Microstrip Patch Antenna Design Documentation

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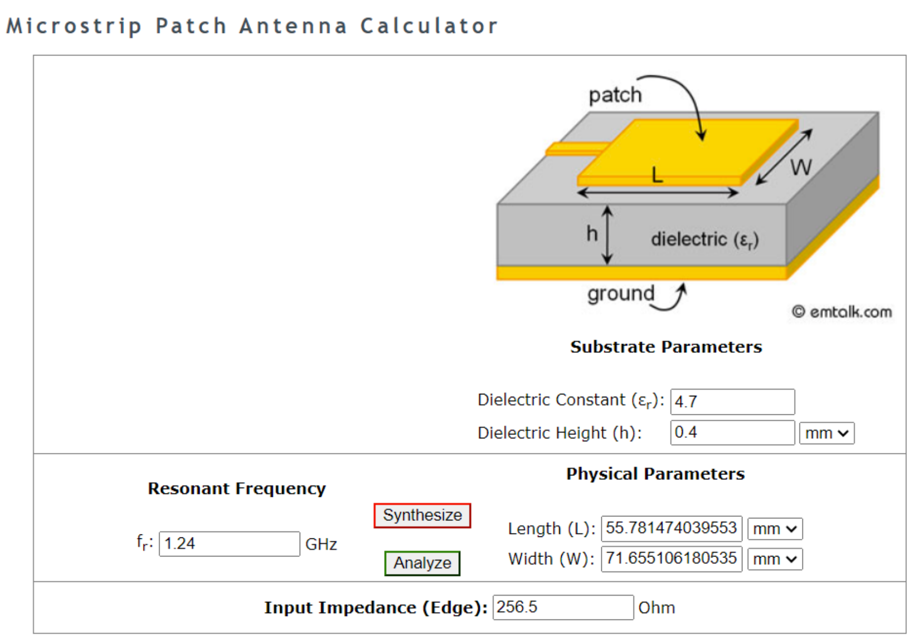
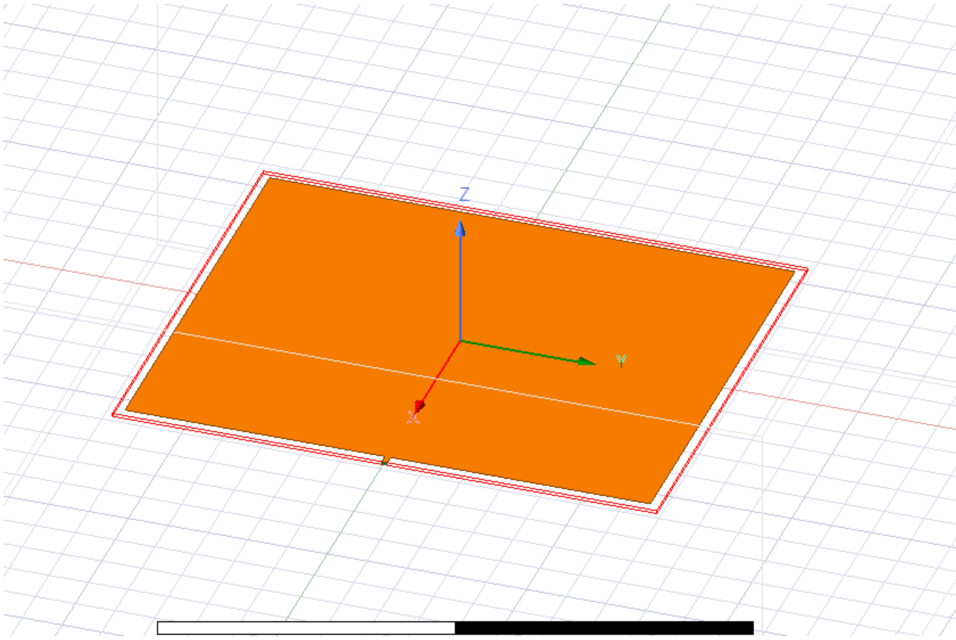
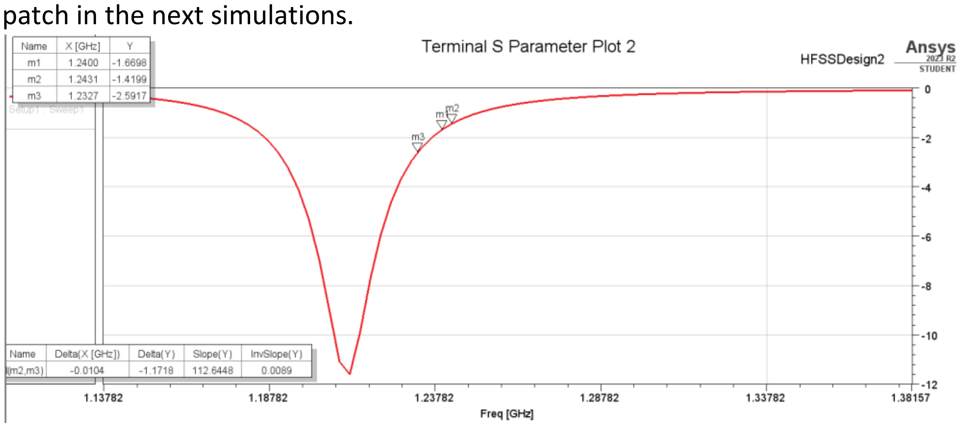
1. Creation of single patch antenna in HFSS:
    a. We created a patch antenna based on [this](#) video with the following modifications
        i. We created designs with and without insets in the patch. Following the simulations with both, we determined we likely won't need the extra bandwidth for the antenna's resonant frequencies that an inset provides. So, the remainder of this documentation will be regarding the patch antenna design with no inset.
        ii. We created the source of the antenna using HFSS's "create Object from edge" function (where the edge was the far "width" edge of the feed line). When we created a 2D object and then reoriented it and sized it as the tutorial video does initially, there were issues in the source-feed line connection seen when creating the terminal lumped port. Specifically, HFSS wasn't recognizing the patch as a possible reference conductor for the terminal port and the design was not passing the validation check. We weren't experiencing issues actually creating the terminal lumped port because we were going to use the ground plane as the reference conductor for the terminal port anyways, but that was when we first noticed there was an issue with the source.
    b. Using [this](#) calculator, we found the theoretical dimensions of our patch so it would have a resonant frequency of ~1.24GHz.

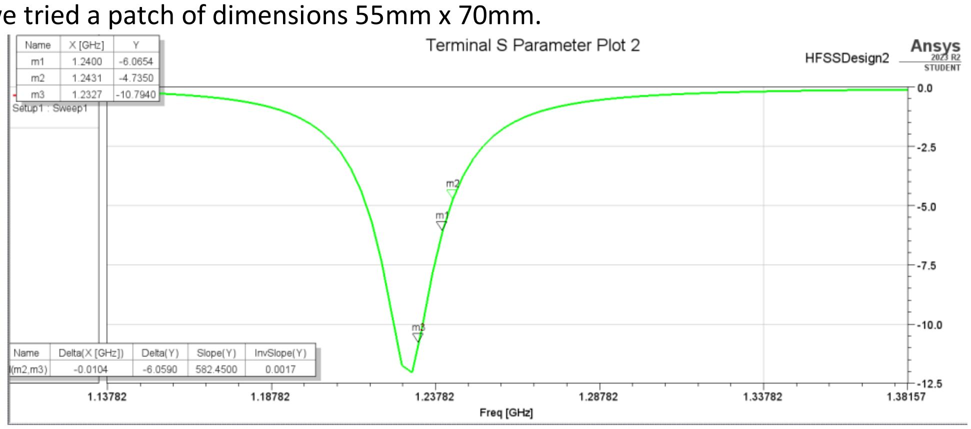


        i.

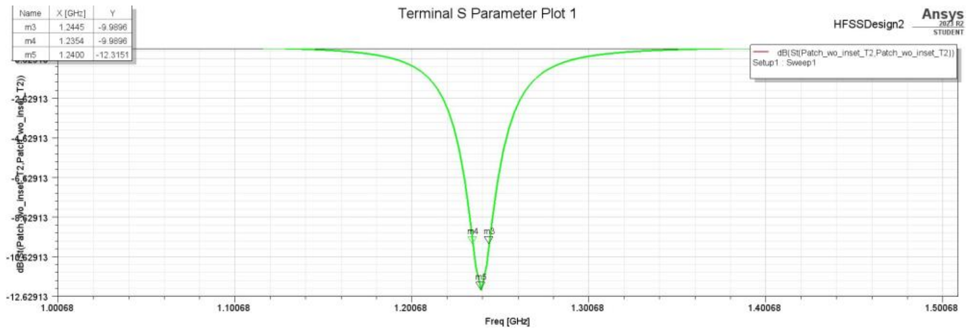
    c. We pulled the dielectric height (0.4mm) from JLC and the dielectric constant of the substrate (4.7) from JLC's site and Prof. Bogatin's PCB research.
    d. substrate dimensions are (6*h + L_patch) x (6*h + W_patch)

e. 

2. Simulations to obtain desired resonant frequency of 1.24 GHz
    a. We did a frequency sweep to look at the resonant frequency of the patch antenna at the theoretical dimensions we got from the calculator(56mm x 72mm), as seen below. Its resonant frequency was below our desired resonant frequency, so we will try a smaller patch in the next simulations.
        i. 

    b. Next, we tried a patch of dimensions 55mm x 70mm.
        i. 

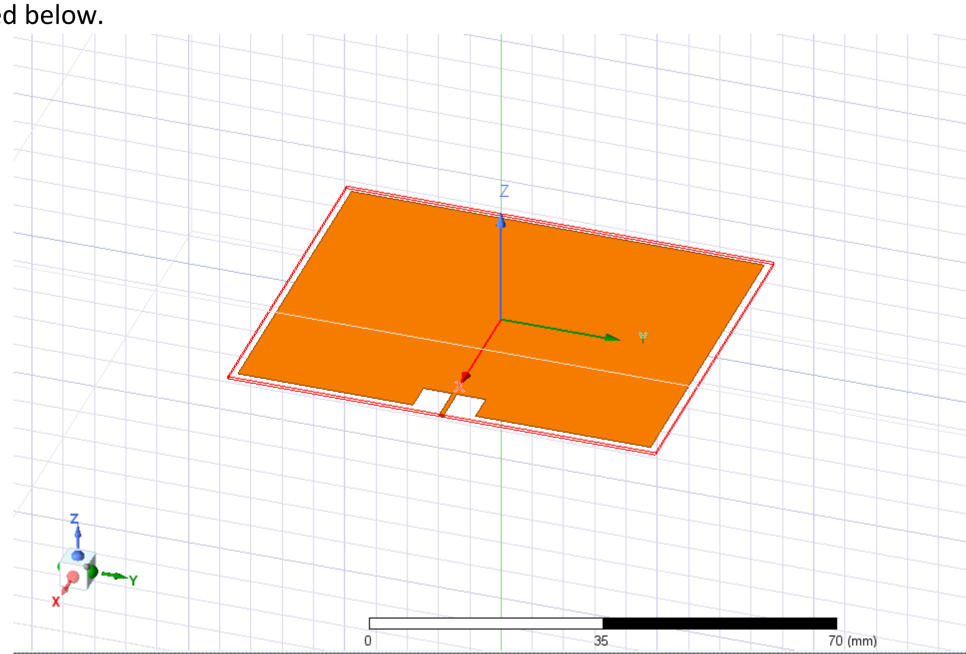
    c. Next 54.6mm x 68.6mm

i. 

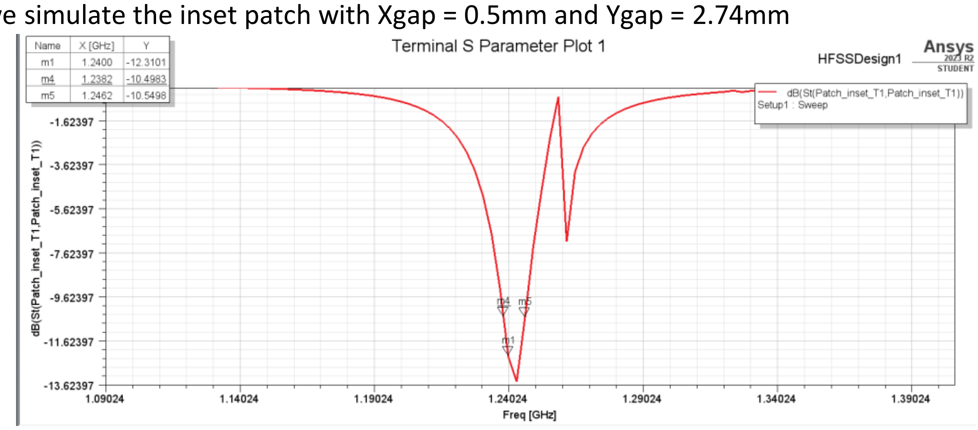
ii. This has our desired resonant frequency with a gain of about 12 dB at 1.24 GHz . It has a –10 dB bandwidth of about 9.1 MHz

The following sections are not up-to-date (we decided that a 9.1 MHz bandwidth was enough and we don't need to investigate expanding the bandwidth with an inset patch design)

3. Next, we investigated if we could get more bandwidth with an inset patch using the model pictured below.

   a. 

4. Now we simulate the inset patch with Xgap = 0.5mm and Ygap = 2.74mm

   a. 

b. The bandwidth is slightly higher than that of the patch w/o inset at about 12.2 MHz. Peak gain is 27% larger than without inset (16.5 dB compared to 13 dB).

5. Now we tried to minimize the smaller frequency spike by increasing the gap width (Ygap = 4mm). This led to a shift in the main resonant frequency so we adjusted patch dimensions to 55mm x 70mm.

a.