CMPE 330 **Spring 2017** **Problem Set #3**

NOTE: You must show complete work for full credit. When nothing else is stated, report two significant figures.

1. A transmission line operating at 125 MHz has $Z_0 = 40\ \Omega$, $\alpha = 0.02$ Np/m, and $\beta = 0.75$ rad/m. Find the line parameters R', L', G', and C'. Find u_p. This parameter set almost certainly cannot correspond to a real physical system. Why? [modified from Ulaby and Ravoioli 2.16, p. 125.]

2. A 50-Ω lossless transmission line is terminated in a load with impedance $Z_\mathrm{L} = (30 - j50)\ \Omega$. The wavelength is 10 cm. Determine: [modified from Ulaby and Ravaioli 2.19, p. 125.]

   a. The reflection coefficient at the load.

   b. The standing wave ratio on the line.

   c. The position of the maximum voltage nearest the load

   d. The position of the current maximum nearest the load

   e. Verify the quantities in parts (a)–(d) using the CD module 2.4 in Ulaby et al. Include a printout of the screen display.

3. *Please report three significant figures in the following problem, which means that you should keep at least four in your calculations.* Consider a transmission line operating at 1.5 GHz with the following parameters, $Z_\mathrm{g} = 50\ \Omega$, $Z_0 = 50\ \Omega$, $Z_\mathrm{L} = (100 + 50j)$ Ω, $v_\mathrm{p} = 1.5 \times 10^8$ m/s, $l = 24$ cm, $v_g(t) = 10\cos(\omega t)$ (V).

   a. Find the values for ω and ϵ_r. Find the normalized load impedance $z_\mathrm{L} = Z_\mathrm{L}/Z_0$.

   b. Find $|\Gamma|$, θ_r, S (the standing wave ratio), and l_max and l_min (the locations of the first voltage maximum and minimum from the load).

   c. Find the input impedance Z_in, the incident wave voltage V_0^+, and V_max and V_min (the maximum and minimum voltages on the transmission line).

   d. Show that the complete expression for $v(z,t)$ in the transmission line may be written

   $$A\cos(3\pi \times 10^9 t - 20\pi z + \phi_1) + B\cos(3\pi \times 10^9 t + 20\pi z + \phi_2),$$

   and find A, B, ϕ_1, and ϕ_2.

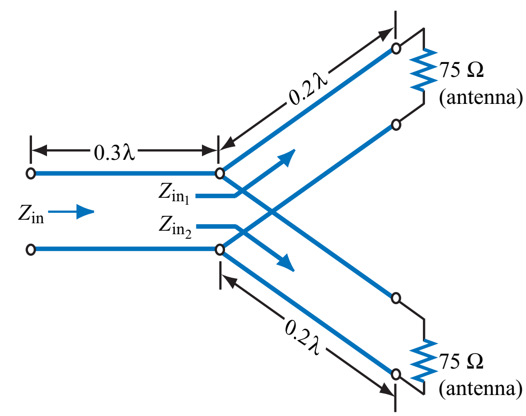
   e. If you look at the time evolution of the peaks of the current and voltage, you can see that the peaks don't move steadily, but instead jump periodically. The formula that governs this motion is given on slide 4.14. One can show that at their fastest, the peaks are moving faster than the speed of light in a vacuum. Why doesn't this motion violate the theory of relativity?

4. 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 in Ulaby and Ravaioli's Fig. P2.33, shown below. All lines are 50 Ω and lossless. [based on Ulaby, et al. 2.33, pp. 126–7.]

   a. Calculate Z_{in1} and Z_{in2}, the input impedances of the antenna-terminated lines at the parallel juncture.

   b. Combine these two impedances in parallel to obtain Z'_{L}, the effective load impedance of the feedline. Is the reactance more capacitive or inductive?

   c. Calculate Z_{in} of the feedline.

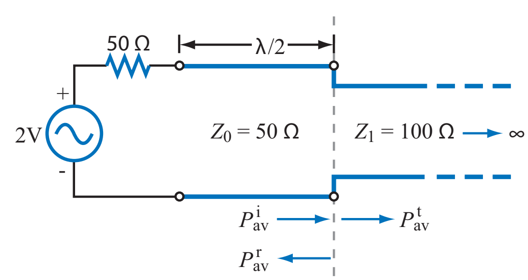


5. A 100-MHz FM broadcast station uses a 200-Ω transmission line between the transmitter and the tower-mounted half-wave dipole antenna. The antenna impedance is 73 Ω. You are asked to design a quarter-wave transformer to match the antenna to the line. [modified from Ulaby and Ravaioli 2.40, p. 125.]

   a. Determine the electrical length and the characteristic impedance of the quarter-wave section. NOTE: You will have to look up the definition of electrical length.

   b. If the quarter-wave section is a two-wire line with a separation between the wires of 3.0 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.

6. For the circuit shown to the right [Ulaby and Ravaioli, Fig. P2.44], calculate the average incident power, the average reflected power, and the average power transmitted into the 100-Ω line. The $\lambda/2$ line is lossless and the infinitely long line is slightly lossy. Note that the input impedance of an infinitely long line is equal to its characteristic impedance as long as $\alpha \neq 0$. Why is it important that $\alpha \neq 0$? [based on Ulaby and Ravaioli 2.44, p. 129.]



7. A 50-Ω lossless line 0.6 λ long is terminated in a load with $Z_L = (50 + j25)\ \Omega$. At 0.3 λ from the load, a resistor with $R = 30\ \Omega$ is connected, as shown in the figure below [Ulaby and Ravaioli, Fig. P2.63]. Find Z_{in} for this circuit.