ECE 391: Suggested Homework Problems

Lossy Lines

1. The voltage amplitude of a sinusoidal wave at the input of a 200m long transmission line is $V_{in} = 5V$. The far end of the line is matched (no reflected waves are excited) and the voltage is measured as $V_{out} = 3V$.
   (a) What is the attenuation in dB/m
   (b) What is the attenuation in Np/m

2. A 100 meter long coaxial cable has a specified attenuation constant of $\alpha = 0.05dB/m$ and is driven by a 8Vpp AC source. The end of the cable is terminated in $R_t = Z_o$.
   (a) Specify the attenuation constant in dB/cm, Np/m, and dB/100ft
   (b) What is the voltage amplitude at the end of this cable?

3. Given a 250Ω distortionless transmission line with $\alpha = 0.02dB/m$ and $L = 0.01uH/cm$. Determine $R$, $G$, $C$ and $v_p$.

4. The following data are specified at $f = 200$KHz for a given transmission line:
   $Z_0 = (52 - j0.4)\Omega$
   $\alpha = 5 \times 10^{-3}dB/m$
   $\beta = 8.3776 \times 10^{-3}rad/m$
   (a) Determine the R, L, G, and C transmission line parameters
   (b) Wavelength
   (c) Phase velocity

5. Consider the transmission line circuit shown below. The transmission line is a coaxial cable of type RG-58A with characteristics as shown in figure 2.

![Diagram of transmission line circuit](image)

Figure 1: Problem 4
(a) Determine the characteristic impedance, propagation velocity, and attenuation constant (in dB/m) of the cable.
(b) Determine the first three parallel resonant frequencies for the shorted cable. Show your calculations and results.
(c) Using ngspice in ac simulation mode, simulate the ideal transmission line circuit (neglecting losses) from f = 1 MHz to f = 1 GHz and show the first three parallel resonant frequencies.
(d) Now, model the transmission line more accurately using the lossy transmission line model in ngspice. The Oxxx element takes the model name LTRA as an argument. For more information, see the ngspice manual. An example spice file input for the lossy line is:

```
O1 t1 in 0 t1 out 0 LOSSYMOD
.MODEL LOSSYMOD LTRA R=0.035 L=2.52n G=0 C=102.4p len=0.3
```

Here, t1_in is the input, t1_out is the output (just like with the Txxx element), and len is the physical length of the transmission line in meters. To plot the magnitude and phase of the input impedance, Z_{in}(f), use the following spice netlist statements:

```
plot (vm(t1 in)/(vm(vin,t1 in)/50)) ; to plot magnitude of Zin\nplot (vp(t1 in)-vp(vin,t1 in))*180/3.1415 ; to plot phase of Zin (in DEG)\n```

Here, vin is the positive output node of the source. Compare the magnitude and phase of Z_{in}(f) and comment on your observations.
(e) Now, suppose the shorted transmission line is replaced with a parallel LC resonant circuit. First, determine the capacitance required to resonate a 40nH inductor at the first resonant frequency found with the T-line circuit. Simulate in ngspice. Show all your calculations for the LC resonant circuit.

6. An open-circuited lossy transmission line is excited with a short 9V pulse of duration $T << t_d$, where $t_d = 0.5\mu\text{sec}$ is the delay time of the line. The propagation velocity is $v_p = 20\text{cm/ns}$. The transmission line is matched at the source side.

![Figure 2: Problem 6](image)

(a) What is the attenuation constant $\alpha$ in nepers/m if the amplitude of the pulse reflected from node B is received back at node A with an amplitude of 3V?
(b) If the attenuation constant is $\alpha = 0.01 Np/m$, what is the attenuation constant in dB/m, dB/100ft and Np/cm?
(c) For $\alpha = 0.01 Np/m$, how much is the voltage amplitude of the pulse attenuated after traveling from the near end to the far end of the line, assuming the line is 50m long? Give your answer in nepers, dB, and in percent.
A source terminated $2V_{rms}$ AC source drives a 75 Ω transmission line with a loss $\alpha = 0.1 \frac{dB}{m}$. The end of the transmission line is terminated in a 6dB (voltage gain) amplifier that has a input impedance, $Z_{in} = 75Ω$. The output of this amplifier drives a 75Ω resistive load. Determine:

a) The RMS voltage at point B
b) The RMS voltage at point C
c) The power delivered to the 75Ω load in dBm.
d) The overall voltage gain or loss (in dB) from point A to point C