ECEN5134 Homework 6

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1 Problem (a)

For this problem, to carry out the simulations, the length of the dipole is set to $1m$. The selected frequency range for this problem is $80MHz$ to $300MHz$. It is possible to find R_{in} by computing the real value of the antenna impedance at different frequencies. To compute the radiation resistance, R_r, the following formula is used:

$$R_{in} = \frac{R_r}{sin^2(\frac{kl}{2})} \tag{1}$$

$$R_r = R_{in} \times sin^2(\frac{kl}{2}) \tag{2}$$

As for plotting the maximum directivity, D_0 across the frequency range, the far field patterns are exported from FEKO and D_0 is extracted using MATLAB scripting. Finally, we attempt to recreate the plot from slide 16.

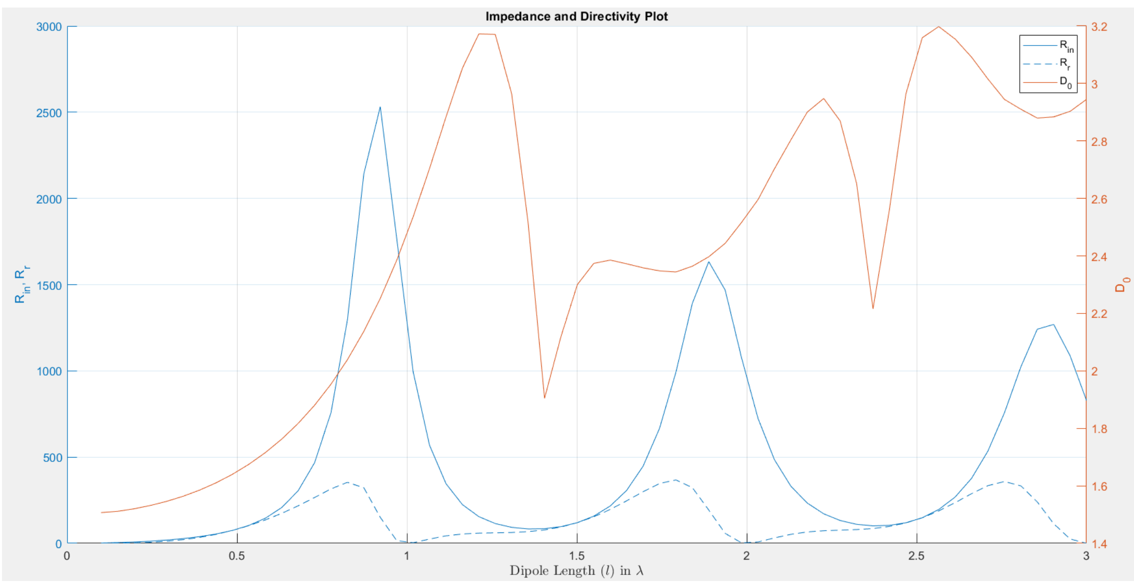

Figure 1: Plots of R_{in}, R_r and D_0.

In the above plot we can see that at times the R_r goes to 0, which is different from the plot shown in slide 16. This primarily occurs because the plot shown in the slide is derived from analytical solutions, and the formula we use to compute the R_r is an approximate. Due to the nature of the solver in FEKO, R_r goes to 0 periodically. Nevertheless, the periodicity of the waveform are maintained. Therefore, we can confidently say that the correct solutions have been obtained from FEKO.

2 Problem (b)

The purpose of the simulations here are to show that the frequency bandwidth increases with the thickness of the dipole antenna. Before starting this problem, the length of the dipole is set to $1m$. The formulas shown in slide 34 are used to compute the radius a for the two different conditions. The values of a obtained are $0.2mm$ and $10mm$. Aside from this, since the length of the dipole is $l = 1m$, which is $\frac{\lambda}{2}$, the center frequency, f_0 is $\frac{300\times10^6}{2} = 150MHz$. Based on these conditions, the FEKO simulations are carried out, which leads to the following plot.

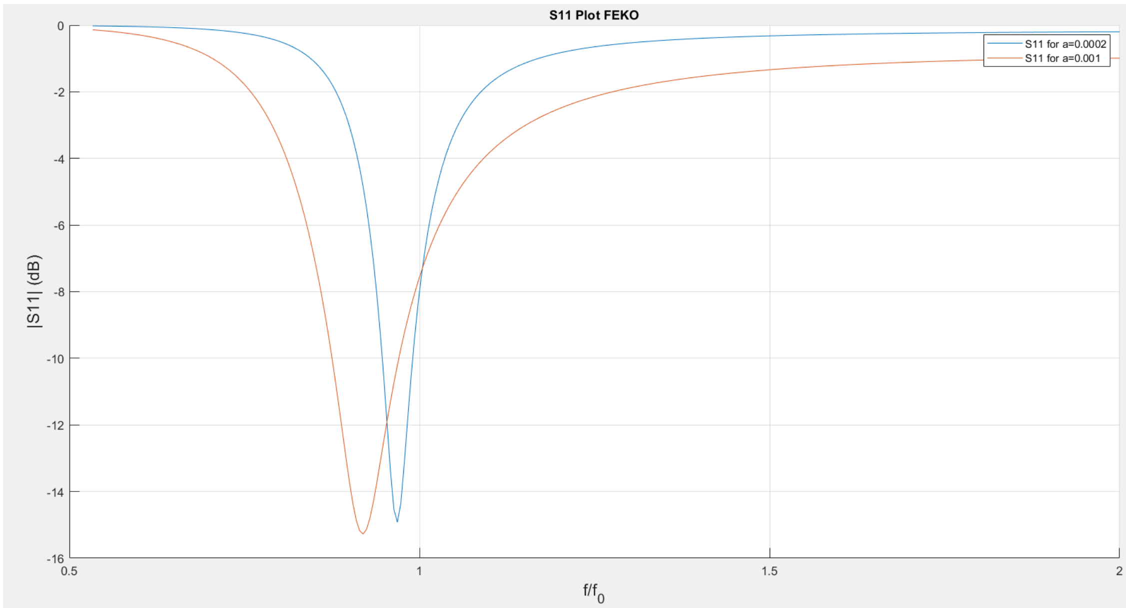

Figure 2: The S_{11} plot from FEKO for different wire thickness.

In the above plot, we can see that the resonant frequencies for $a = 0.2mm$ and $a = 10mm$ are $145.4MHz$ and $137.7MHz$ respectively. With the same conditions, the S_{11} is plotted in HFSS.

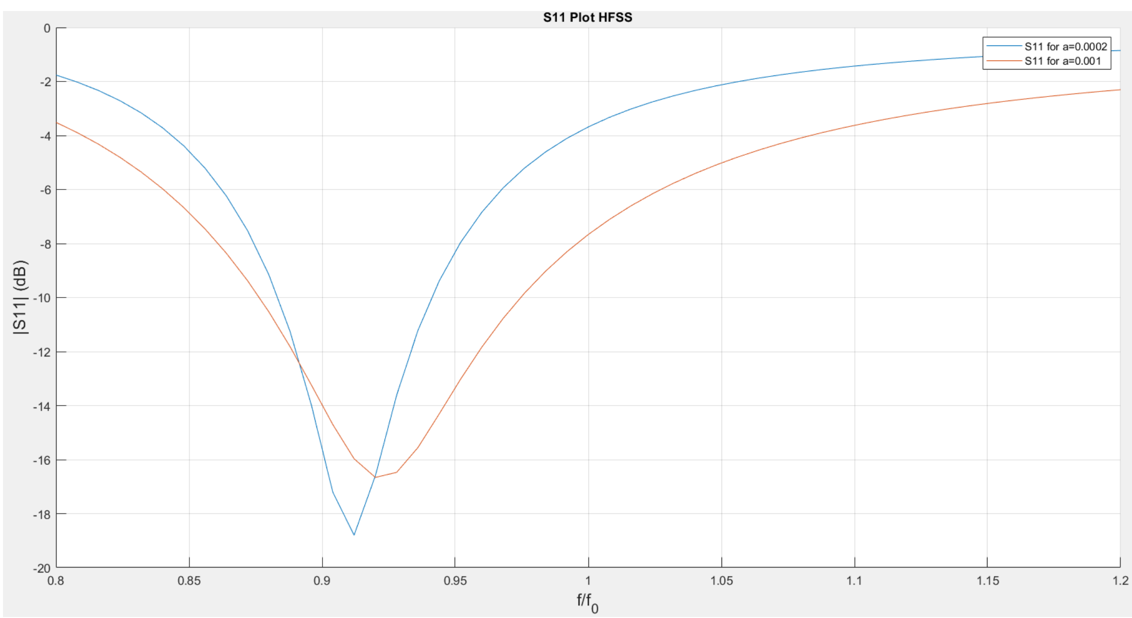

Figure 3: The S_{11} plot from HFSS for different wire thickness.

If we look at the HFSS plot, we can see that it does not quite match the patterns in FEKO. The resonant frequency for $a = 10mm$ is more or less the same as in FEKO. However, for $a = 0.2mm$ the resonant frequency is lower. It is possible that the HFSS solver made an error in this case, since the FEM method used by HFSS is not suitable for simulating a thin dipole.

Please note that it each time I had to simulate for the thin dipole, I had to wait approximately 20 minutes, and even then I could not get the data trend to match FEKO. It is possible that something is wrong with my HFSS settings, but I simply could not find the issue and ran out of time on this.

In spite of this difference, we can still see an expected trend in both FEKO and HFSS. As the radius of the wire dipole is increased, the bandwidth also increases. We can observe this if we look at the following table.

Software	a (mm)	**Resonant (MHz)**	**Below 10dB Range (MHz)**	**Bandwidth (%)**
FEKO	0.2	145.1	142.1 – 148.5	4.41
FEKO	10	137.9	131.3 – 145.4	10.22
HFSS	0.2	136.78	132.48 – 141.20	6.38
HFSS	10	138	131.17 – 145.85	10.64

Table 1: Data from the S_{11} plots.

In the case of $a = 10mm$, both FEKO and HFSS lead to the approximately the same bandwidth. However, they differ for $a = 0.2mm$, where FEKO displays a bandwidth of 4.41%, while HFSS shows a bandwidth of 6.38%.

Nevertheless, while there might be a mismatch between the resonant frequencies when comparing the S_{11} from FEKO and HFSS, especially at $a = 0.2mm$, we can clearly see that the bandwidth increases along with the wire thickness. Hence, the objective of this problem is fulfilled.

3 Problem (c)

For this part of the problem, in the simulation setup, we use a PEC plane and a Hertzian dipole that is vertically polarized (perpendicular to the PEC). In FEKO simulations are done by varying the height, h, between the dipole and the PEC plane. Radiation patterns are plotted for $h = 2\lambda$ and $h = 5\lambda$. It should also be noted that the simulation frequency is $150MHz$, therefore, $\lambda = 2$.

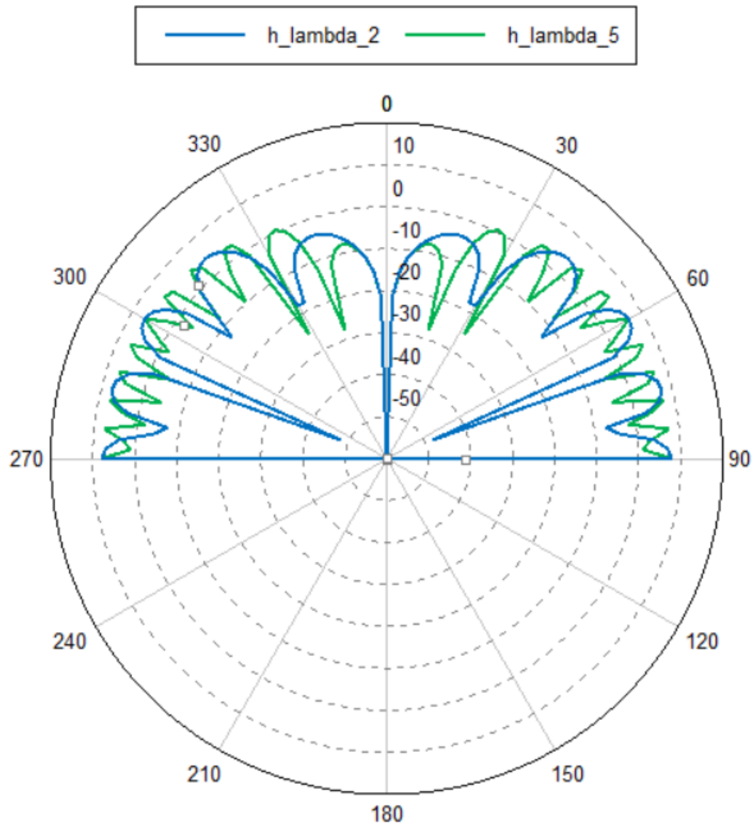

Figure 4: Radiation patterns on the PEC for $h = 2\lambda$ and $h = 5\lambda$.

By looking at the above polar plot, we can observe that the radiation plots of the dipole for the different h are cut-off from $\theta = 90°$ to $\theta = 270°$. This shows that there is no E-field below the PEC plane. The plot above matches exactly the one shown in slide 54. As h increases, the number of lobes also increases by the following equation.

$$\text{Number of Lobes} = 2 \times \left(\frac{h}{\lambda}\right) + 1 \tag{3}$$

4 Problem (d)

The radiation pattern for the horizontally polarized dipole on a PEC plane is shown below.

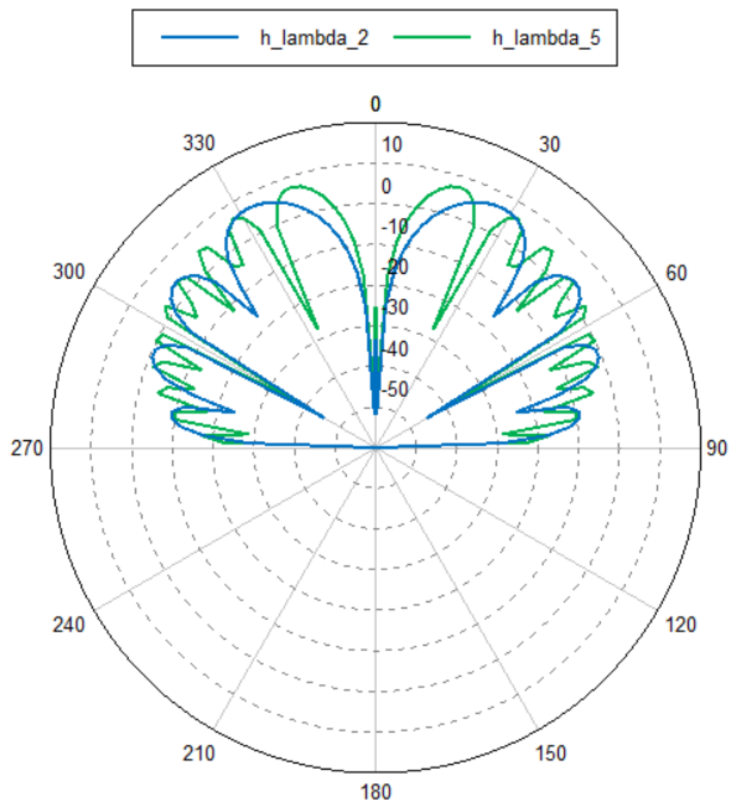

Figure 5: Radiation patterns of the horizontally polarized dipole on the PEC.

The plot above matches that of slide 64. Like the previous subsection, the number of lobes increases with h. Based on the above plot we can see that the number of lobes align with the following equation, which is meant for horizontally polarized dipoles.

$$\text{Number of Lobes} = 2\left(\frac{h}{\lambda}\right) \tag{4}$$

In the above plot we see that there is an approximate null at $\theta = 0°$. This happens primarily due to the 180° phase shift of the horizontal E-field on the PEC plane (in image theory, compared to the horizontal E-field source, the reflected E-field travels in the opposite direction). As a result of the 180° phase shift, there is destructive interference.

However, if we replace the PEC with a PMC plane, we get a large lobe at $\theta = 0°$. Using image theory, we determine that the horizontal E-field has no phase change on the PMC (the actual and reflected E-field are in the same direction). As a result, we get constructive interference, which leads to a lobe at $\theta = 0°$. These properties are illustrated in the following plot.

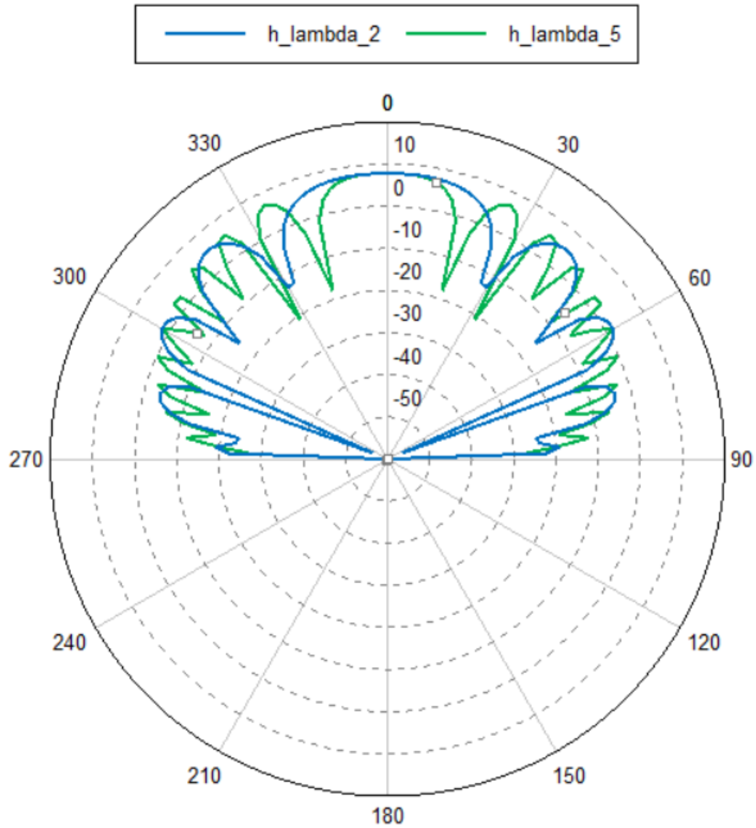

Figure 6: Radiation patterns of the horizontally polarized dipole on the PMC.

Besides this the obvious difference at $\theta = 0°$, the radiation plot for the PMC seems to have the same number of lobes as the PEC.