

ELEN 3401 Electromagnetics Problem Set #2

DUE: Friday Feb. 14

Please include your name and UNI on the assignment

Problem 1: Prototype Link

You are testing a prototype link interconnecting a CPU and high-speed memory with a length of 1 cm and for an operating signal frequency of 100 GHz. The link inductance is $L' = 25$ nH/m, and its capacitance is $C' = 1$ nF/m. Determine whether this link needs to be modeled as a transmission line. Provide a rationale.

Problem 2: Characteristic Impedance

Consider a transmission line where both the magnitude and phase of the characteristic impedance Z_0 are known. The voltage or current propagating on the transmission line are not known.

- a. Explain what information can be derived from Z_0 about the magnitude and phase of the voltage and current on the line.
- b. If the imaginary component of Z_0 is nonzero ($\text{Im}[Z_0] \neq 0$), what can be determined about the phase relationship between the voltage and current.
- c. If $\text{Im}[Z_0] \neq 0$, what can be determined about the loss properties of the line.

Problem 3: Voltage and Current on Transmission Lines

Consider a transmission line with a characteristic impedance $Z_0 = 100 \Omega$ ($\text{Im}[Z_0] = 0$). At a given position ($z = z'$) on the line, the voltage amplitude is measured to be 1V: $|\tilde{V}(z')| = 1 \text{ V}$.

- a. Determine what is known about the *total* current on the line.
- b. Sketch the forward-traveling voltage and current waves on the transmission line at a snapshot in time, showing their amplitudes and phases.
- c. Sketch the backward-traveling voltage and current waves on the transmission line at a snapshot in time, showing their amplitudes and phases.

Problem 4: Standing Waves on a Short-circuited Transmission Line

For each of the following characteristics of standing waves on a lossless short-circuited line, find the frequency of the source exciting the line:

- a. The distance between successive nodes of the voltage amplitude is 50 cm and the dielectric is air.
- b. The distance between successive nodes of the current amplitude is 50 cm and the dielectric is nonmagnetic with $\epsilon = 9\epsilon_0$.