EECS 3604 Lab 2 : Maxwell's Integral Equations

Submission details: Write your responses to the following questions and submit them electronically as a lab report, along with any code that you write. If your responses are handwritten, scan them for electronic submission. Submission is via Moodle. Due date: February 22, 2016.

Grading details: 70% of your lab grade is for correctly completing the lab requirements; 20% is for clear writing and good presentation, including readable and well-documented code; 10% is for extra work or analysis that expands on or goes beyond the lab requirements.

Note: You may complete this lab in python (using numpy) instead of MATLAB if you wish.

Lab part 1: In this lab we will use the integral form of Faraday's law

$$\oint_C \vec{E} \cdot d\vec{\ell} = -\frac{\partial}{\partial t} \int_S \vec{B} \cdot d\vec{S} \tag{1}$$

where S is a surface, and C is the closed contour around that surface. Recall that $\oint_C \vec{E} \cdot d\vec{\ell}$ is equal to the electromotive force (i.e., voltage) around the loop C.

Given the following:

- Let C represent a rectangular loop of wire in the x-y plane, with corners $(-x,-y)$ and (x,y); further, S is the surface enclosed by this loop. (As always, the vector $d\vec{S}$ is perpendicular to the surface at each point.)
- Let $\vec{B} = \hat{z}\cos(4\pi(x+y))\sin(8\pi t)$.

Your task is to write a MATLAB function, `faraday(x,y,t)`, which numerically calculates the integral on the right side of (1), and obtains the voltage gain around the loop of wire at time t. Plot voltage with respect to time for various x and y.

Lab part 2: In this part, at $t = 0$ the loop of wire is again in the x-y plane with corners $(-x,-y)$ and (x,y). However:

- Let $\vec{B} = \hat{z}$, i.e., $\vec{B}$ is a constant, non-oscillating field in the $\hat{z}$ direction.
- The loop of wire is *rotating about the x axis*, at a rate of r revolutions per second.

Your task is to write a MATLAB function, `faraday_r(x,y,t,r)`, which numerically calculates the integral on the right side of (1), and obtains the voltage gain around the loop of wire at time t. *If you wish, you may numerically calculate both the surface integral and the time derivative.* Plot voltage with respect to time for various x, y, and r.

Ideas for the extra work portion. Doing any one of the following would qualify you for the 10% "extra work" grade:

- A different (complicated!) shape of the wire loop
- Rotating loop in the presence of a changing field
- Write new functions to calculate Ampere's law, with a nonzero current density
- Other components of comparable difficulty (ask the instructor if unsure)