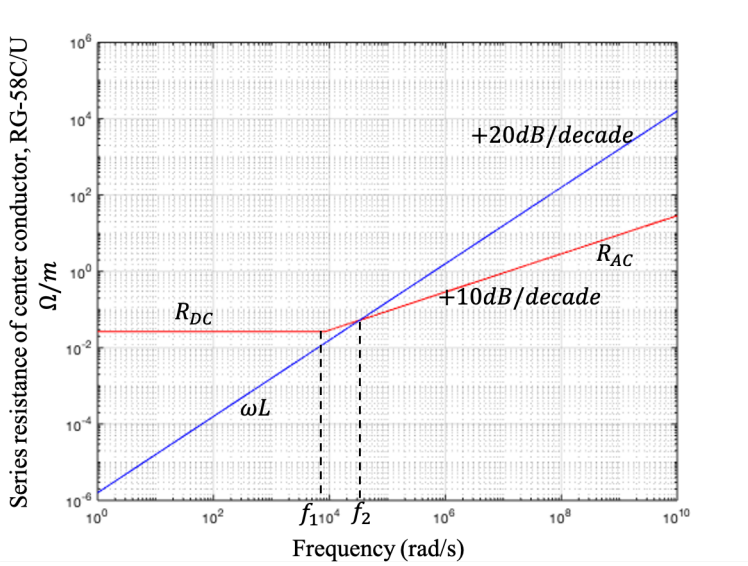
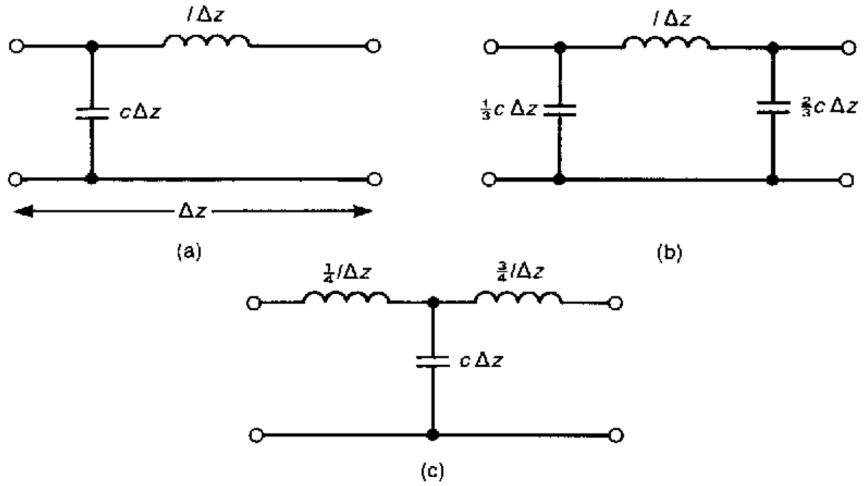
ECE 498YVS-EMC Homework 3 Due: Thursday, Sept. 19, 2024, 11:59PM Central Time

Recommended Reading: Paul: Chapter 4.

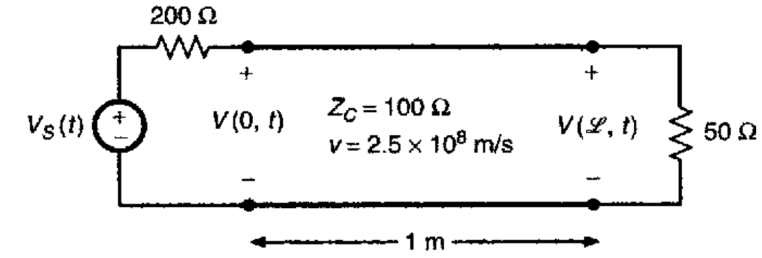
1. The skin effect governs the behavior of all conductors. As an example, Figure below depicts the series resistance of RG-58C/U coaxial cable plotted as a function of frequency. The plot uses log-log axes. Assume the center conductor radius $r = 0.455$ mm, and per-unit-length inductance $L = 253$ nH/m. The conductivity of copper is $\sigma = 5.8 \times 10^7$ S/m.
   a) Calculate the DC resistance of center conductor.
   b) Calculate frequency f_1 where skin depth approximately take effect on center conductor.
   c) Calculate frequency f_2 where $\omega L > R_{copper}$.

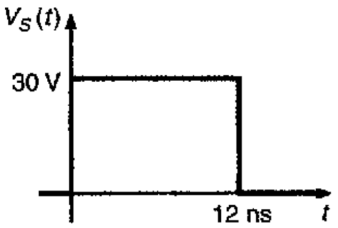


2. For the per-unit-length representations of a lossless transmission line shown below in three structures, derive the transmission-line equations in the limit as $\Delta z \to 0$. Note that the total per-unit-length inductance and capacitance in each circuit are l and c, respectively. This shows that the structure of the per-unit-length equivalent circuit is not important in the limit as $\Delta z \to 0$.

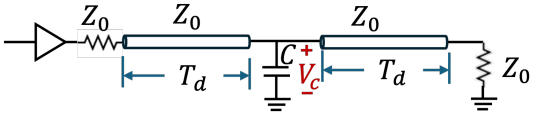


3. Sketch the input voltage to the line V(0, t) and the load voltage V(L, t) for the problem depicted in the figure below for $0 < t < 20$ ns. What should these plots converge to in the steady state?

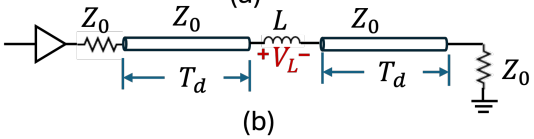




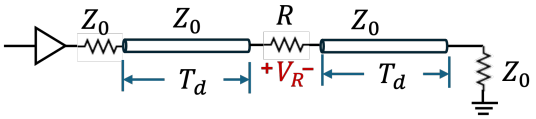
4. In transmission lines, various types of discontinuities can occur, such as reactive (capacitive or inductive) and resistive mismatches. These discontinuities can affect the voltage $V(z)$ along the transmission line.
Consider a constant voltage $V_{in}(t) = V_0$ is injected into four transmission lines with different discontinuities (parallel C, series L, and series R where $R = Z_0$). The line is matched everywhere else (source impedance, characteristic impedance, and load impedance are all Z_0.



(a)

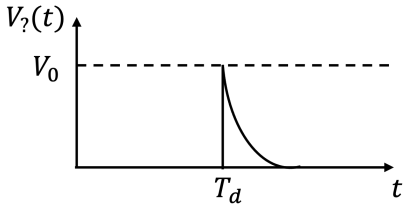


(b)

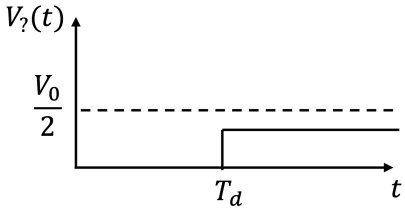


(c) $R = Z_0$

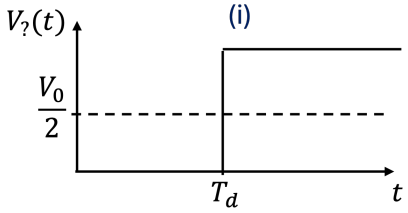
a) The four voltage plots are related to the voltage at the discontinuity immediately after the signal reaches that point. Match circuit diagram (a) to (c) to voltage output (i) to (iv). Hint: one voltage output can't be matched.



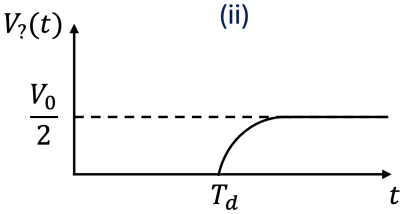
(i)



(ii)



(iii)



(iv)

b) Explain in part (a), why voltage in (i) is V_0, while in figure (iv) is only $V_0/2$.

c) Discuss how reactive elements (capacitor and inductor) impact transient behavior and reflection differently compared to the resistive mismatches.

d) (**For graduate students only**) How do reactive (L and C) discontinuities impact on Signal Integrity and radiated emissions?

5. (For Graduate students only) Use LTSPICE to confirm your answer for circuit (a) to (c) in problem 4. You can explore various L, C, and R values in your simulation.