EE381 Homework 2

Due Date: 02/03 At the beginning of class

These problems exercise/test your knowledge of: (1) the transmission line model concept; (2) modeling specific and popular types of transmission lines; (3) calculating voltages, impedances, power dissipation; (4) also included is an interesting problem on the design of a distortionless line—something that is important not only for microwave transmission lines, but also very important for fiber-optic based optical communication/data transmission systems.

2.2 Ulaby 7th Edition

2.2 A two-wire copper transmission line is embedded in a dielectric material with $\epsilon_r = 2.6$ and $\sigma = 2 \times 10^{-6}$ S/m. Its wires are separated by 3 cm, and their radii are 1 mm each.

(a) Calculate the line parameters R', L', G', and C' at 2 GHz.

(b) Compare your results with those based on CD Module 2.1. Include a printout of the screen display.

2.6 Ulaby 7th Edition

2.6 A coaxial line with inner and outer conductor diameters of 0.5 cm and 1 cm, respectively, is filled with an insulating material with $\epsilon_r = 4.5$ and $\sigma = 10^{-3}$ S/m. The conductors are made of copper.

(a) Calculate the line parameters at 1 GHz.

(b) Compare your results with those based on CD Module 2.2. Include a printout of the screen display.

2.13 Ulaby 7th Edition

2.13 In addition to not dissipating power, a lossless line has two important features: (1) it is dispersionless (u_p is independent of frequency); and (2) its characteristic impedance Z_0 is purely real. Sometimes, it is not possible to design a transmission line such that $R' \ll \omega L'$ and $G' \ll \omega C'$, but it is possible to choose the dimensions of the line and its material properties so as to satisfy the condition

$$R'C' = L'G' \qquad \text{(distortionless line)}$$

Such a line is called a ***distortionless*** line, because despite the fact that it is not lossless, it nonetheless possesses the previously mentioned features of the lossless line. Show that for a distortionless line,

$$\alpha = R'\sqrt{\frac{C'}{L'}} = \sqrt{R'G'}\,,$$

$$\beta = \omega\sqrt{L'C'}\,,$$

$$Z_0 = \sqrt{\frac{L'}{C'}}\,.$$

2.20 Ulaby 7th Edition

2.20 A 300 Ω lossless air transmission line is connected to a complex load composed of a resistor in series with an inductor, as shown in Fig. P2.20. At 5 MHz, determine: (a) Γ, (b) S, (c) location of voltage maximum nearest to the load, and (d) location of current maximum nearest to the load.

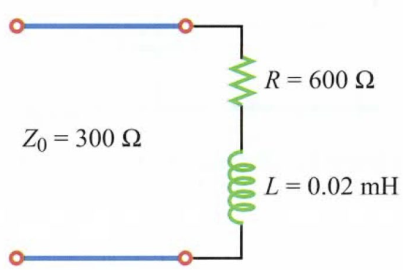

Figure P2.20 Circuit for Problem 2.20.

2.25 Ulaby 7th Edition

2.25 Apply CD Module 2.4 to generate plots of the voltage standing-wave pattern for a 50 Ω line terminated in a load impedance $Z_L = (100 - j50)$ Ω. Set $V_g = 1$ V, $Z_g = 50$ Ω, $\epsilon_r = 2.25$, $l = 40$ cm, and $f = 1$ GHz. Also determine S, d_{max}, and d_{min}.

2.33 Ulaby 7th Edition

2.33 Two half-wave dipole antennas, each with an impedance of 75 Ω, are connected in parallel through a pair of transmission lines, and the combination is connected to a feed transmission line, as shown in Fig. P2.33. All lines are 50 Ω and lossless.

*(a) Calculate Z_{in_1}, the input impedance of the antenna-terminated line, at the parallel juncture.

(b) Combine Z_{in_1} and Z_{in_2} in parallel to obtain Z'_L, the effective load impedance of the feedline.

(c) Calculate Z_{in} of the feedline.

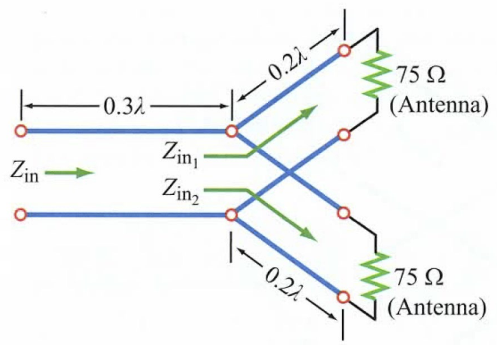

Figure P2.33 Circuit for Problem 2.33.

2.40 Ulaby 7th Edition

2.40 A 100 MHz FM broadcast station uses a 300 Ω transmission line between the transmitter and a tower-mounted half-wave dipole antenna. The antenna impedance is 73 Ω. You are asked to design a quarter-wave transformer to match the antenna to the line.

(a) Determine the electrical length and characteristic impedance of the quarter-wave section.

(b) If the quarter-wave section is a two-wire line with $D = 2.5$ cm, and the wires are embedded in polystyrene with $\epsilon_r = 2.6$, determine the physical length of the quarter-wave section and the radius of the two wire conductors.

2.42 Ulaby 7th Edition

2.42 A generator with $\widetilde{V}_g = 300$ V and $Z_g = 50\ \Omega$ is connected to a load $Z_L = 75\ \Omega$ through a 50 Ω lossless line of length $l = 0.15\lambda$.

*(a) Compute Z_{in}, the input impedance of the line at the generator end.

(b) Compute $\widetilde{I}_i$ and $\widetilde{V}_i$.

(c) Compute the time-average power delivered to the line, $P_{in} = \frac{1}{2}\mathfrak{Re}[\widetilde{V}_i \widetilde{I}_i^*]$.

(d) Compute $\widetilde{V}_L$, $\widetilde{I}_L$, and the time-average power delivered to the load, $P_L = \frac{1}{2}\mathfrak{Re}[\widetilde{V}_L \widetilde{I}_L^*]$. How does P_{in} compare to P_L? Explain.

(e) Compute the time-average power delivered by the generator, P_g, and the time-average power dissipated in Z_g. Is conservation of power satisfied?

2.45 Ulaby 7th Edition

2.45 The circuit shown in Fig. P2.45 consists of a 100 Ω lossless transmission line terminated in a load with $Z_L = (50 + j100)\ \Omega$. If the peak value of the load voltage was measured to be $|\widetilde{V}_L| = 12$ V, determine:

*(a) the time-average power dissipated in the load,

(b) the time-average power incident on the line,

(c) the time-average power reflected by the load.

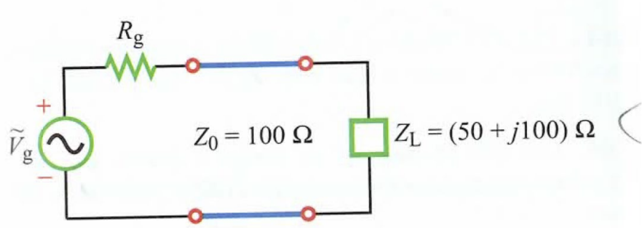

Figure P2.45 Circuit for Problem 2.45.