ASSIGNMENT 11

(due Thursday December 15, 2022)

NOTE: Please submit: (1) a single PDF with your answers, calculations and requested plots for both problems, and (2) the FEKO *.cfx files for both problems.

1. (50 points) Create in *FEKO* a project for a 6-turn circular loop antenna of closely spaced turns operating at $f_0 = 50$ MHz. The radius of the loop is $\lambda/30$. The loop is fed by a 50-Ω voltage source. The radius of the wire is $\lambda/300$ and the spacing between the turns is $\lambda/100$. The wire is made of copper. You can easily create the 6-turn loop using the "helix" utility under the tab "Construct" in CADFEKO. To excite the 6-turn loop, connect the two ends of the loop by a 3-piece "polyline" and put a port (with the voltage source) in the middle of the wire polyline. Make sure that the feed wire does not intersect the loop turns. For best results, the excitation vertical wire should be inside the loop antenna.

A. Report the following antenna parameters in your assignment report:
   (a) the maximum directivity of the antenna along with a 3-D directivity plot;
   (b) the radiation efficiency;
   (c) the gain of the antenna along with a 3-D gain plot;
   (d) the complex input impedance of the loop.

B. Set the internal impedance of the voltage source to be equal to the resistance $R_{in} = \mathrm{Re}\, Z_{in}$ of the 6-turn loop. Insert a lumped capacitor at the loop terminals in series with the loop. Calculate the capacitance so that it cancels the loop's inductive reactance (see your solution to part A-d) at f_0 = 50 MHz. If necessary, optimize the capacitance value for zero input reactance. Simulate the project and report the following:
   (a) the input impedance of the so tuned loop;
   (b) the radiation efficiency.

C. Calculate analytically the radiation resistance R_r of the loop bearing in mind that it is a small loop antenna; see equation (12.10) in Lecture 12.

D. Calculate analytically the loss resistance R_l of the loop using formula (12.32) in Lecture 12 along with the plot of the ohmic resistance due to proximity (page 15 in Lecture 12).

E. Calculate analytically the antenna efficiency using your answers in parts C and D. Does it agree with the efficiency obtained from the simulation?

2. (50 points) Analyze (using *FEKO*) a circular loop antenna whose circumference is $C = 2\pi a = \lambda$ and whose wire radius b is such that $\Omega = 2\ln(C/b) = 10$. Assume frequency of $f_0 = 300$ MHz. Plot the 3-D field magnitude pattern as well as the gain patterns in the two orthogonal principal planes and the plane of the loop at f_0. Obtain and plot the input resistance and reactance of the loop versus frequency from $0.7 f_0$ to $1.3 f_0$. Do these plots agree with Storer's prediction (see Lecture 12)? Optimize the antenna for best impedance match to a 150-Ω load at f_0. What is the circumference of the optimized antenna?