additionally the barge wires were modeled as thin copper strips connecting vertically to the bottom copper plane. The results of the simulation can be found in Fig 8, where at 116.4MHz the signal drops to -3dB, and further demonstrates a 40dB per 0.6 decade drop between 100MHz and 1GHz. The simulation results therefore capture a more realistic version of the decade drop as compared to the VNA output results in Fig 3.

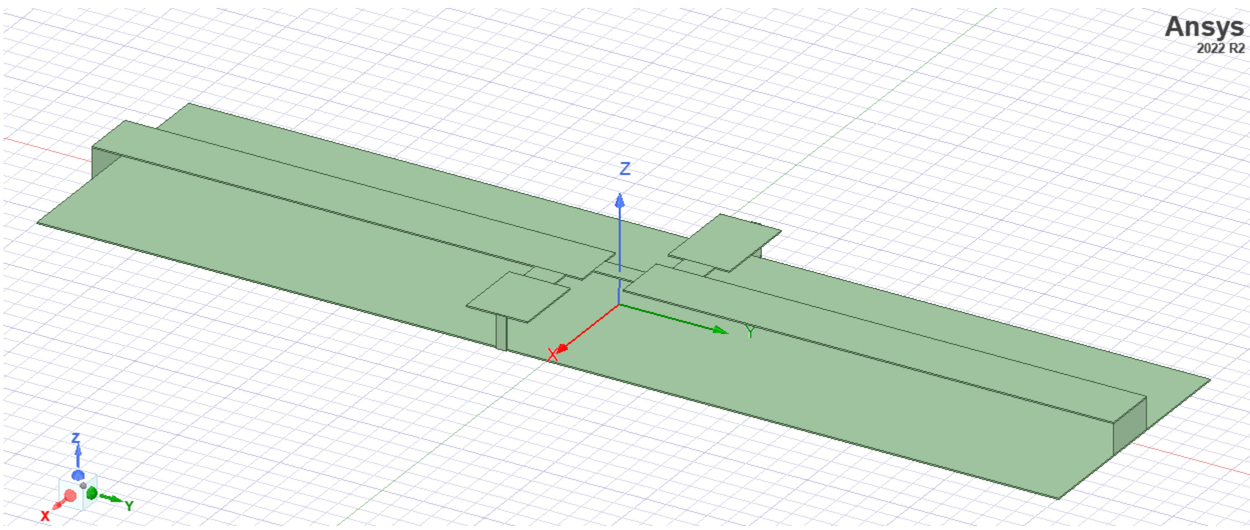

Fig 7. 3D LPF model

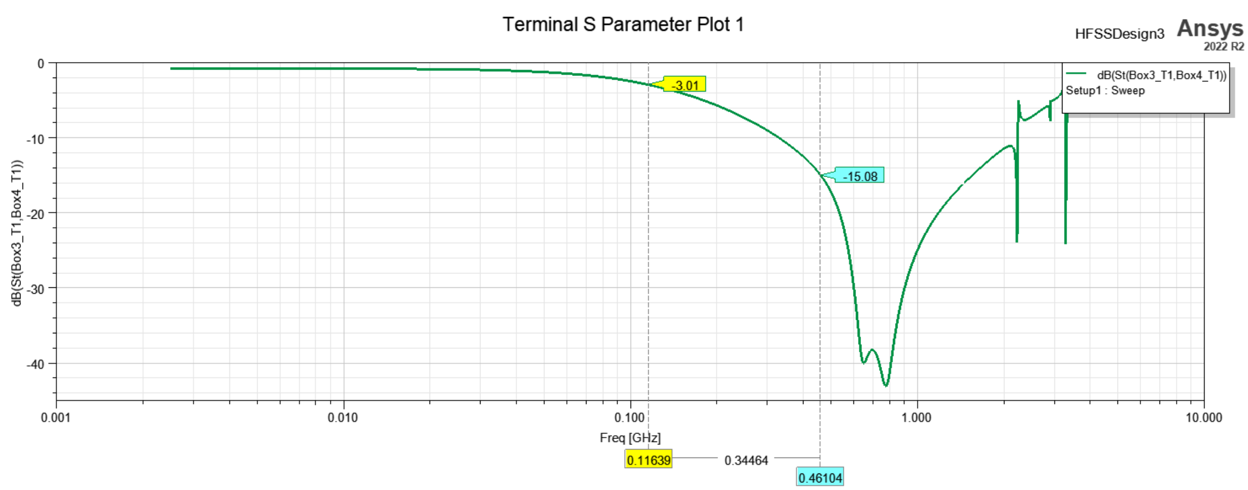

Fig 8. 3D LPF S param output