ECE5430/6430 - Homework 9 Answer Key

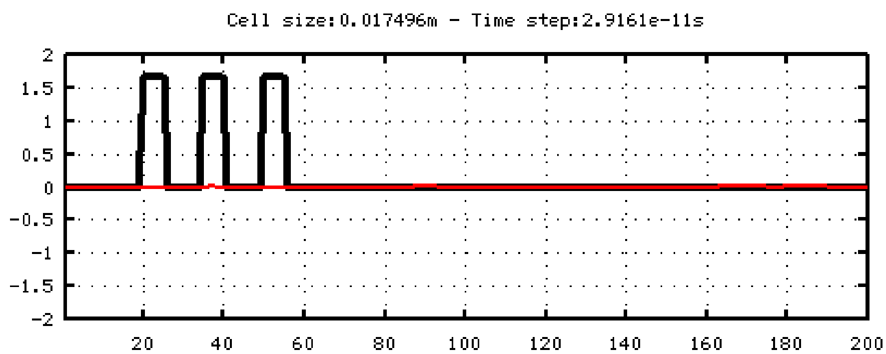
C. J. Cela, March 2010

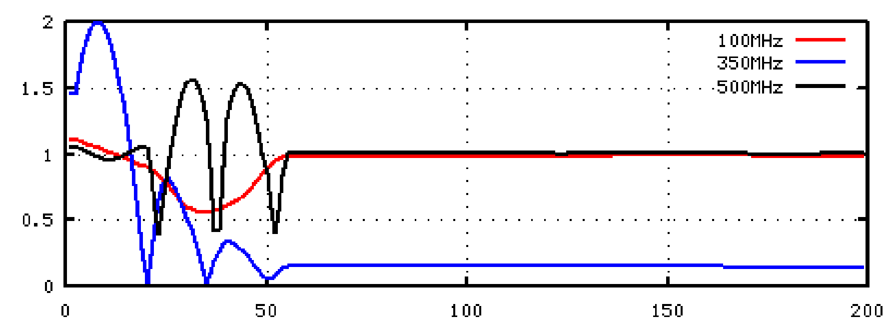
Problem 1:

Note: Use code with the D-H formulation for this simulation.

1. (50 points) Using dielectric slabs of er = 6 and σ = 0, construct a filter that when illuminated by a narrow Gaussian pulse attenuates the electric field at a frequency of 350Mhz to less than 30% of the value present in the incoming waveform. Report: code used, number of slabs and thickness of each (in cells and meters, include calculations and rationale), E field plots supporting your results (time and frequency domain).

On a slab having er=6 in vacuum, the reflection coefficient of the 2nd interface (from inside the slab onto vacuum) will be negative. Because of this, if the slab has a thickness of a quarter wavelength for a frequency of 350MHz, the reflected portion will add to the incoming waveform creating destructive interference for the 350MHz components at the zone before the dielectric slab.





Grading key (points deducted):

- Using a lossy of dispersive formulation (chi or sigma != 0): -10
- Frequency not 350MHz, or cell size too large (> 3.4 cm) : -20
- Attenuation less than 70%: -15
- Source not Gaussian pulse: -10
- Incorrect or missing plot: up to -20, at grader's discretion.
- Other issues: At grader's discretion.

2. (10 points) For the previous problem, and using simulations, determine what is the minimum separation (in cells) between slabs? Can the slabs be in contact with each other? Why?

While the slab separation has an effect on the attenuation, the minimum separation in cells is one cell, as we need the interface to produce a reflection. Because of this, the slabs cannot be in contact with each other.

Grading key (points deducted):

At grader's discretion.

3. (40 points) Modify the code in the problem so the material properties for each cell (model) and the source location can be read from an ASCII file. Report the code added to read the information, an example set of model file(s), and a time and frequency domain plot of the simulation.

The code must now read 3 variables/arrays:

1) The vector sigma()
2) The vector er()
3) The z-coordinate where to place the source

These values can be read from one of more files, using the Matlab/Octave function "load" or the C-library function fopen, fread, fclose.

Example:

To load sigma, er, and the position of source from 3 different ASCII files called permittivity.txt, conductivity.txt, and source.txt:

```
sigma = load("conductivity.txt");
er = load("permittivity .txt");
sourcepos = load("source.txt");
```

The files can be created in any text editor, and should have just one value (for the source), or one value per cell of the model (for the other files).

Grading key (points deducted):

Code does not read model: -10
Code does not read source location: -10
Missing input file (model and/or source): -10
Missing plot (should match plot on part 1): -10
Conductivity or permittivity values are missing (i.e. not one per cell): -10
Other issues: At grader's discretion.

Problem 2 (Extra credit):

1. On your own words: Describe what electric polarization inside a material is, and how it is related to permittivity.

Electric polarization is a slight relative shift of positive and negative electric charge in opposite directions within a dielectric, induced by an external electric field. The permittivity of a material is a value that characterize the tendency (or not) of the material to become electrically polarized.

Grading key:
+1 in HW9/extra credit column if answer correct.

2. On your own words: Describe what is the difference between a non- lossy dielectric medium, a lossy dielectric medium, and a lossy dispersive medium in terms of EM propagation.

Non- lossy dielectric medium: Wave is not attenuated by the medium, energy is not transformed from EM to other kinds (i.e. thermal).

Lossy dielectric medium: Waveform is attenuated as it travel through the medium, as EM energy is transformed into heat.

Lossy dispersive medium: Components of different frequencies travel at different speed inside dispersive medium, producing waveform distortion as seen in time domain.

Grading key:
+1 in HW9/extra credit column if answer correct.

3. Read Yee's paper. What type of materials (non-lossy dielectric medium, a lossy dielectric medium, and a lossy dispersive medium) can be treated using the formulation used in that article?

Non-lossy dielectric medium.

Grading key:
+1 in HW9/extra credit column if answer correct.