ECE 5317/6351

Microwave Engineering

Fall 2019

Homework #1

Text: *Microwave Engineering* by David M. Pozar, 4th edition, Wiley, 2011

All plots should be made accurately and neatly (using a plotting software of your choice), with axes properly labeled.

In all problems the transmission line is lossless and the filling material is nonmagnetic, unless the problem states otherwise.

Problems from the Pozar book (4th Ed.):

2.3, 2.5, 2.7, 2.8, 2.9, 2.11, 2.12, 2.14, 2.16, 2.17, 2.19, 2.24.

(Please see the notes on the next page.)

Extra problems:

E1) A coaxial cable used for cable TV has a characteristic impedance of 75 Ω. The cable is filled with polyethylene, which has a relative permittivity of 2.25 and a loss tangent of 0.0004. Find the parameters (L, C). Also, find the parameter G at 1.0 GHz. If the manufacturer says that the attenuation is 0.204 dB/m at 1 GHz, find the value of R at this frequency. Hint: you can solve for R using "trial and error", searching for the value of R that will give you the correct attenuation.

E2) For the same cable as in Prob. E1, find the parameters (L, C, G, R) at 10 GHz. Hint: From the formulas for G and R, note how they vary with frequency, so you can use your results from Prob. E1.

E3) For the same cable as in Prob. E2, find the attenuation in dB/m at 10 GHz.

Notes:

1) In Prob. 2.3, assume that the conductivity of copper is $\sigma = 5.8 \times 10^7$ S/m and the loss tangent of the Teflon is 0.0004. Take the relative permittivity of the Teflon as 2.1. Use the formulas in Notes 3 for the coax to solve for the (R, L, G, C) parameters.

2) In Prob. 2.5, start from basic electrostatic and magnetostatic principles, as was done in Notes 3 for the coax. Assume a vertical electric field in the -y direction that is uniform, and a horizontal magnetic field in the x direction that is also uniform. That is, assume

$$\underline{E} = -\underline{\hat{y}}E_0, \quad \underline{H} = \underline{\hat{x}}H_0 .$$

Note that the surface charge density ρ_s on the lower surface of the top plate can be found from

$$\rho_s = \underline{D} \cdot \underline{\hat{n}} = \underline{D} \cdot \left(-\underline{\hat{y}}\right).$$

Also, the magnetic field $\underline{H}$ inside the structure is related to the surface current $\underline{J}_s$ flowing on the lower surface of the top plate as

$$\underline{J}_s = \underline{\hat{z}}J_{sz} = \underline{\hat{n}} \times \underline{H} = \left(-\underline{\hat{y}}\right) \times \underline{H} .$$

Calculate R by using the same formula as in Notes 3 for the coax, but use the width w in place of the circumferences $2\pi a$ and $2\pi b$.

3) In Prob. 2.14, the “50 Ohm transmitter” means that the Thévenin impedance of the transmitter is 50 Ohms.

4) In Prob. 2.16, note that RMS is being used instead of peak phasor notation (like we use in the class notes).

5) In Prob. 2.19, λ means λ_g, which is the same as λ_d since the line is lossless. In your plot, you can choose the plotting variable to be z / l.