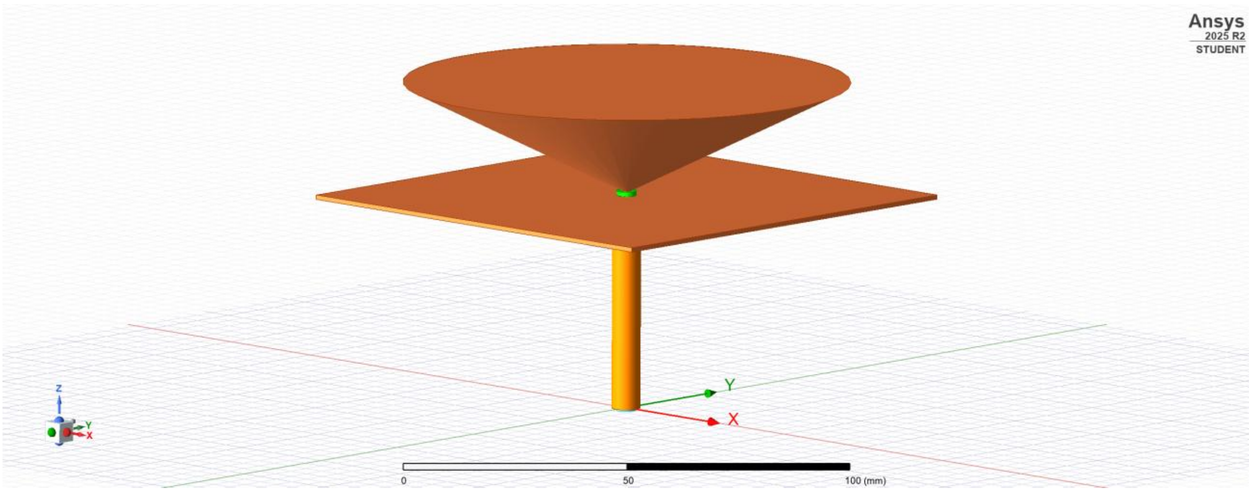
ECE-5344-D01 Final Exam Pt. 1

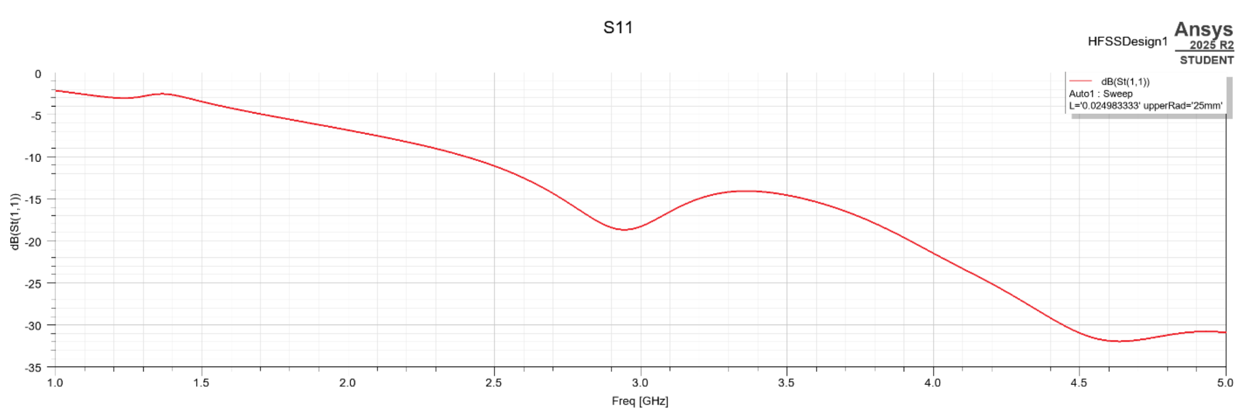
Jason Bissias

The design of the default spec monocone antenna is as shown in the figure below, with the cone's base radius of 25 mm (about $L = \lambda/4$) compared to the tip radius of 1 mm to achieve the 90° angle specified. The orange is copper and the green is air as dielectric. Included in the design is also a PEC backing for the port at the base of the coaxial wire.

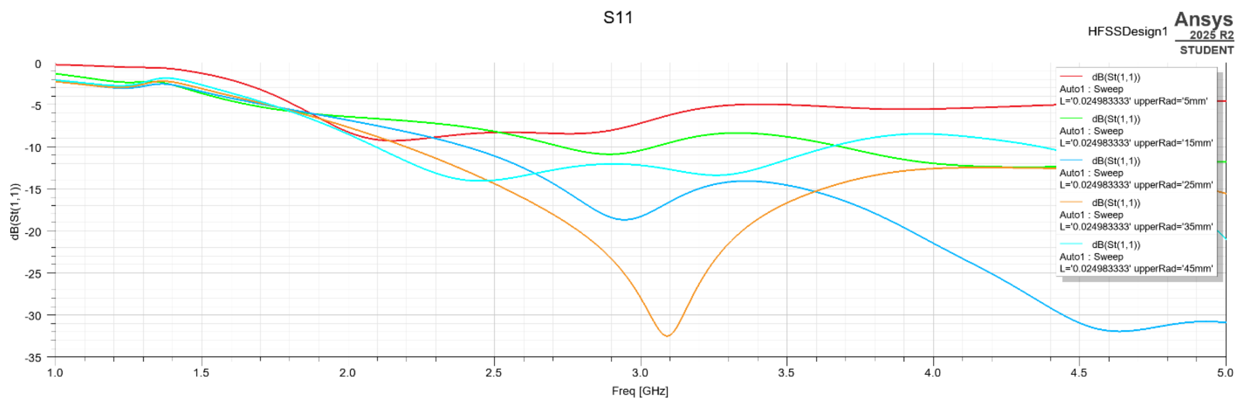


a. S11 Plot

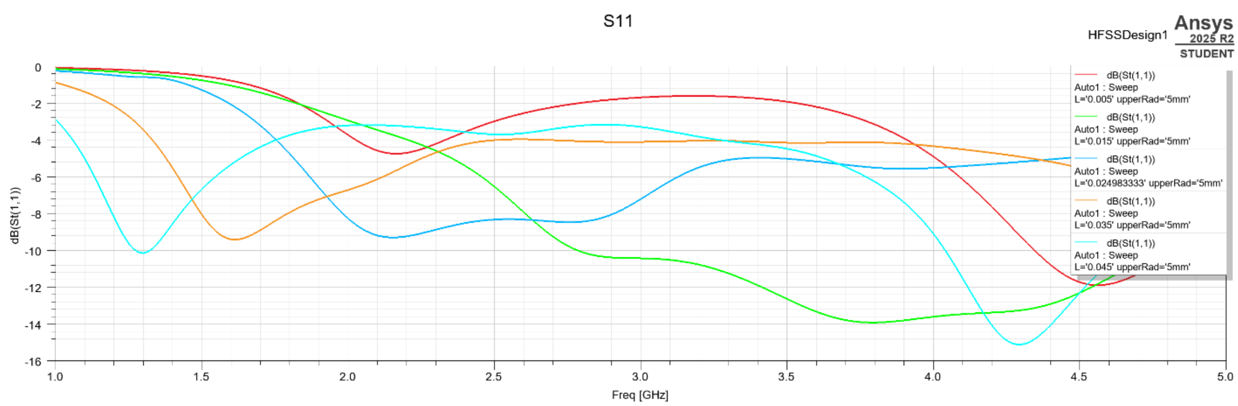
The S11 plot of the antenna by default looks like this (note that "upperRad" refers to the cone's base radius, the "upper" designation being consistent with the coordinate system):



It quickly drops out of the -10 dB minimum gain for the spec. To find a specification of the antenna that works, first I looked at the variations in the base radius (thus affecting the angle of the cone):



Bringing the radius down to 5 mm, therefore an angle of about 35° at L = λ/4, produces the best characteristics so far. Then I looked at the variations in the cone length:

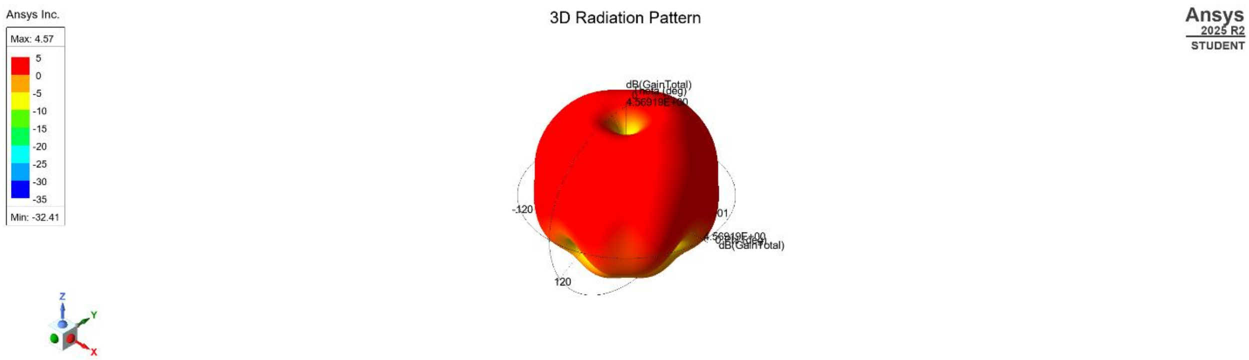


From here it is seen that L = λ/4 (~25 mm) and 35 mm are the best candidates. The ~25 mm option has a wider bandwidth, but the 35 mm has a smoother and more predictable curve. Comparing the two via their radiation patterns (figures in the next section), the L = ~25 mm option was chosen as the final design since the spec is met best and also the radiation pattern is more consistent.

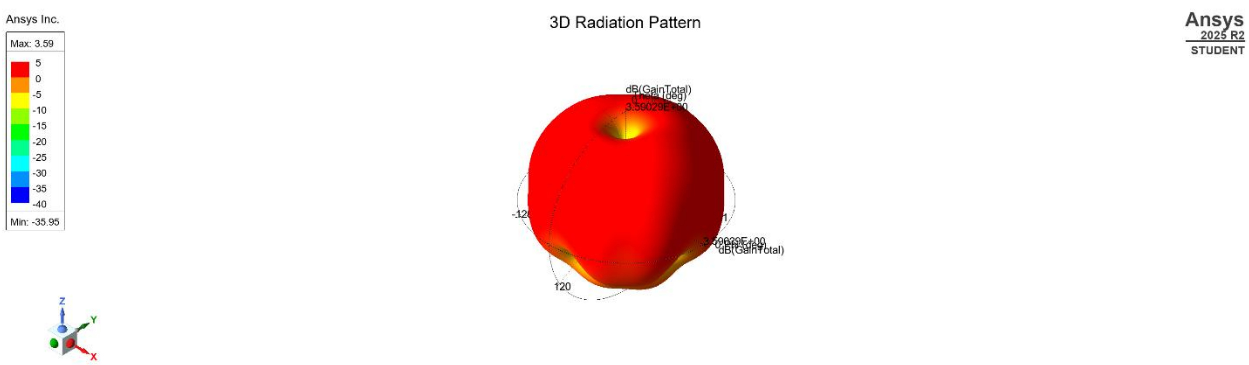
b. Radiation patterns

i. 3D Radiation Pattern

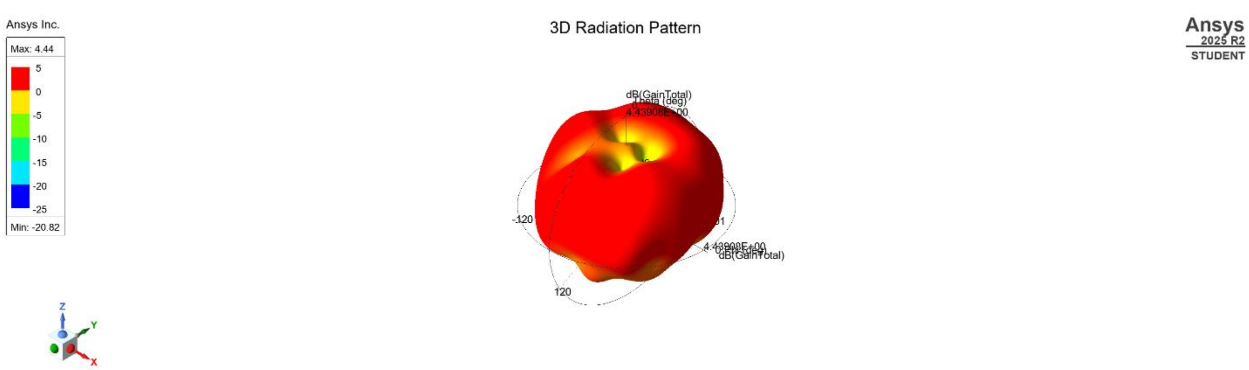
The default radiation pattern:



The base radius = 5 mm, L = λ/4 radiation pattern:



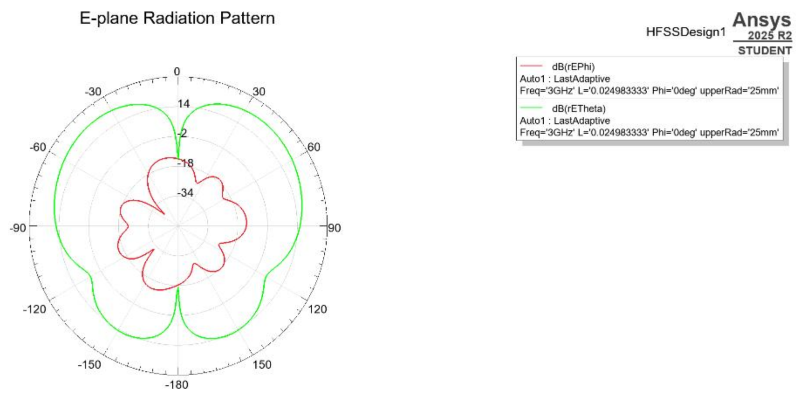
The base radius = 5 mm, L = 35 mm radiation pattern:



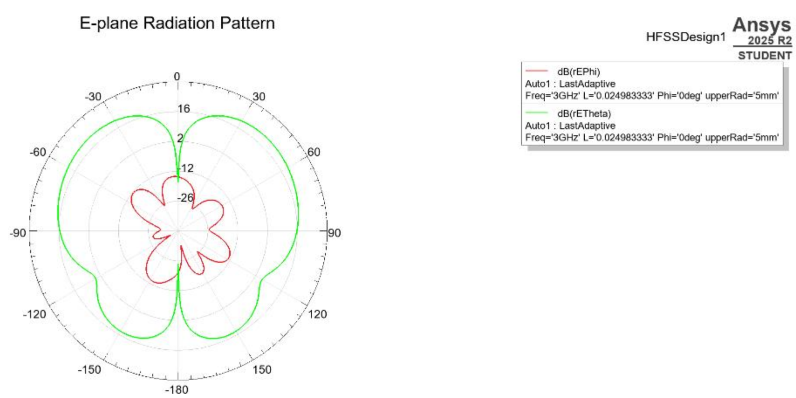
Clearly, the middle option has less directivity than the default option, however it is more consistent than the final option.

ii. E-plane radiation pattern

The default E-plane radiation pattern:

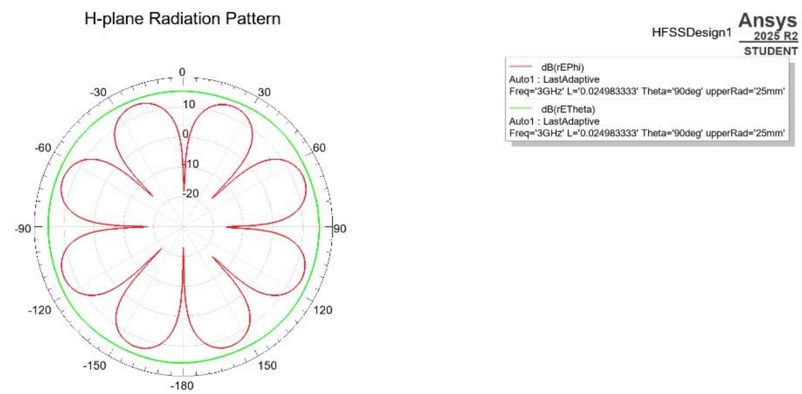


The base radius = 5 mm, L = λ/4 radiation pattern:

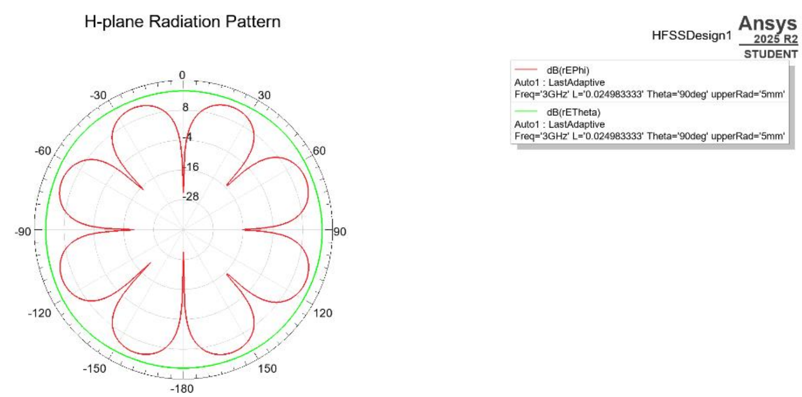


iii. H-plane radiation pattern

The default H-plane radiation pattern:



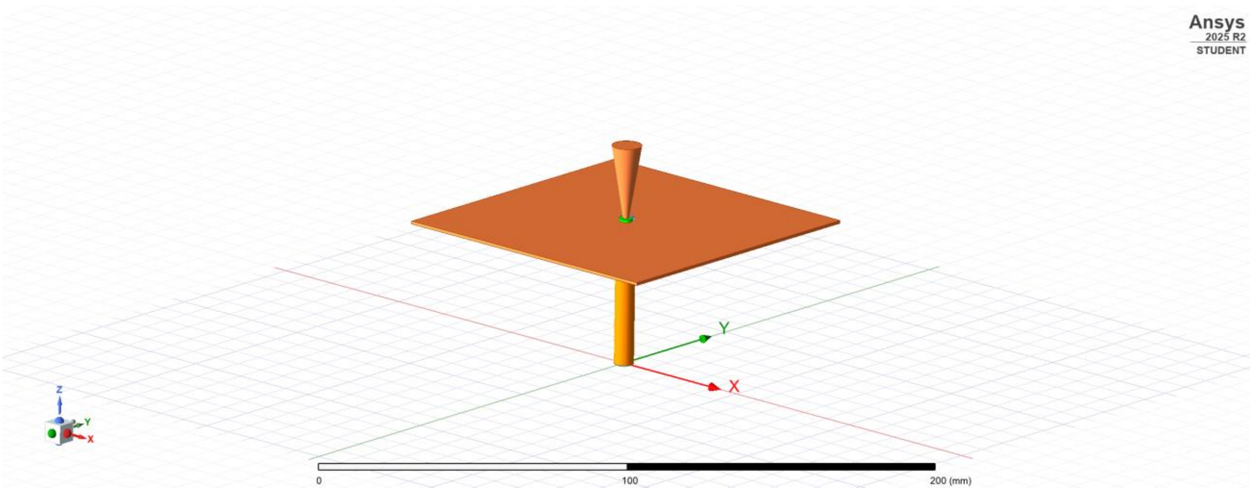
The base radius = 5 mm, L = λ/4 radiation pattern:



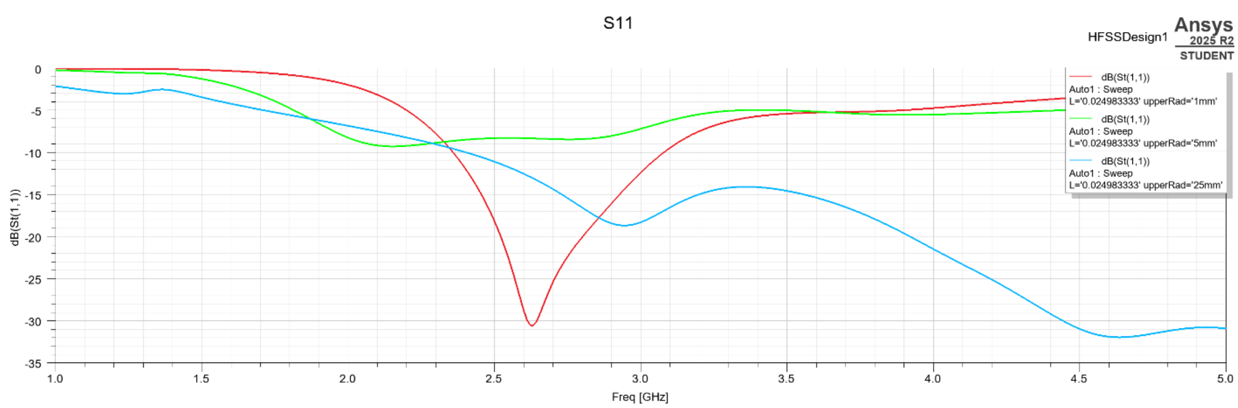
For both the E-plane and H-plane patterns, the rE_θ components are nearly identical, with lower gain in most directions for the E-plane and just slightly higher gain in all directions for the H-plane for the modified spec. The rE_ϕ component, meanwhile, sees a slightly different shape for the E-plane (lower gain and thus more pronounced lobes in the modified spec) and an overall higher gain in all directions for the H-plane (and thus fatter lobes) for the modified spec.

Conclusion:

Therefore, with these modifications in mind, the final antenna looks like this:



It actually begins to look a lot more like a monopole antenna, which explains the lower directivity. However, it holds just enough of its conical characteristics to produce high bandwidth. Below are the S11 measurements where the base radius is 1 mm (therefore the cone becomes a cylinder) compared to the conical solutions.

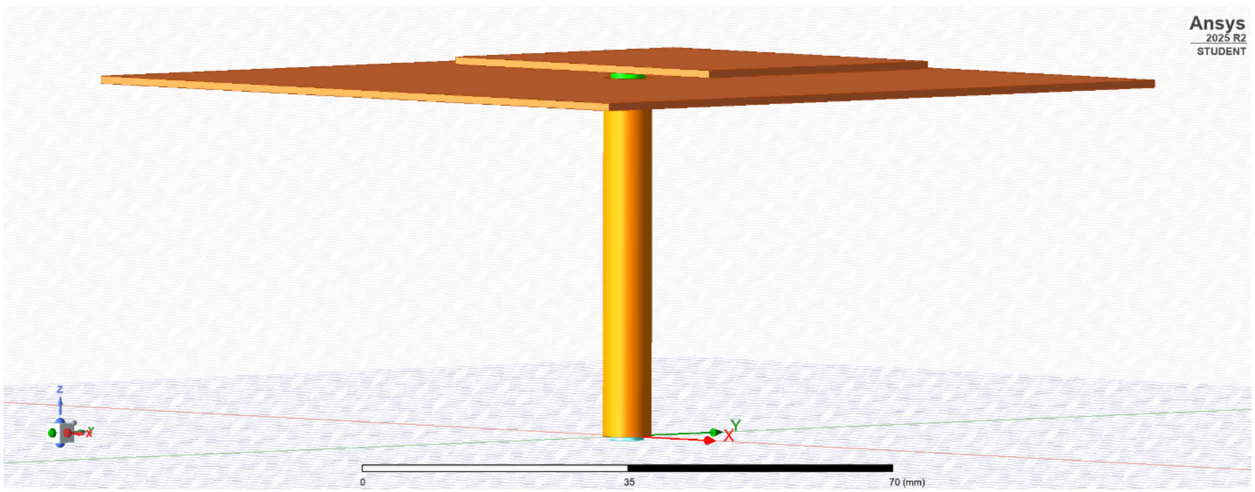


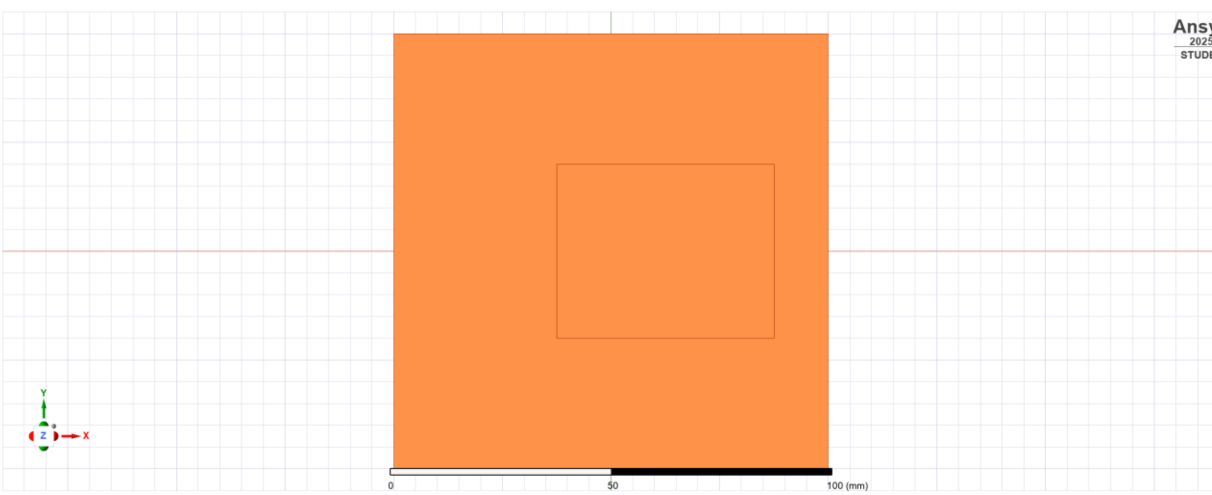
Clearly, the conical shape of the antenna contributes to preventing that deep loss in gain at 2.6 GHz, as it begins to trend that way before maintaining gain above -10 dB.

ECE-5344-D01 Final Exam Pt. 2

Jason Bissias

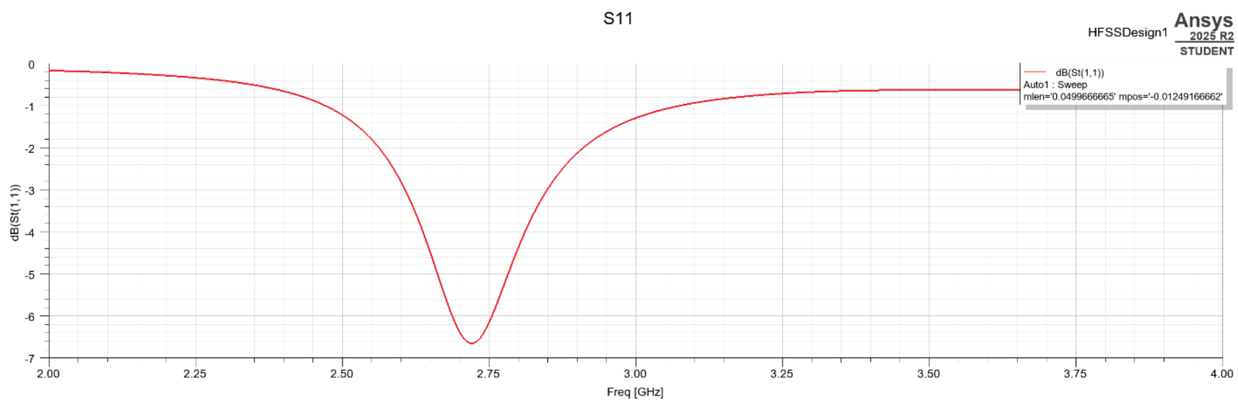
The design of the default spec microstrip patch antenna is as shown in the figure below, with the patch's length of about 50 mm (about L = λ/2) and the position being a quarter of L away from the origin along that direction. The orange is copper and the green is air as dielectric. Included in the design is also a PEC backing for the port at the base of the coaxial wire.



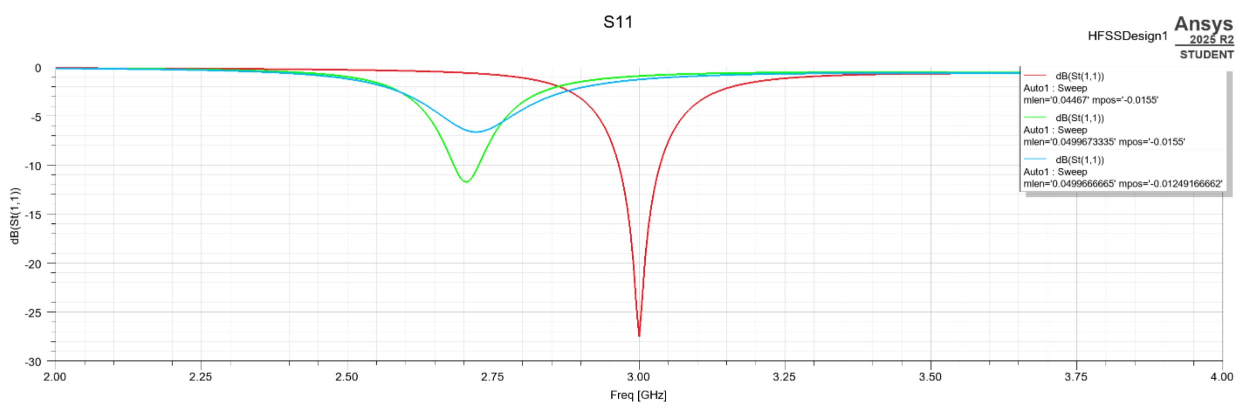


c. S11 Plot

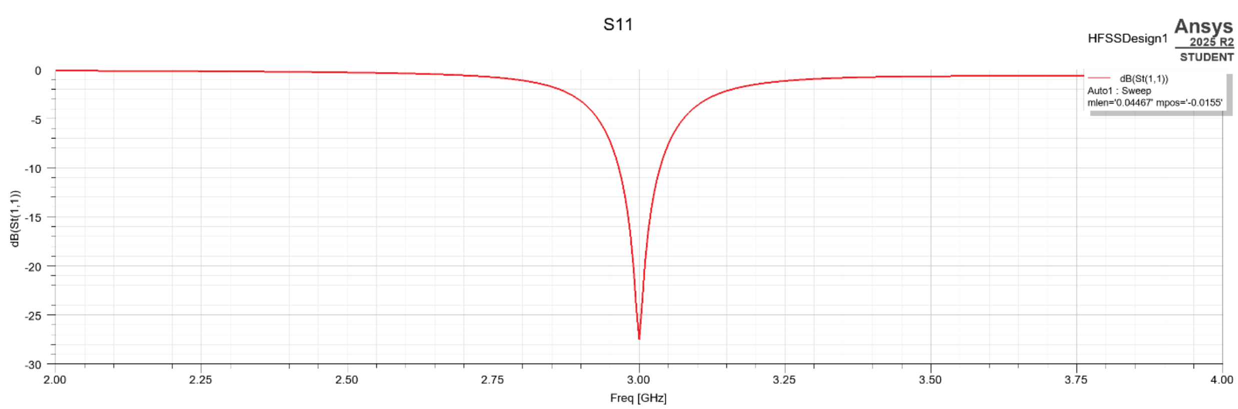
The S11 plot of the antenna by default looks like this:



Its response is not centered on the center frequency of 3 GHz and even there it is not well matched. To find a specification of the antenna that works, first I looked at the variations in the position, with the one I eventually chose being shown below. Then, I checked for the length of the antenna before I reached the best fit (after a few extra simulation sweeps to get it precisely onto 3 GHz):



On its own, here is the final result:

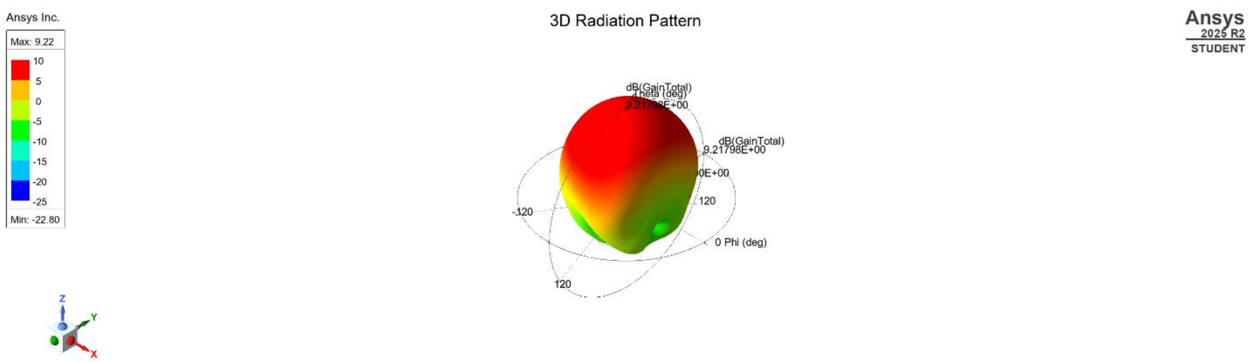


From here it is seen that a shorter antenna increased the center frequency of the antenna and by placing the antenna further towards the edge (therefore the center of the patch is closer to the coaxial line) the match at 3 GHz was improved.

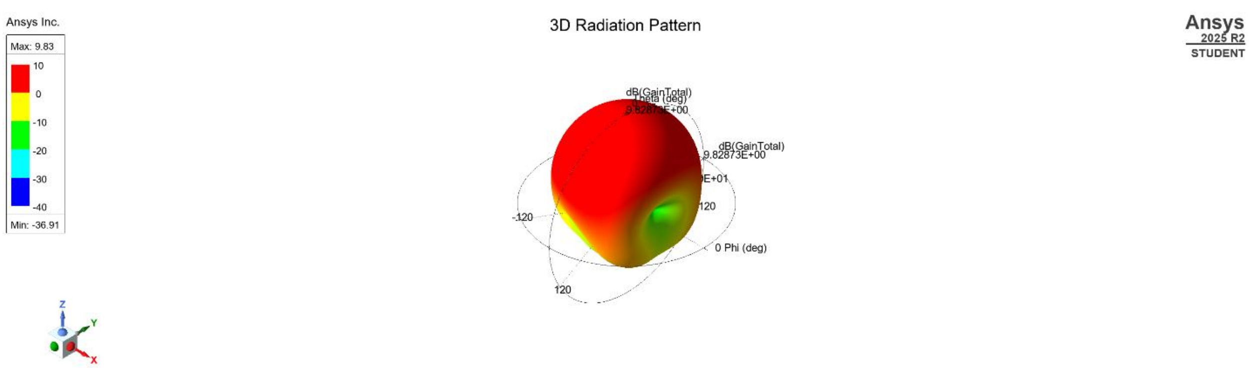
d. Radiation patterns

iv. 3D Radiation Pattern

The default radiation pattern:



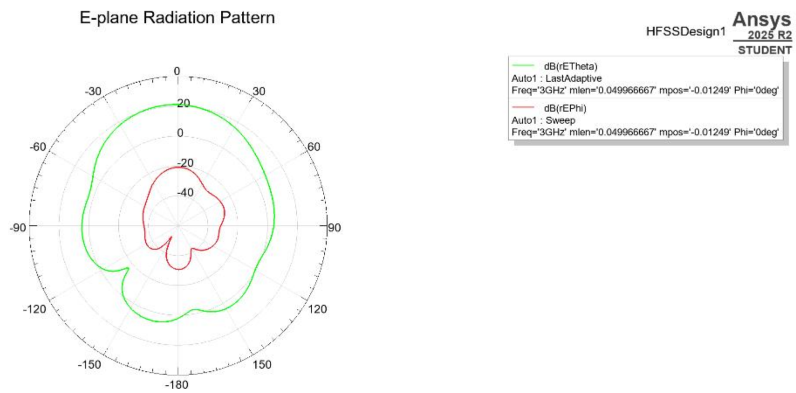
The final radiation pattern:



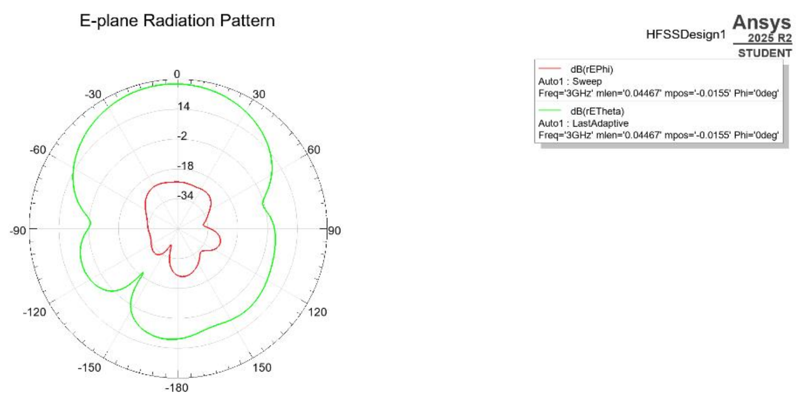
The final pattern has larger main lobes (in that direction, the gain is about equal, if not slightly worse, per the max values in the legend) and smaller back lobes.

v. E-plane radiation pattern

The default E-plane radiation pattern:

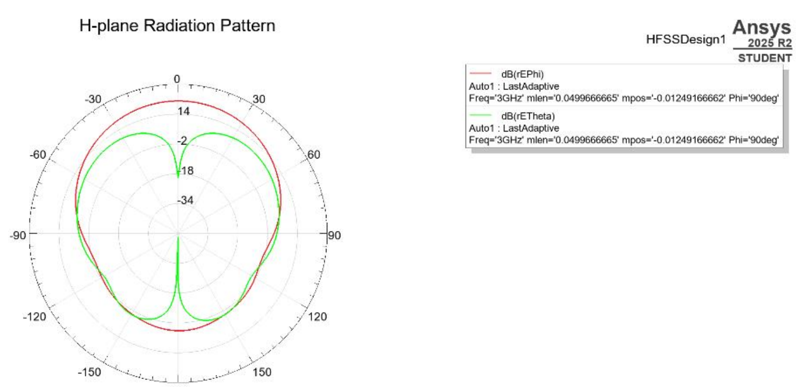


The final radiation pattern:

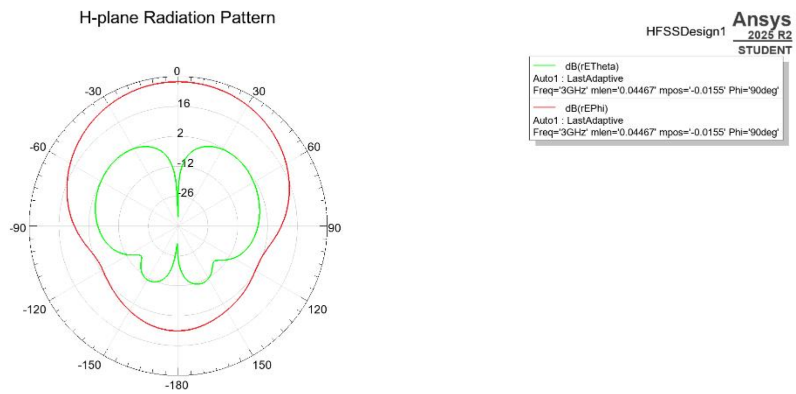


vi. H-plane radiation pattern

The default H-plane radiation pattern:



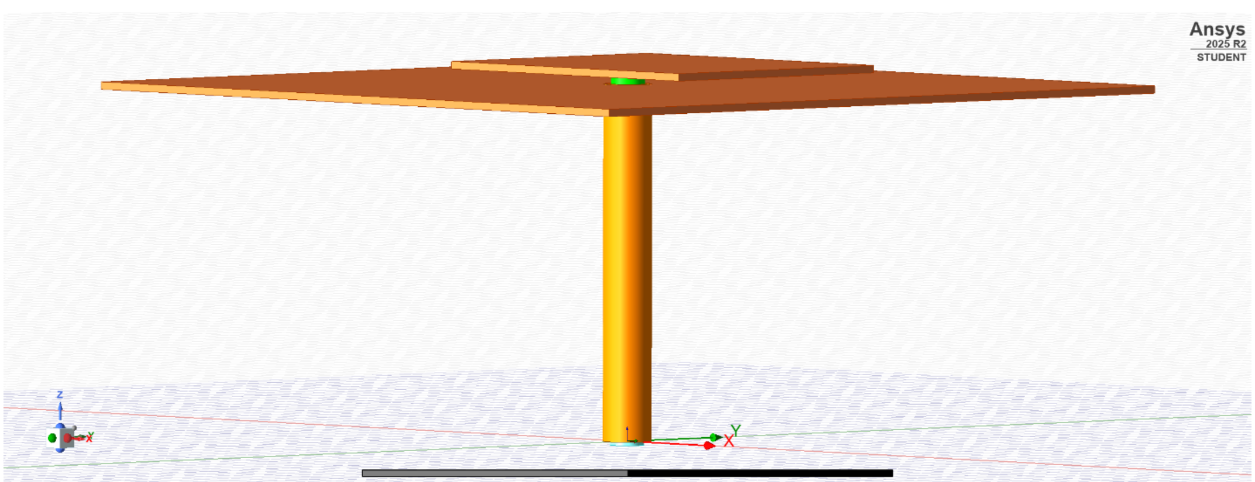
The final radiation pattern:

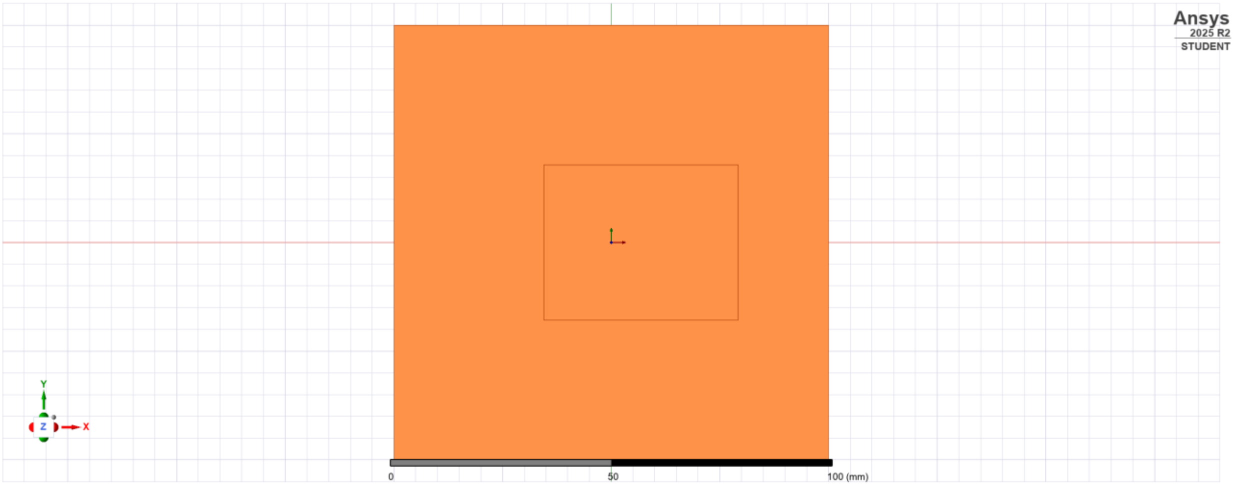


For this antenna, the E-plane marginally loses gain in both components with the modification but earns gain in the H-plane. The shape of both maintain strong similarities, with minor permutations- most notably, the rE_φ component of the H-plane experiences slimmer back lobes and a sharper intersection between the main ones and the back ones. The gain in that regard is about equal for the main lobes, and the antenna gains some directivity in that regard. The E-plane has a similar trend, just less pronounced.

Conclusion:

Therefore, with these modifications in mind, the final antenna looks like this:





The adjustments of this antenna are very predictable and easily tunable, allowing for an efficient design process to meet design goals.