EHB 456E
Antennas
Term Project
Ultra Wide Band Antenna Design

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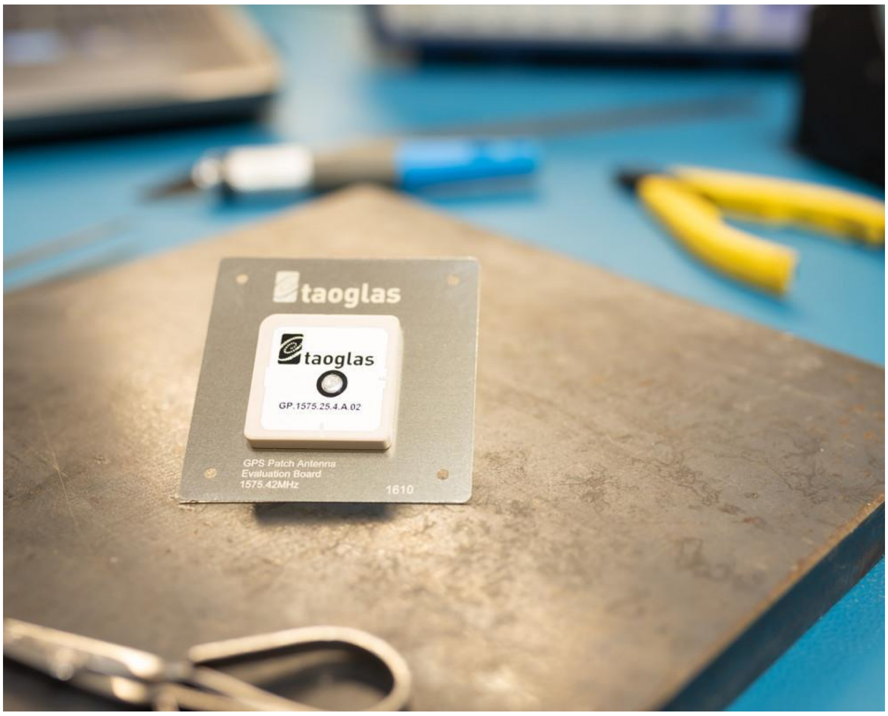

Figure 1.1: A patch antenna, specifically designed for GPS [1].

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1. ANTENNA REQUIREMENTS

First of all; the project started with research about microstrip antennas. Before beginning the design, a calculator has been used to get an idea for dimensions of the antenna. Figure 1.1 suggests a design for a simple shaped patch antenna.

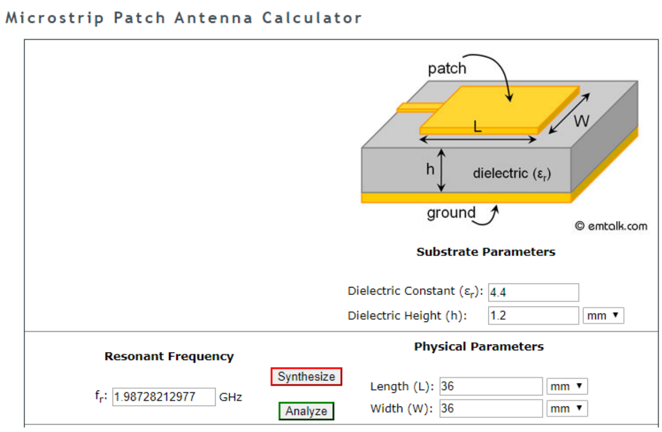


Figure 1.1: Microstrip Patch Antenna Calculator [2].

From this figure, 36 – 36 mm dimensions look solid for the patch at 2 GHz center frequency.

Moreover, the design that is taken as reference can be examined in Figure 1.2.

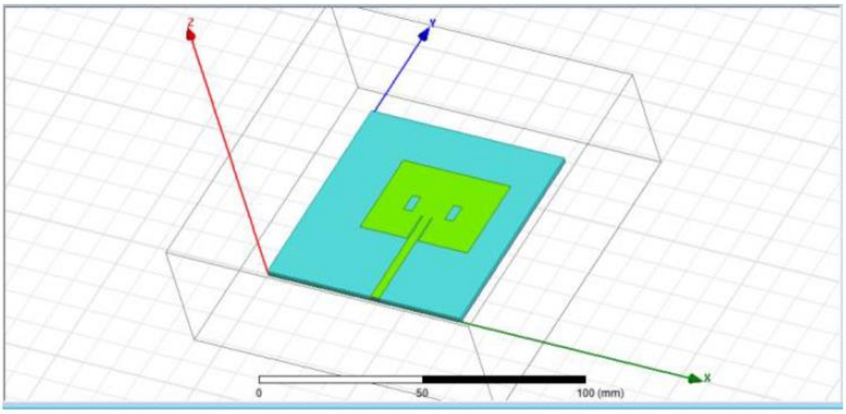
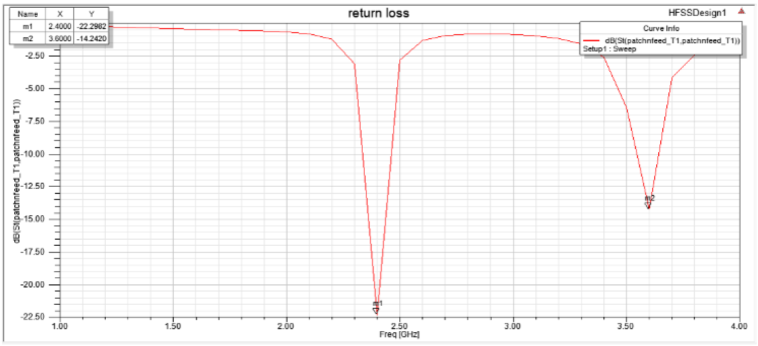


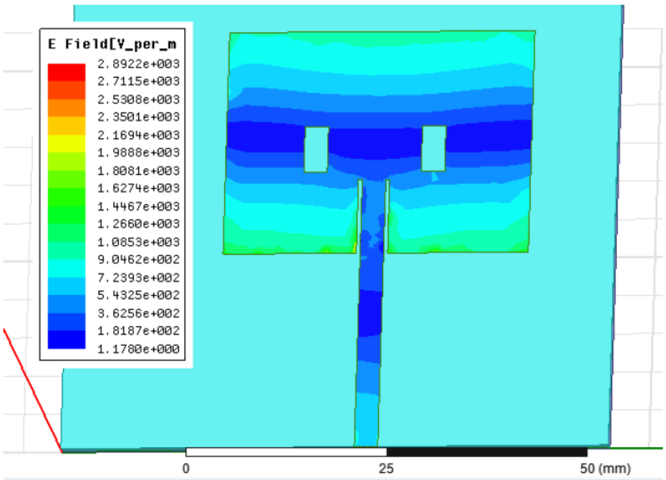
Figure 1.2: Reference design.

This design is from the "Design of Dual Band Micro Strip Antenna for 2.4 GHz and 3.6 GHz" paper, published in May 2019 [3].

In this design, authors tried to achieve a dual band system for a patch antenna, with 2 slots on the patch. The results for the simulation in Figure 1.3 are thus.



(a)



(b)

Figure 1.3: Return Loss (a) and Current Distribution (b) from reference [3].

Inspired from the reference; the designed antenna in this project became like Figure 1.4.

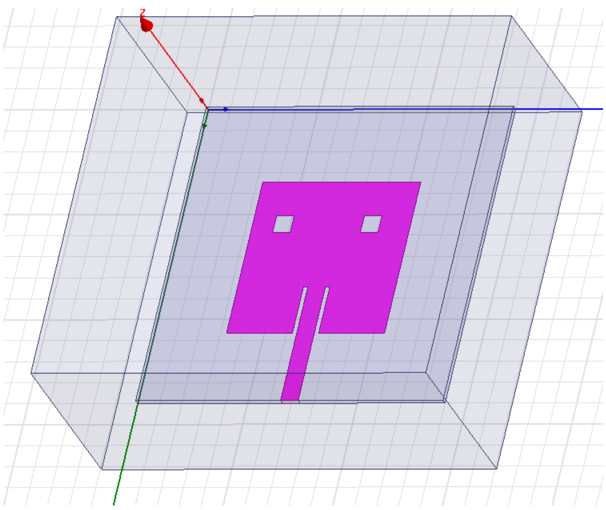


Figure 1.4: Antenna design.

All the lengths can be seen in Figure 1.5.

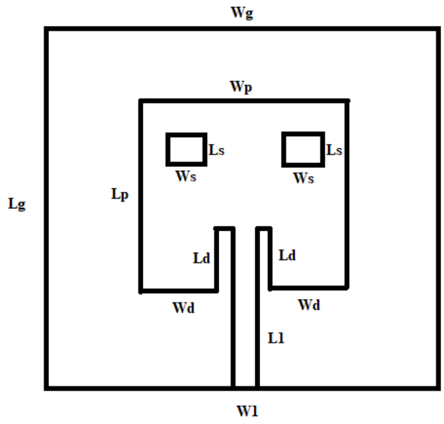


Figure 1.5: Lengths on the Antenna.

For the designed antenna all the parameters are given in the Table 1.1.

Table 1.1: Parameters of the Antenna.

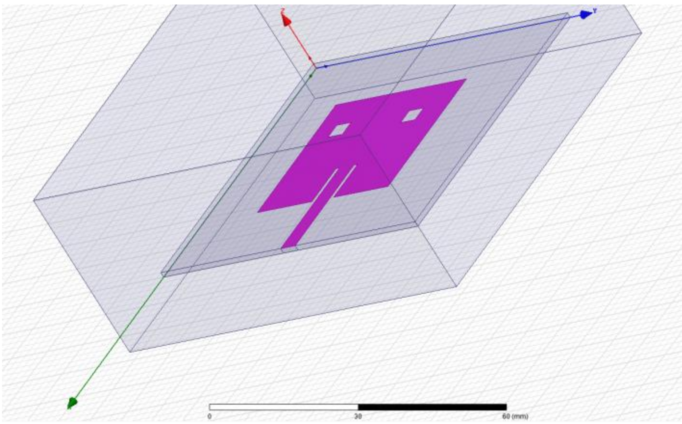
Parameter	Value
Lg (Length of Substrate)	70 mm
Wg (Width of Substrate)	70 mm
Thickness of Substrate	1.2 mm
Lp(Length of Patch)	36 mm
Wp (Width of Patch)	36 mm
Ls(Length of Slots)	4 mm
Ws (Width of Slots)	4 mm
Ld(Length of Depth)	9 mm
Wd (Width of Depth)	15 mm
L1(Length of Feeding Line)	27 mm
W1 (Width of Feeding Line)	4 mm
Єr (FR-4 Epoxy dielectric)	4.4
Center Frequency	2 GHz
Stride	0.01 GHz
Measured Band	1 GHz – 5 GHz

2 subtracted slots are equal and mirrored on y = 35 line; which cuts the center point of the antenna at (35,35). Feeding line is also perfectly fit, with respect to y = 35 line.

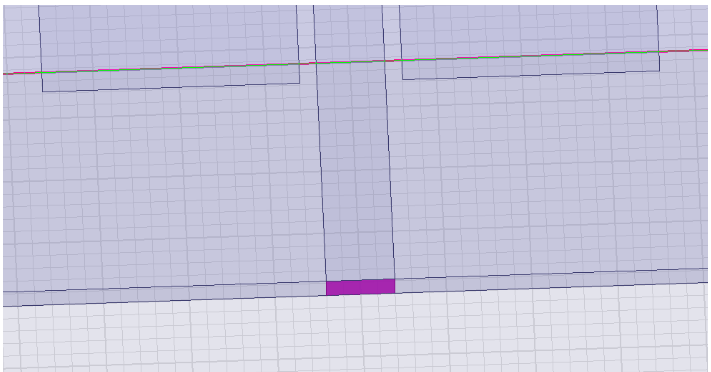
From this point, we can go onto the simulation. There we will check if the designed parameters on paper is adequate for a UWB antenna or not.

2. MODELING AND SIMULATION

For simulation HFSS 15.0 is used. After the design in hand; the antenna realized in a .hfss project. FR4 is used as a substrate (a lossy material) and the thickness is chosen as 1.2 mm. The design can be seen in Figure 2.1.



(a)



(b)

Figure 2.1: Patch (a) and Feeding Point (b).

There were a lot of trial and error at the length choices to maximize gain at the 2 GHz. For this goal patch length and width started with 30 mm at first. After trying 40, 33 and 35 mm solutions; 36 mm were decided to be used. The simulation at Figure 1.1 was right after all!

Radiation box chosen as standart vacuum and Ground chosen as Copper. In the next chapter we will see the simulation results.

3. SIMULATION RESULTS

First of all, the characteristic impedance thought to be checked. The smith chart plotted for this results can be seen in Figure 3.1.

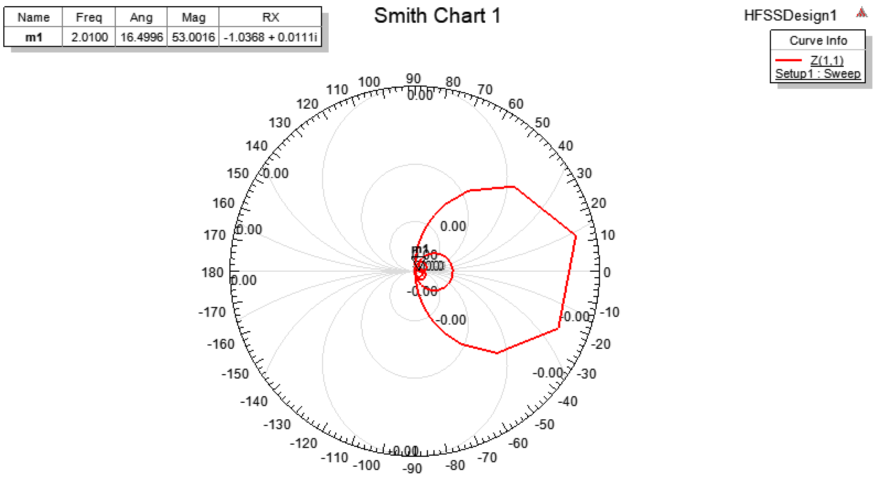


Figure 3.1: Input Part of the Antenna.

We could have plotted the characteristic impedance; for both real and imaginary parts. Instead decided to plot a smith chart. From the marker it can be seen that at 2 GHz, real part is around 50 ohms. Also this point is really close to the center of the smith chart. This is a good result, given that a quarter wave matcher is probably not needed. However, at a different frequency; we can easily use a matching circuit.

Also; the 3D radiation pattern can be seen in Figure 3.2.

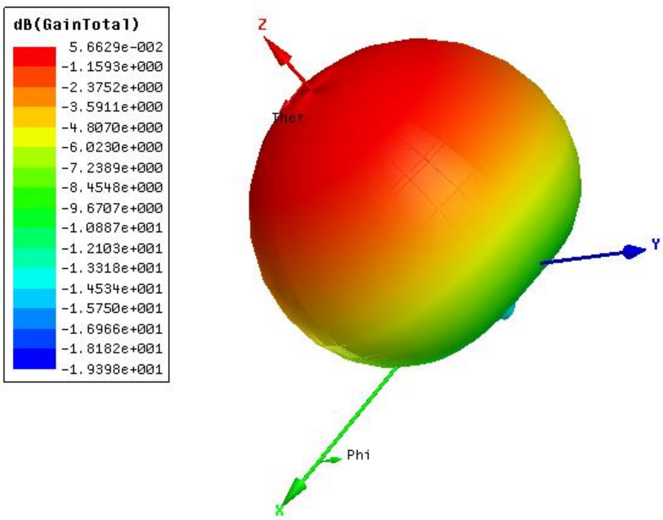


Figure 3.2: 3D Radiation Pattern.

The gain total is looking like what we were expecting. Maximum at positive Z axis.

For the next plot, gain and directivity thought to be compared at Phi : 90 degrees. The expectation is that because of the basic relation between gain and directivity given in Equation 3.1;

$$Gain = Efficiency\ x\ Directivity \tag{3.1}$$

The gain is expected to be lower. The plot is in dB unit. Plot is in Figure 3.3.

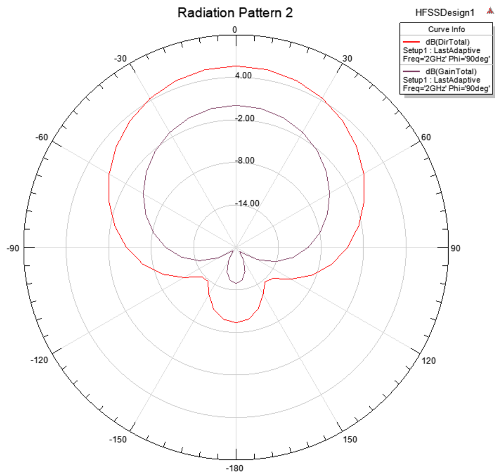


Figure 3.3: Gain and Directivity of the Antenna at f = 2GHz.

As expected, the gain is indeed lower than the directivity.

For polarization of the antenna, we can check the Phi = 0 degree plane. From that point we can either check gain or directivity. However; we will need to look at Phi and Theta components. This is plotted at Figure 3.4.

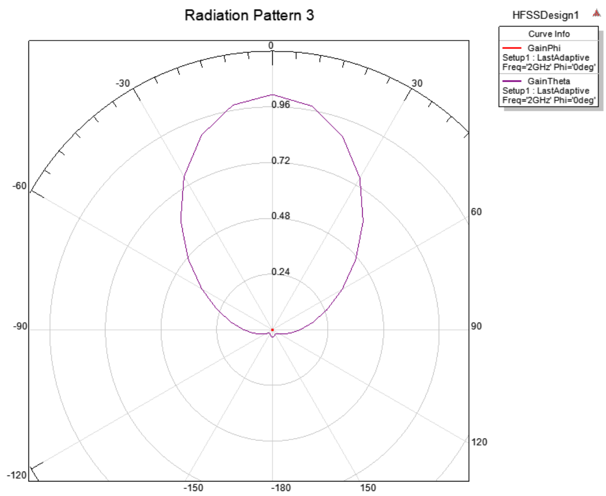


Figure 3.4: Gain and Directivity of the Antenna at f = 2GHz.

The Phi component compared to the Theta component in Gains, is so small. And Theta component is parallel to the transmission line. From this point we can say this antenna is linearly polarized.

Finally; we can plot the Return Loss for the antenna with 0.01 GHz stride over 1 GHz to 5 GHz; in Figure 3.5.

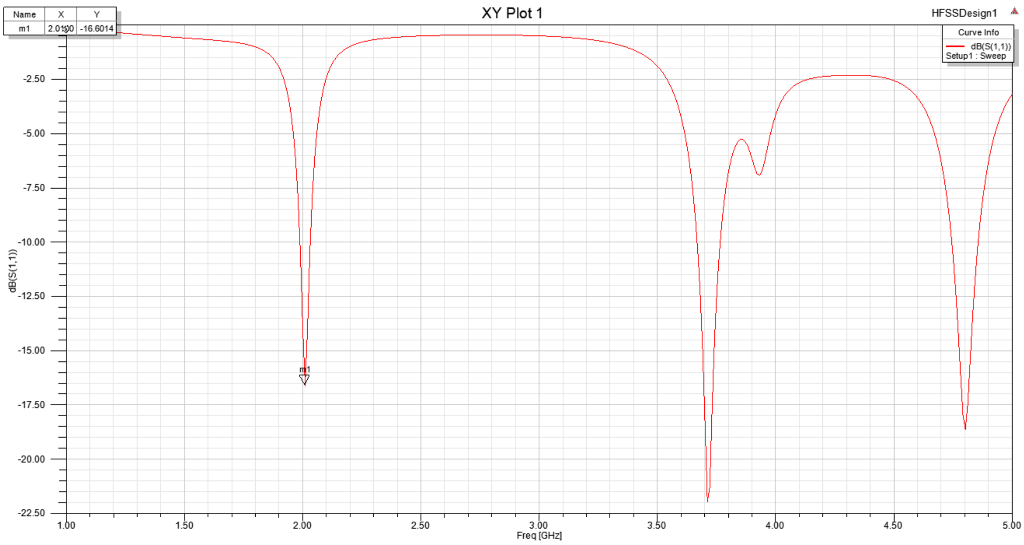


Figure 3.5: Return Loss of the antenna.

This figure is, well, not what we expected. At 2GHz we got 16 dB which is nice but the band is so small around this frequency. The design gave us 3 frequency values to be radiating in 1 to 5 GHz band with a good gain values. What we were trying to achieve was a wide band antenna. For this goal; we need to adjust the “ground” plane dimensions, maybe get a lower gain but a bigger bandwidth.

4. CONCLUSION

We begin our road for a UWB antenna design; with a reference design from a journal paper. After a basic simulator we draw a general structure for the antenna with 2 slots. Moreover, with a lot of optimization, finally decided the patch dimensions in our microstrip antenna. We simulated our design in HFSS; looked for the return loss, the characteristic impedance, 3D radiation patterns (just because it looked nice & colorful), polarization and gain radiation patterns for our antenna.

With a lot more experience and time; we saw that any antenna at 1 – 10 GHz frequency band can be realized with the simulation programs. The simulation today is really advanced; giving the user the ability to build almost anything in the modeler.

Our design specifically, met a really good gain and decent input impedance value. It is known that not all IC circuits are using 50-ohm transmission lines but, we manage to get close to 50 at 2 GHz. However, we most certainly not met the wide band application, for the center frequency at least. An ultra-wide band antenna should be able to radiate and receive in a wide band.

Well at least, we learned that for a UWB antenna, the return loss should be under -10 dB for at least 500 MHz in the band. For that goal, ground should be selected in a lower area; maybe just under the feeding line.

Thank you for an amazing semester :)

5. BIBLIOGRAPHY

[1] Url 1 - https://www.taoglas.com/product/gp-1575-25-4-a-02-gps-1575-42mhz-patch-antenna-254mm-2/

[2] Url 2 - http://www.emtalk.com/mpacalc.php

[3] **Soundarya S., Meghana S., Shanthi P.** "Design of Dual Band Micro Strip Antenna for 2.4 GHz and 3.6 GHz", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-8, Issue-1, May 2019