MCC121 - Lab 1 - Part A

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1 Part 1

The purpose of this laboratory is analysis of a rectangular waveguide using ANSYS HFSS software and interpreting the results. The dimensions of the waveguide are a=40mm and b=10mm, with an assumed length of c=100mm. The frequencies of interest are 4-9GHz. First I'll analytically calculate the cutoff frequencies for this particular waveguide. The formula is given in the lab manual and as well in Pozar's book:

$$f_{m,n} = \frac{c}{2\sqrt{\mu_r * \epsilon_r}} \sqrt{(\frac{m}{a})^2 + (\frac{n}{b})^2}$$

Trying out all the modes with integer values m=1,2,... and n=1,2,... for our particular waveguide we get: $f_{1,0} = 3.74GHz$ and $f_{2,0} = 7.5GHz$, as the only possible modes ($f_{0,1} = 15GHz$). Following is the list of my variables and a graph of the S_{21} parameters annotated with markers. Since past the marker the wave is attenuated by 0db, in other words not attenuated at all, and therefore propagation occurs and as such we must be above the cutoff frequency.

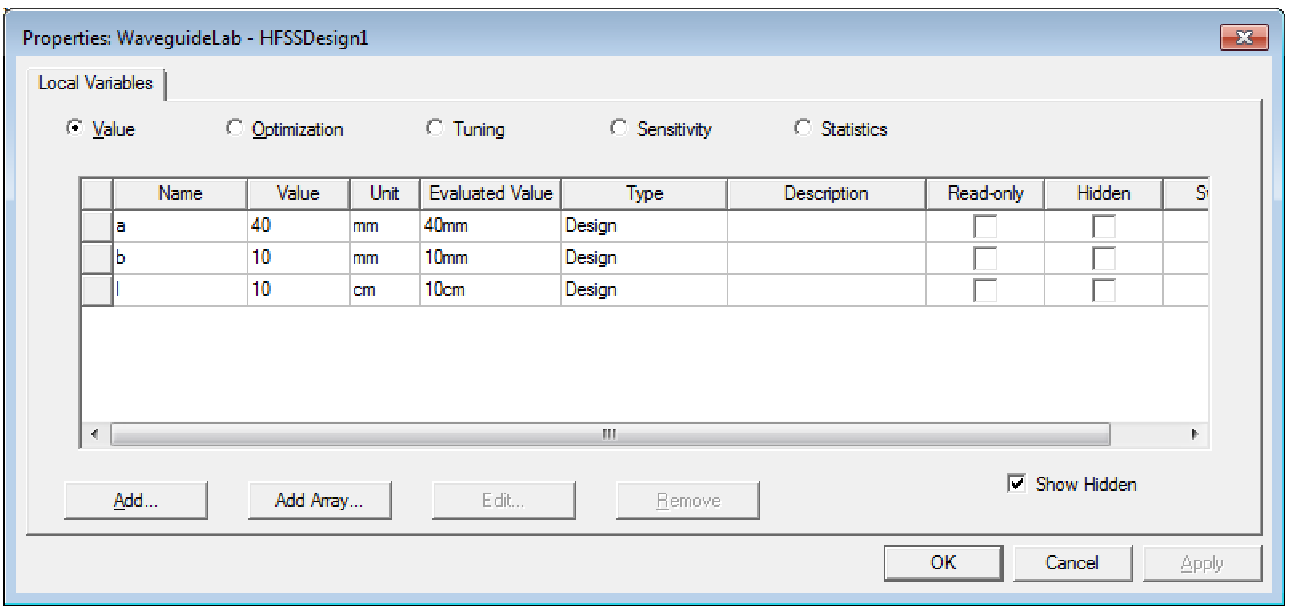


Figure 1: Variables used in part A

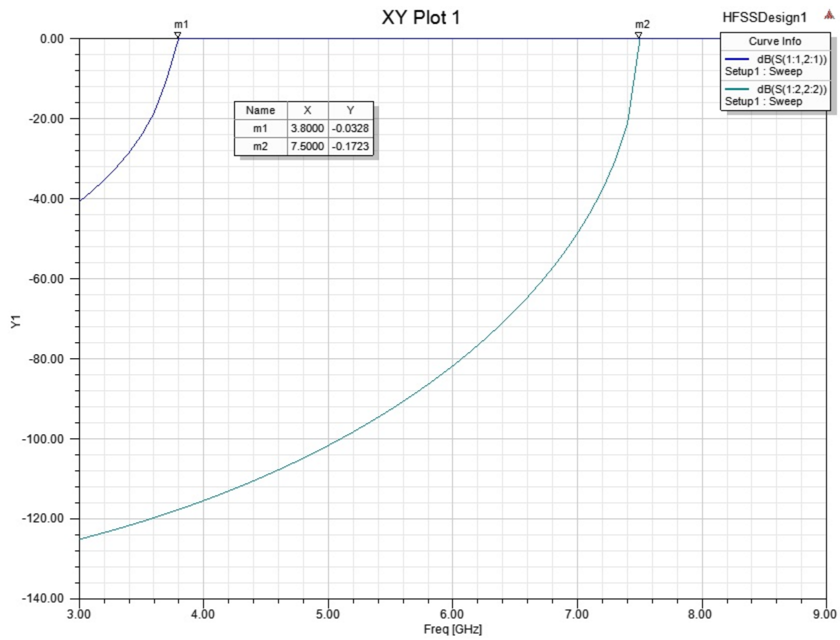


Figure 2: Cutoff Markers on S-parapmeters

Now since I know how the waveguide will behave I'll pick frequencies that are appropriate to show that, namely: 1) 3GHz : no propagation of any mode, 2) 4GHz: propagation of TE10 mode 3) 8GHz: propagation of TE10 and TE20 modes. I've also attached a graph of both modes, simultaneously excited, please see below.

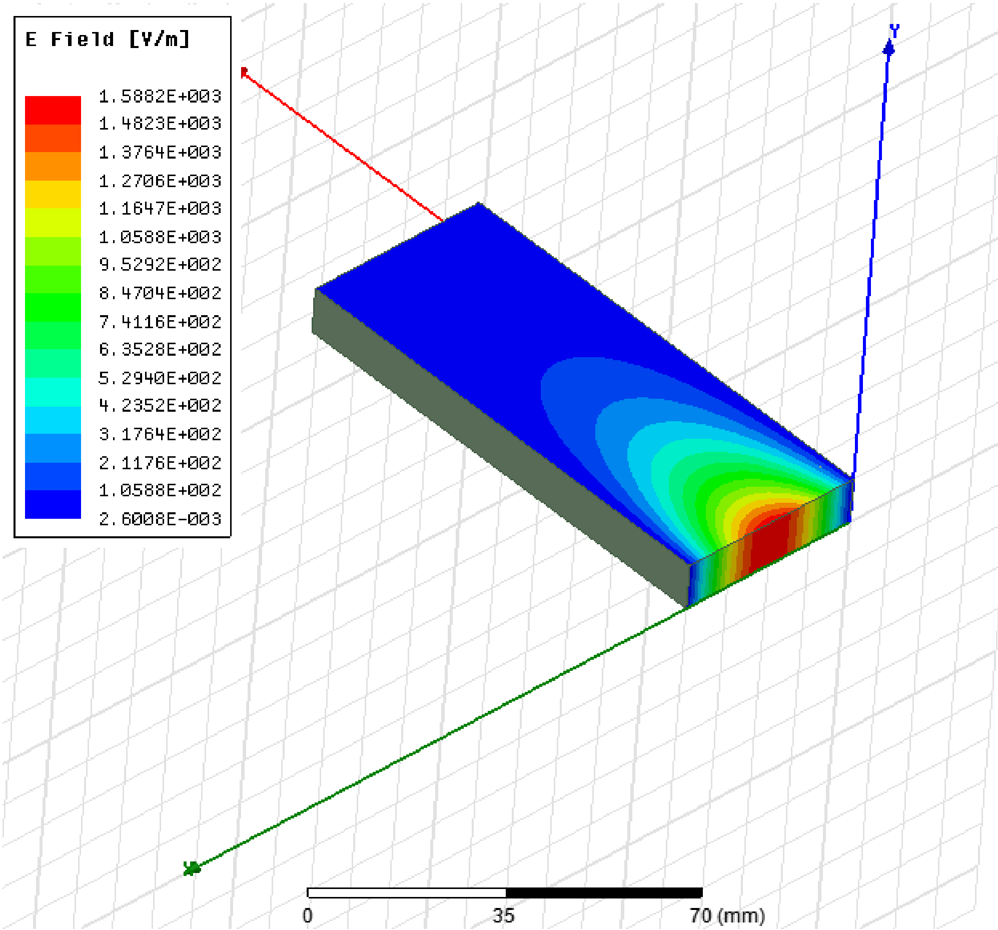


Figure 3: 3GHz. No propagation is seen in any mode, even the lowest, TE10.

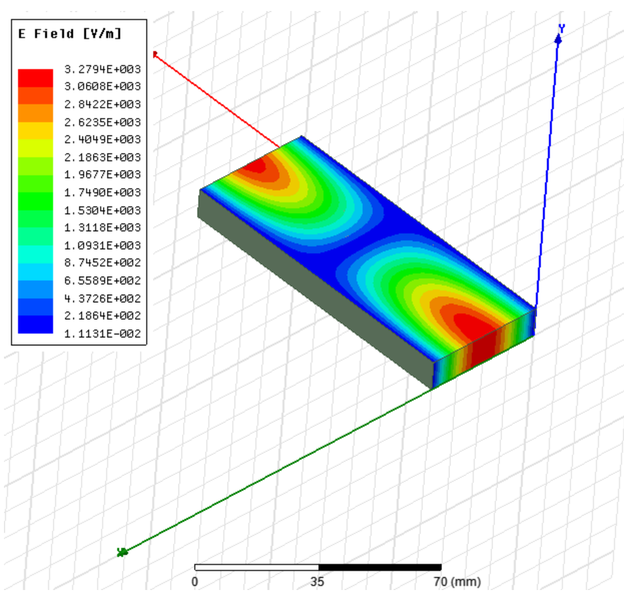


Figure 4: 4GHz. Propagation is now seen in the TE10 mode.

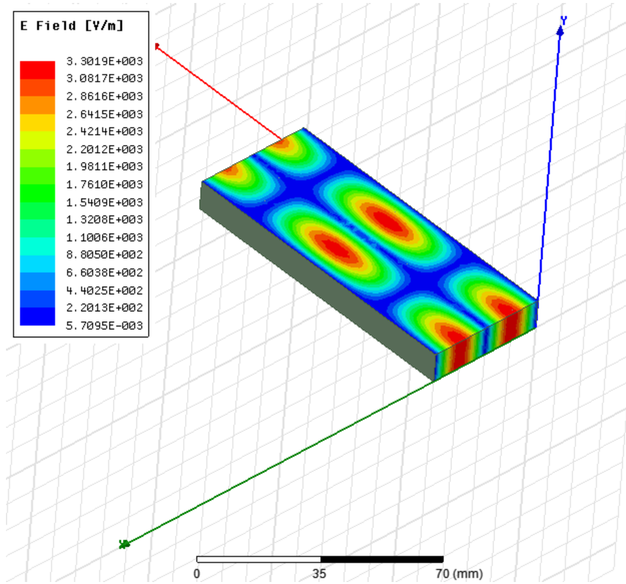


Figure 5: 8GHz. Excitation in the TE20 mode now leads to propagation.

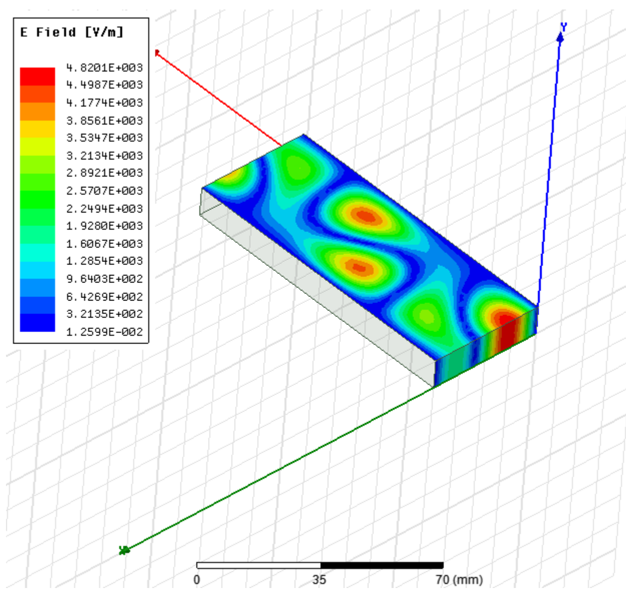


Figure 6: 8GHz. Excitation in both TE10 and TE20 simultaneously propagating.

2 Part 2

The second part of this lab entails the design of a 3 sectioned waveguide with the outside sections larger in width than the middle section. Simulation is again carried over a frequency range from 4-9GHz. See the drawn object below. The length of each section is set to 50mm for the first part of this exercise.

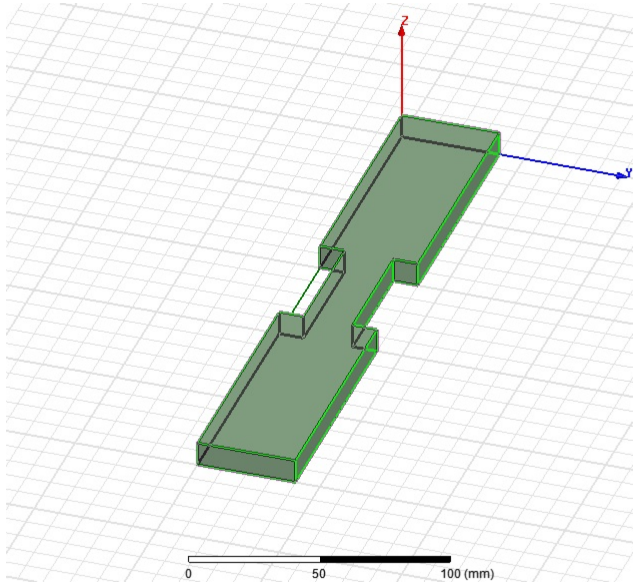
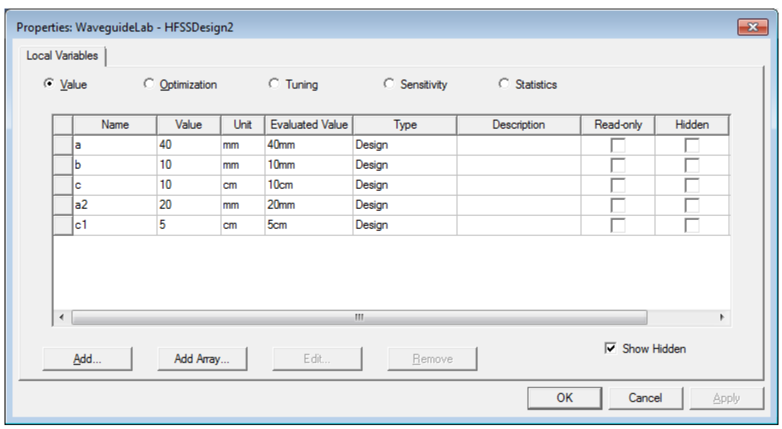


Figure 7: The particular waveguide shape used in the simulation.


Properties: WaveguideLab - HFSSDesign2

Local Variables

Value Optimization Tuning Sensitivity Statistics

Name	Value	Unit	Evaluated Value	Type	Description	Read-only	Hidden
a	40	mm	40mm	Design			
b	10	mm	10mm	Design			
c	10	cm	10cm	Design			
a2	20	mm	20mm	Design			
c1	5	cm	5cm	Design			

Add... Add Array... Edit... Remove Show Hidden

OK Cancel Apply

Figure 8: Variables used in this section.

The width, a2 in my case, was varied over discrete length points of 10,15,20,30 millimetres and the S-parameters are plotted below. The trend is that the wave requires higher frequency in order to propagate through the bottleneck.

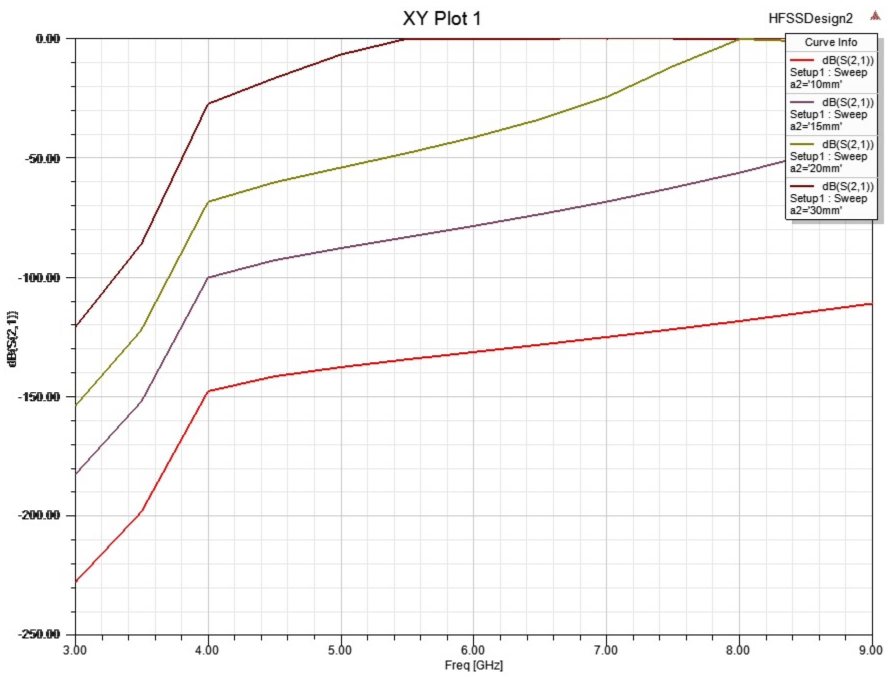


Figure 9: Part B S-parametres.

The frequency point of choice is 8GHz. There I can see the sushi roll shaped waves beginning to propagate around the $a_2 = 20mm$ mark.

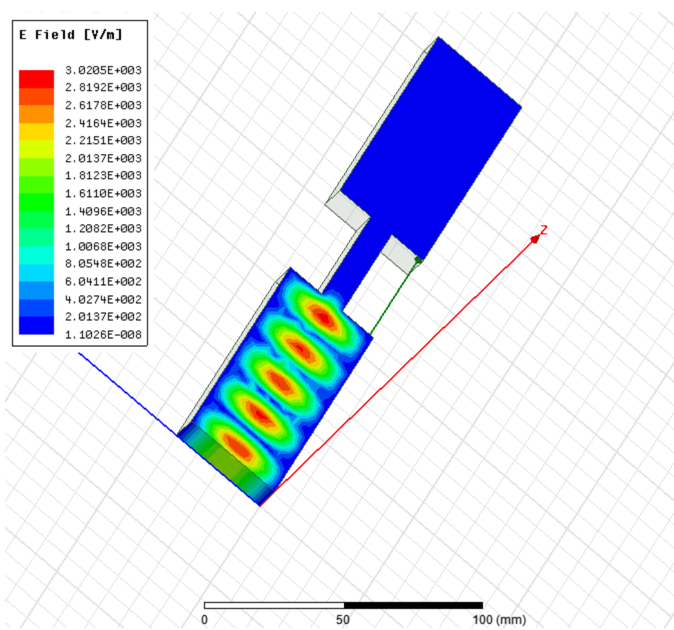


Figure 10: Midsection width of 10mm.

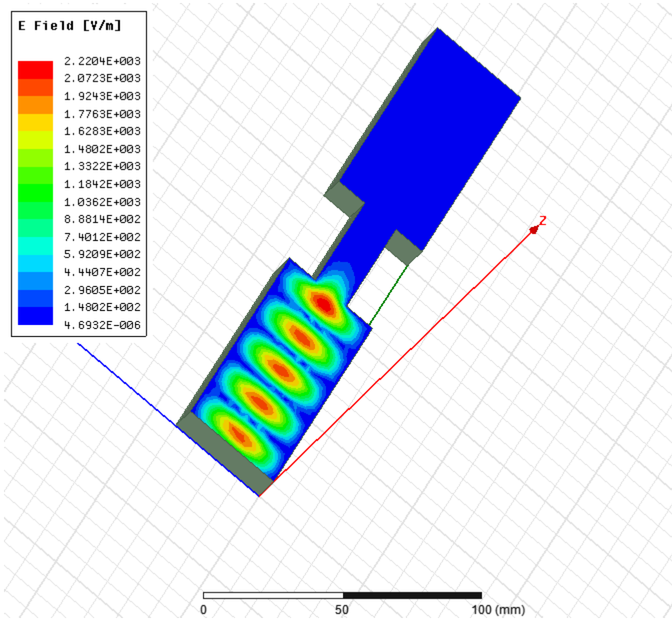


Figure 11: Midsection width of 15mm.

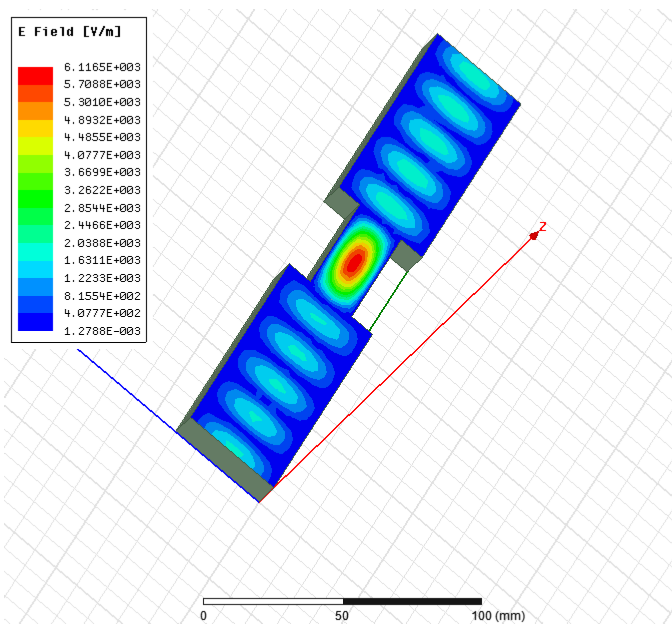


Figure 12: Midsection width of 20mm.

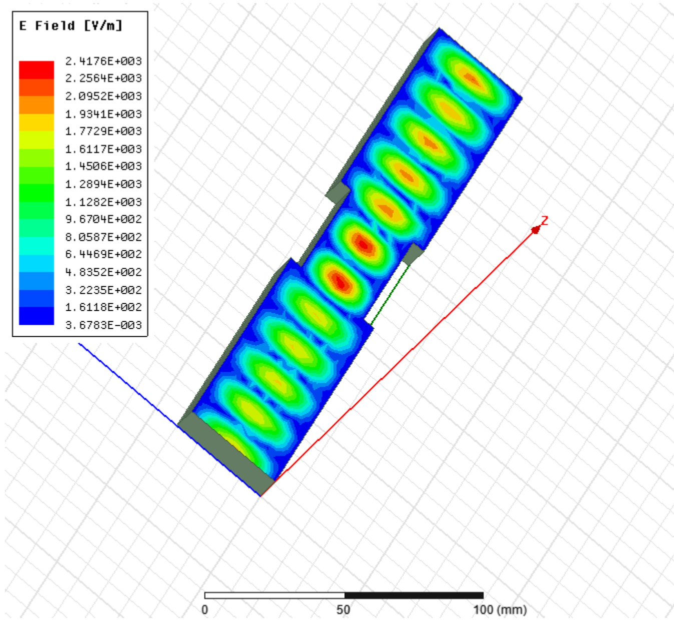


Figure 13: Midsection width of 30mm.

From the above images I can see the wave begins to propagate at 20mm. Below that the midsection is too small, effectively increasing the overall cutoff frequency above 8Ghz and not allowing the incoming wave to propagate. At 30mm we can see the wave propagating freely, by the line of sushi rolls in Figure 13.

We plot the s-parameters for the variable length of the midsection. Length = 20,15,10,5 mm. Note the graph also includes two lines of a=10,c=5 and a=15,c=5. We can see that for a single frequency, say 6 GHz the wave is attenuated proportionally to the inverse of length, so the longer it is the larger the attenuation. What's interesting to note is that the cutoff frequency remains the same, around 8Ghz.

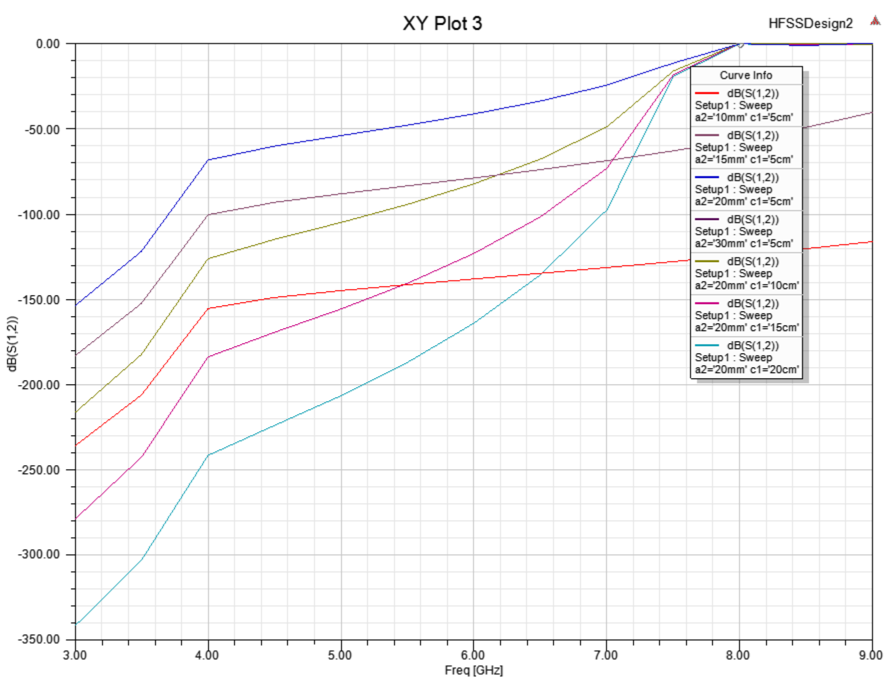


Figure 14: Sparameters of elongating the midsection.

Finally I present the results from the propagation plots.

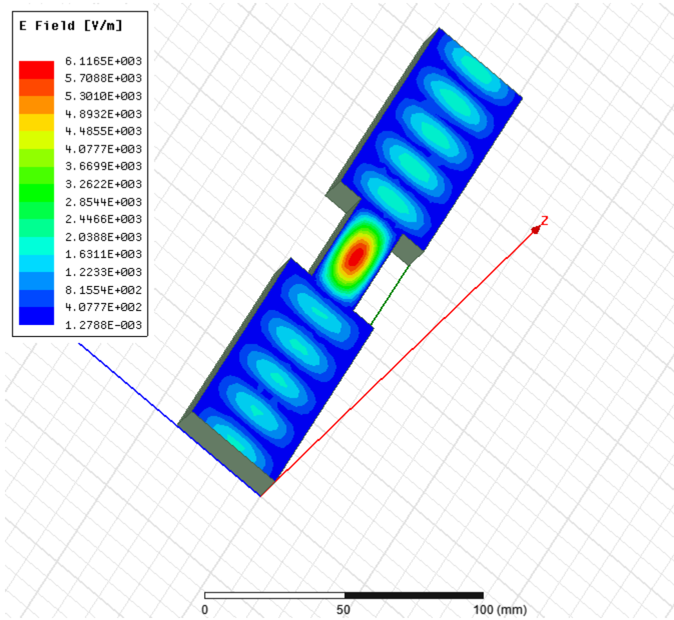


Figure 15: Midsection length of 5mm.

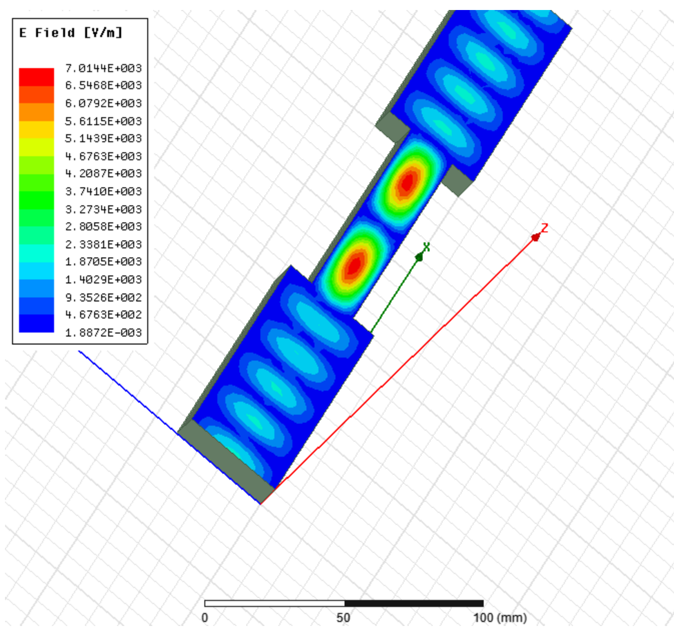


Figure 16: MMidsection length of 10mm.

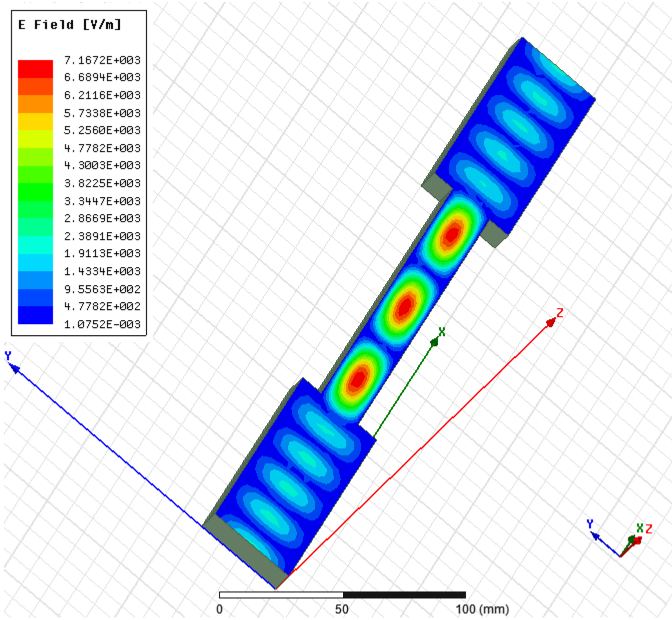


Figure 17: Midsection length of 15mm.

From this laboratory I believe that this type of element can be used as a high pass filter, because the length or width of the midsection element allows controls the effective cutoff frequency and/or attenuation at the output of the waveguide. The control of the attenuation of the propagated wave at certain frequency bands, is indicative of a filter.