ECEU574 Wireless Communication Circuits Spring, 04
Assignment 5 Prof. Brady

1. Transatlantic Cable. The transatlantic cable was laid in approximately 1865, and had a length $l = 3600km$. The following transmission line parameters hold for the cable over the frequency range of interest (10-1000Hz): $L = 460nHm^{-1},\ C = 75pFm^{-1},\ R = 0.007\Omega m^{-1}$, and $0 < G << C$.

a. Heaviside's Fix. Determine whether or not the cable may be considered to have no dispersion, using Heaviside's condition. Does the condition hold? Show your work.

b. High-Reactance Approximation. Determine whether or not the cable may be considered to have no dispersion using the high-reactance approximation. Does the high-reactance condition hold? Show your work.

c. Attenuation and phase functions. Start with the expression for jk from the notes, and determine approximate formulas for its real part (attenuation α) and imaginary part ('phase constant' β). Use the fact that $0 < G << C$, and $\sqrt{\frac{r}{j}} = \sqrt{r}(1-j)$ for any real number r. Does the term 'phase constant' apply to the expression for β?

d. Phase velocity. Determine an expression for the phase velocity v.

e. Total attenuation. Determine an expression for the total attenuation (over the entire cable length). What is the relative attenuation of a signal at $1kHz$ relative to one at $10Hz$ (in dB)?

f. Ideal phase delay. The ideal phase transfer function (radians versus frequency) of any linear time-invariant system should be linear in f. How does the phase delay (seconds versus frequency) of the same system vary with f?

g. Actual phase delay. The expression for the total phase delay of the transatlantic cable is $\theta = \frac{l}{v}$, where v is the phase velocity from part d, and l is the cable length. How far from ideal is the transatlantic cable at $1kHz$, using $10Hz$ as the reference? Express your answer as a percentage.

h. Cable repair. Engineer a solution for the dispersion and distortion of the transatlantic cable which could be implemented prior to deployment, based on class notes. You may use only passive components. Support your proposal with calculations. Specify the implementation, and the resulting expressions for attenuation and phase delay.