ECEN452: ULTRA HIGH FREQUENCY TECHNIQUE
LAB09: Patch Antenna
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BACKGROUND:

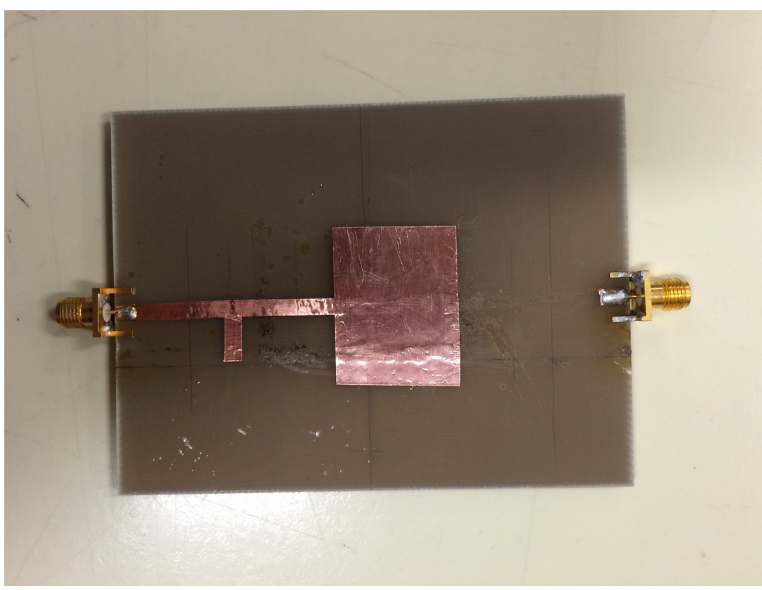
The thickness of microstrip line is one important parameter that controls the non-TEM mode behavior and frequency dispersion of the line.

GIVEN:

Speed of light = 299,792,458 m/s
Design Frequency = 3GHz
Relative Permittivity = 4.1 (FR4)
h = 1.5748 mm (Thickness of substrate)
t = 43.1 um (Thickness of copper)
Characteristic Impedance = 50 ohm

Length = 24.2557 mm
Width = 31.2896 mm
Distance = 45 mm (d > 40mm, Design restriction)

!Check: $h \ll \lambda$



Figure

MEASURED:

Unmatched Patch Antenna

Load Impedance = 133 +j22
Magnitude = 134.807
Phase = 0.16393 = 9.3925 degree

Matched Conditions are covered at the end

Smith Chart Solution:

Length of stub = wavelength * 0.165 = 9.3025 mm
Distance from load = wavelength * 0.151 = 8.5132 mm

Wavelength = 56.3784 mm

Note: Unlike usual, we obtained the results by rotating from reference plane toward the load.

BACKGROUND:

In this lab, impedance matching can be realized by two of the well-known methods, which are single stub matching and the quarter wave transformer. In our design, we use single stub matching to realize the impedance matching but explicitly, we could have done the quarter wave transformer matching and obtain the same impedance matching. Typical directivity for microstrip patch antenna is 7dB. It is known that the narrower beam width, the higher directivity.

Since we are using the rectangular patch antenna, the resonant length 'L' will determine the operating frequency. On the other hand, the width 'W' controls the impedance and efficiency.

Microstrip line Calculator Results:

W = 3.06445 mm
Effective relative permittivity = 3.14011
Wavelength/4 = 14.1080 mm

Calculation:

First we assume that the ratio is greater than 2:

$$A=\frac{Z_o}{60}\sqrt{\frac{\epsilon_r+1}{2}}+\frac{\epsilon_r-1}{\epsilon_r+1}\left(0.23+\frac{0.11}{\epsilon_r}\right)=1.4868$$

$$B=\frac{377\pi}{2Z_o\sqrt{\epsilon_r}}=5.8492$$

$$\frac{W}{d}=\frac{2}{\pi}\left[B-1-\ln(2B-1)+\frac{\epsilon_r-1}{2\epsilon_r}\left\{\ln(B-1)+0.39-\frac{0.61}{\epsilon_r}\right\}\right]=2.0163>2$$

Therefore, our assumption was correct.

Now, for simpler expression, let

$$\frac{W}{d}=ratio=2.0163$$

We can calculate the effective dielectric constant for the microstrip model:

$$\epsilon_e = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \frac{1}{\sqrt{1 + \frac{12}{ratio}}} = 3.1379$$

$$Z_o = \frac{120\pi}{\sqrt{\epsilon_e}\left[ratio + 1.393 + 0.667 \ln\left(ratio + 1.444\right)\right]} = 50.2255\,\Omega$$

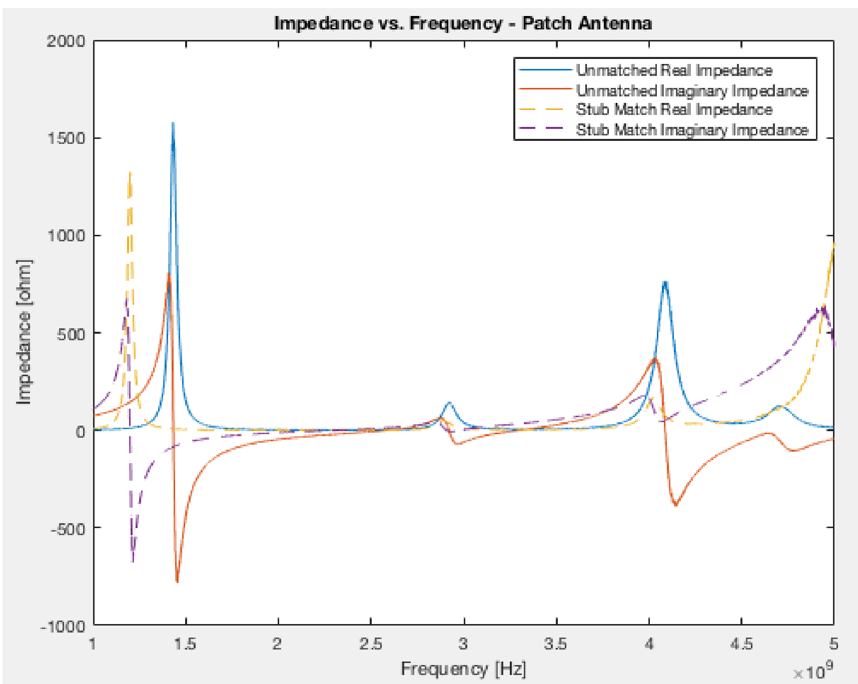
Note that our calculation shows a great harmony with the results from the online microstrip calculator.

$$\lambda = \frac{c}{f\sqrt{\epsilon_e}} = 56.413221\,mm$$

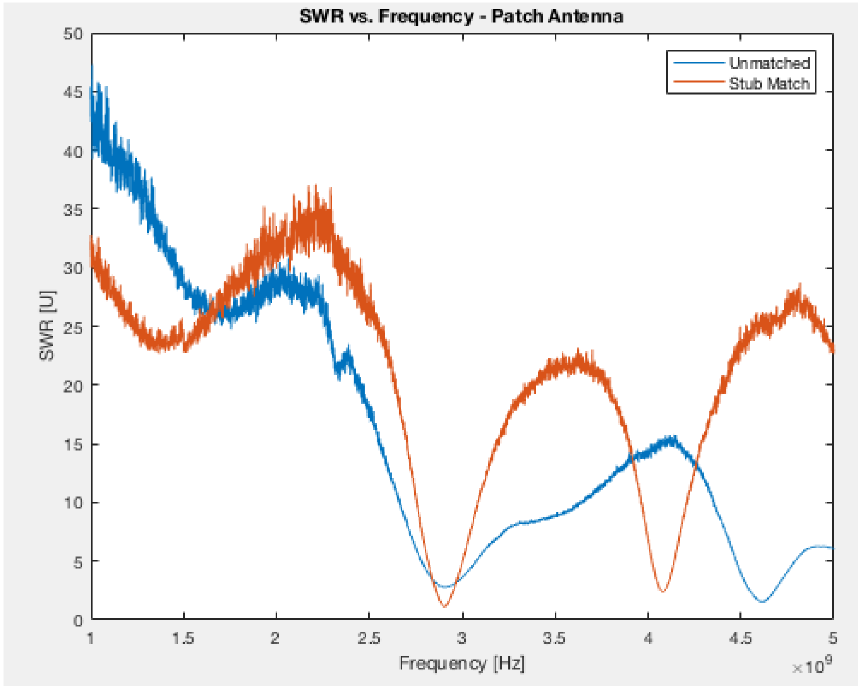
$$length\ of\ stub = \lambda * 0.165 = 9.30818\,mm$$

$$distance\,\text{¿}\,the\ load\ for\ stub = \lambda * 0.151 = 8.5184\,mm$$

LAB MEASUREMENT:

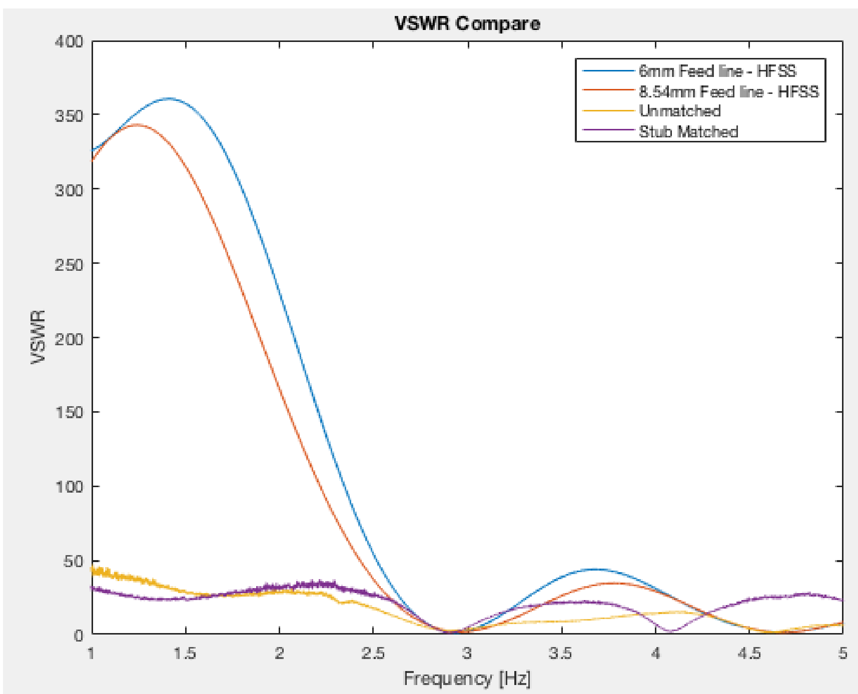


Figure



Figure

In the lab, after stub matching on our design, we obtained -26dB and VSWR = 1.1



Figure

HFSS version shows a horrible VSWR before 2.5GHz and recall that all the values were from the lab. I was wondering how both plots would behave under the same parameters in two different measurements. It turned out that not a good idea it was.

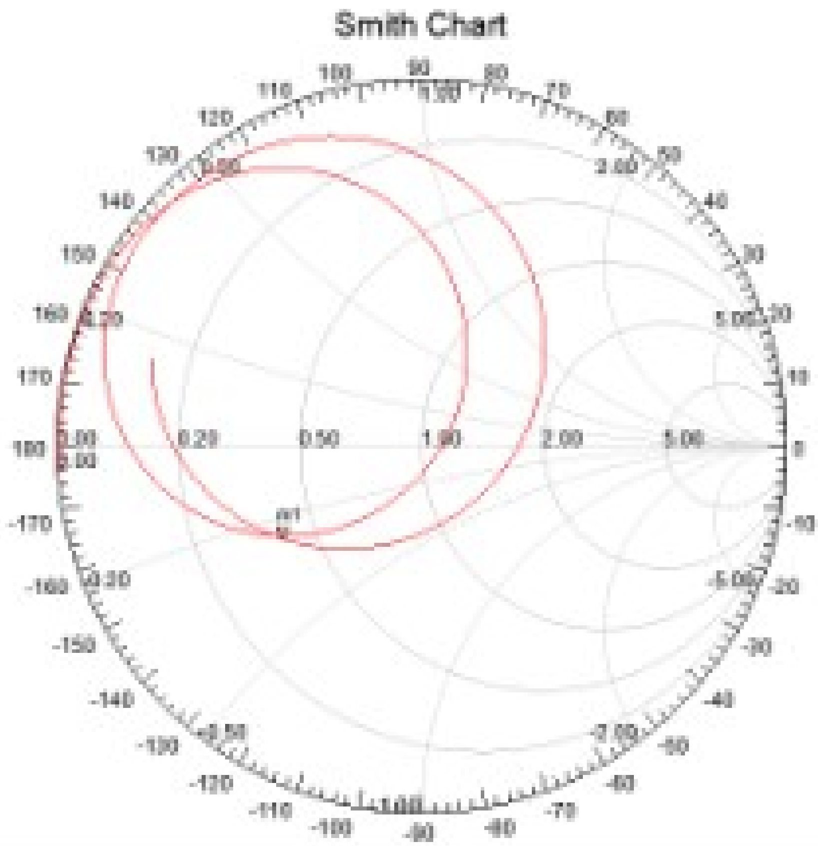


Figure. Smith Chart from HFSS