HW #2

All are at the end of Chapter 2.

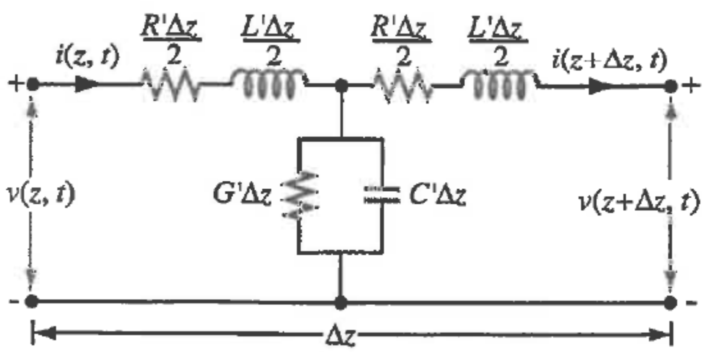
P1. Problem 2.1 in 7/E (i.e. Problem 2.1 in 6/E)

Problem 2.1 A transmission line of length l connects a load to a sinusoidal voltage source with an oscillation frequency f. Assuming the velocity of wave propagation on the line is c, for which of the following situations is it reasonable to ignore the presence of the transmission line in the solution of the circuit:

(a) $l = 20$ cm, $f = 20$ kHz,
(b) $l = 50$ km, $f = 60$ Hz,
(c) $l = 20$ cm, $f = 600$ MHz,
(d) $l = 1$ mm, $f = 100$ GHz.

P2. Problem 2.3 in 7/E (i.e. Problem 2.3 in 6/E; **2.4 in Answer Sheet**).

Problem 2.4 Show that the transmission line model shown in Fig. 2-37 (P2.4) yields the same telegrapher's equations given by Eqs. (2.14) and (2.16).



P3. Problem 2.4 in 7/E (i.e. Problem 2.4 in 6/E; **2.3 in Answer Sheet**). Read Section 2.2 before working on this problem. Use formulas given in Table 2.1, which we do not cover in class. The purpose of this homework problem is for you to learn about transmission lines other than co-ax cables.

Problem 2.3 A 1-GHz parallel-plate transmission line consists of 1.2-cm-wide copper strips separated by a 0.15-cm-thick layer of polystyrene. Appendix B gives $\mu_c = \mu_0 = 4\pi \times 10^{-7}$ (H/m) and $\sigma_c = 5.8 \times 10^7$ (S/m) for copper, and $\varepsilon_r = 2.6$ for polystyrene. Use Table 2-1 to determine the line parameters of the transmission line. Assume $\mu = \mu_0$ and $\sigma \simeq 0$ for polystyrene.

P4. Problems 2.6 & 2.8 (same problems #'s in 7/E & 6/E; **Problems 2.2 & 2.5 in Answer Sheet**). Read Section 2.2 before working on this problem. Use formulas given in Table 2.1, which we do not cover in class. Find properties of copper from the above problem or in Table B2 in Appendix B of the textbook. The purpose of this homework problem is for you to learn about actual (not ideal) co-ax cables.

Problem 2.2 Calculate the line parameters R', L', G', and C' for a coaxial line with an inner conductor diameter of 0.5 cm and an outer conductor diameter of 1 cm, filled with an insulating material where $\mu = \mu_0$, $\varepsilon_r = 4.5$, and $\sigma = 10^{-3}$ S/m. The conductors are made of copper with $\mu_c = \mu_0$ and $\sigma_c = 5.8 \times 10^7$ S/m. The operating frequency is 1 GHz.

Problem 2.5 Find α, β, u_p, and Z_0 for the coaxial line of Problem 2.2.

P5. Problem 2.13 in 7/E (same # in 6/E; **Problem 2.6 in Answer Sheet**).

Problem 2.6 In addition to not dissipating power, a lossless line has two important features: (1) it is dispertionless (μ_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

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

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

$$\alpha = R'\sqrt{\frac{C'}{L'}} = \sqrt{R'G'}, \qquad \beta = \omega\sqrt{L'C'}, \qquad Z_0 = \sqrt{\frac{L'}{C'}}.$$

P6. Problem 2.16 in 7/E (same # in 6/E; **Problem 2.9 in Answer Sheet**).

Problem 2.9 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'.

Hint: This is a lossy transmission line since $\alpha \neq 0$, but Z_0 is purely resistive.

P7. Problem 2.19 in 7/E (i.e. Problem 2.19 in 6/E; Problem 2.12 in Answer Sheet).

Problem 2.12 A 50-Ω lossless transmission line is terminated in a load with impedance $Z_L = (30 - j50)\ \Omega$. The wavelength is 8 cm. Find:

(a) the reflection coefficient at the load,
(b) the standing-wave ratio on the line,
(c) the position of the voltage maximum nearest the load,
(d) the position of the current maximum nearest the load.

P8. Problem 2.17 in 7/E (i.e. Problem 2.17 in 6/E; Problem 2.10 in Answer Sheet).

Problem 2.10 Using a slotted line, the voltage on a lossless transmission line was found to have a maximum magnitude of 1.5 V and a minimum magnitude of 0.6 V. Find the magnitude of the load's reflection coefficient.

P9. Problem 2.21 in 7/E (i.e. Problem 2.21 in 6/E; Problem 2.13 in Answer Sheet).

Problem 2.13 On a 150-Ω lossless transmission line, the following observations were noted: distance of first voltage minimum from the load = 3 cm; distance of first voltage maximum from the load = 9 cm; $S = 3$. Find Z_L.

P10. Problem 2.31 in 7/E (i.e. Problem 2.31 in 6/E; Problem 2.21 in Answer Sheet).

Problem 2.21 A voltage generator with $v_g(t) = 5\cos(2\pi \times 10^9 t)$ V and internal impedance $Z_g = 50$ Ω is connected to a 50-Ω lossless air-spaced transmission line. The line length is 5 cm and it is terminated in a load with impedance $Z_L = (100 - j100)$ Ω. Find

(a) Γ at the load.

(b) Z_{in} at the input to the transmission line.

(c) the input voltage $\widetilde{V}_i$ and input current $\widetilde{I}_i$.