Homework 8
EE691-82 Applied EM- FDTD Method, Spring 2012
Friday, April 13, 2012

1) Determine the FDTD update equations for the electric field components $\mathcal{E}_x$, $\mathcal{E}_y$, & $\mathcal{E}_z$ (based on 9.43) and the auxiliary variables $\mathcal{J}_x$, $\mathcal{J}_y$, & $\mathcal{J}_z$ (based on 9.39) for the case of a single pole Debye dispersive medium in terms of τ_1, $\Delta\varepsilon_1$, β_1 and k_1. Use the Yee cell indices/locations as shown in Figure 1b (i.e., those shown centered on visible cell faces) of the Chapter 3 notes.

2) For the case of a medium-wet soil at 70°F (take average of the values for the medium and wet soils given in the notes), determine and plot the overall relative permittivity ε_r and conductivity σ versus frequency for the range $0.01 \le f \le 100 \text{ GHz}$. Further, given that the propagation constant is defined as $\gamma = \sqrt{j\omega\mu(\sigma + j\omega\varepsilon)} = \alpha + j\beta$ and that phase velocity is defined as $v_p = \dfrac{\omega}{\beta}$, plot the phase velocity versus frequency for $0.01 \le f \le 100 \text{ GHz}$. Assume the soil is non-magnetic and note that σ and ε are both functions of frequency. For all the plots, use a logarithmic scale for the frequency axis and label minimum and maximum values. Also, use a logarithmic scale for the vertical axis for the conductivity plot. Label the maximum and minimum values on each plot.

3) Using the results of 1) and 2), determine the time step Δt and the FDTD update equations (auxiliary, electric, and magnetic) for the case of the medium-wet soil. Assume a Courant stability factor of $S = \dfrac{v_p \Delta t}{\Delta} = 0.5$ and a cubic lattice ($\Delta = 4 \text{ mm}$). Base the time step Δt on the worst case phase velocity v_p in the frequency range (i.e., the phase velocity resulting in the shortest wavelength). The coefficients in the update equations should be constants, i.e., only variables should be $E_?$, $J_?$, $H_?$, and the time & spatial indices.

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Due Wednesday, April 18, 2012