**EE 389 – HW 15**

Due May 8, 2008

In this homework assignment you will look at the effects of a lossy transmission line. A 50 Ω RG58 cable is lossy at frequencies of about 100 kHz and lower. We will want to simulate frequencies from about 10 Khz to 100 kHz. To see what happens, we will need about ten wavelengths of a 10 kHz signal on the transmission line, so the line length will need this long (10 wavelengths of a 10 kHz signal). To properly simulate a 100 kHz signal, we need about 10 points per wavelength, so $\Delta x$ will need to be about one tenth of the wavelength of a 100 kHz wave.

1. Start with the field equations for $V$ and $I$ on a lossy transmission line:

$$\begin{aligned}\frac{\partial v}{\partial x} &= -L\frac{\partial i}{\partial t} - Ri \\ \frac{\partial i}{\partial x} &= -C\frac{\partial v}{\partial t} - Gv\end{aligned}$$

   where $L$ is the inductance per unit length, $R$ is the resistance per unit length, $C$ is the capacitance per unit length, and $G$ is the conductance per unit length. Develop a set of FDTD equations to simulate the signals on the line. (The equations will look somewhat like those on the top of page 10 of the handout "Electromagnetic Simulation using the FDTD Method".)

2. Modify your program include the effects of $R$ and $G$ on the signal. With a source on the left hand side of the transmission line, show how the signal propagates down the line for a 10 kHz signal and a 100 kHz signal. For the transmission line properties, use the characteristics of a typical RG-58 cable: $C = 101$ pF/m, $L = 252.5$ nH/m, $R = 0.028$ Ω/m, and $G = 5.91 \times 10^{-14}$ S/m. Verify that the amplitude of the signals decays with distance according to the formula $e^{-\alpha x}$, where $\alpha$ is the real part of

$$\gamma = \sqrt{(G + j\omega C)(R + j\omega L)}$$

   Also, verify that the wavelength is $2\pi/\beta$, where $\beta$ is the imaginary part of $\gamma$.

3. Modify your program to show what happens when a signal goes from a transmission line with one characteristic impedance to another. Let the left side of the array be an RG-58 cable with a characteristic impedance of 50 Ω, and the right side be an RG-59 a characteristic impedance of 75 Ω. (For RG-6, use $C = 67.3.1$ pF/m, $L = 377.3$ nH/m, $R = 0.161$ Ω/m, and $G = 5.91 \times 10^{-14}$ S/m. Put a hard sinusoidal source at the left hand side of the array.

   Show what happens for a 10 kHz and a and 100 kHz signal.

4. Your final program should do the following:

   (a) Ask whether you have a single transmission line, or two transmission lines joined in the middle.

   (b) Ask for the parameters of the transmission line(s): $L$, $C$, $R$ and $G$.

(c) Ask for the length of the transmission line, and the frequency of the input signal.

Your program should calculate the number of cells needed (to have twenty wavelengths of the signal on the line, and to have at least ten points per wavelength), and display a simulation of the wave on the transmission line.