Fields and Waves I

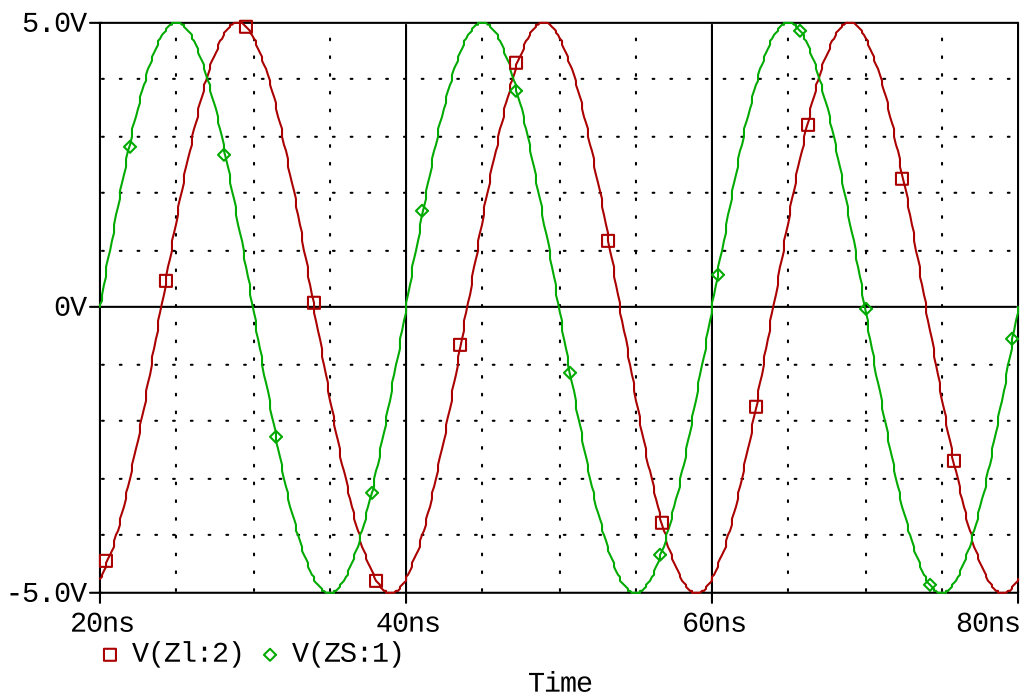
Name _______________ ECSE-2100 Fall 2002 Section ____________

Homework 1

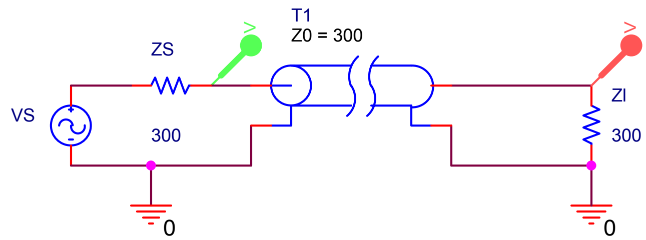
Due Thursday 23, January, 2003

Note: You will need to use PSpice for this homework. Information regarding PSpice and where to obtain it is provided on the course website. Click on "Class Information". On the left side, click on "Projects". In the main frame, there is a link to a pdf-file "Design with PSpice". At the beginning of this file is link on where to get an evaluation copy of PSpice. Alternatively, the computers in the classroom have this version. There are other versions of Spice, but if you need my help, you are better off using this version. The pdf-file provides a detailed description on implementing PSpice for problems in this course.

1) Wave Parameters – Measurements



The above figure is a plot of the voltage as a function of time at the input and the output of a Z_0 = 300 [Ω], v_p = 2.5E8 [m/s] transmission line. V(ZS:1) is the input voltage and V(Zl:2) is the output voltage. This plot is similar to those we made performing the experiments in Lesson 1.1, though notice that the line parameters are different. The PSpice circuit is shown on the next page.



What is the period, T?

What is the frequency, f?

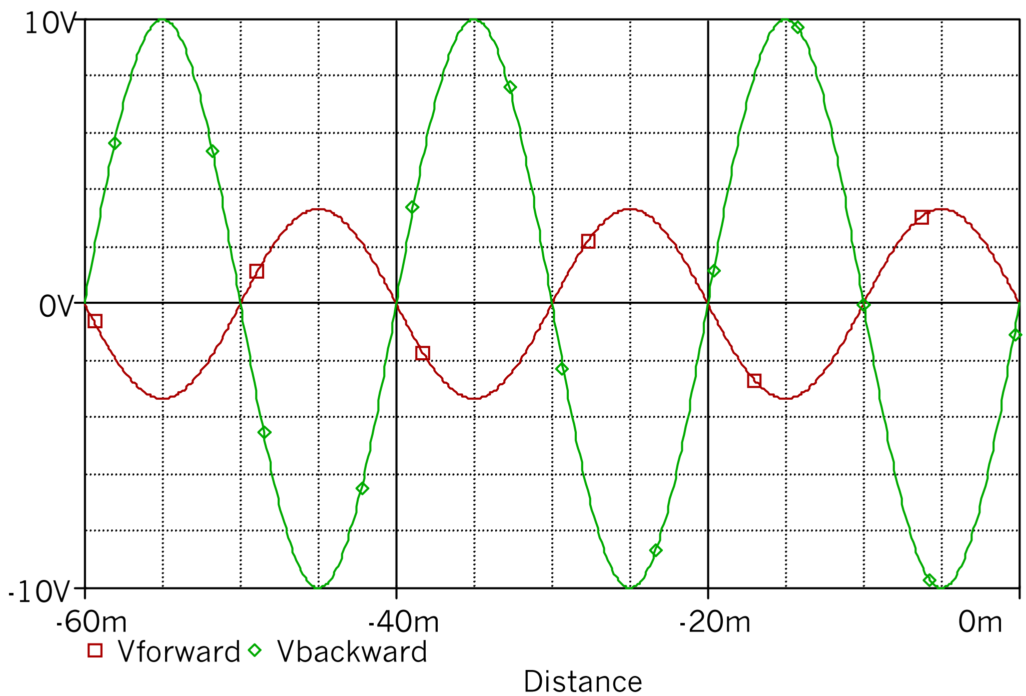
What is the spatial frequency, β ?

What is the shortest possible length of the transmission line?

What is the second shortest possible length of the transmission line?

Determine the forward propagation voltage wave in phasor form?

2) Wave Parameters - Spatial Plots



The above figure represents the instantaneous (t = 0) voltage on a transmission line as function of distance for both a forward (positive) propagating wave and a backward (negative) propagating wave. (As good engineers, you should recognize that the plot is a fictitious measurement, not something we could perform in the laboratory). A position reference is given such that z = 0 at the load. The transmission line parameters are identical to our RG 58 A/U spools in class.

What is the amplitude of the forward wave, V^+? the backward wave, V^-?

What is the wavelength, λ?

What is the frequency of the wave, f?

What is the radial frequency, ω ?

What is the spatial frequency, β ?

What is the load reflection coefficient, Γ_L?

Determine the total voltage on the line in time domain form.

Determine the total current on the line in time domain form.

Determine the total voltage on the line in phasor form.

3) Lumped Parameters

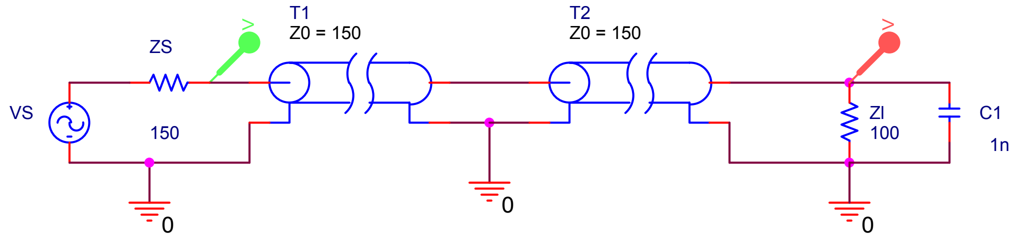
We want to model a 20 [m] length of transmission line with, Z_o = 150 [Ω] and v_p = 2.4E8 [m/s]. For this line, what are the inductance/m and capacitance/m, *l* and *c*, of the transmission line?

What size *L* and *C* do we use if we want to have 10 *LC* sections in our lumped parameter box?

Using PSpice, run a frequency sweep for both the transmission line circuit and the lumped parameter circuit. Include source and load impedances that are matched to the circuit. Your frequency range should be broad enough that the comparison between the two circuits is interesting. (Interesting means there is something different about them). Include both plots in your homework.

Approximately, at what frequency would you estimate the lumped parameter circuit is no longer a valid model of the transmission line? At this frequency, how does the wavelength compare to the effective "length" of each *LC* section?

4) Standing Wave Patterns



The above circuit represents a single transmission line (Z_o = 150 [Ω], v_p = 2E8 [m/s]) with a load that is a resistor and capacitor in parallel. In the circuit, two transmission lines are shown, but they have identical properties. The node between the lines may be used to make measurements, similar to the measurements made on the lumped parameter box. Effectively, we can measure the voltage at an arbitrary distance from the load by changing the time delay of T2 (the property that determines the "length" of the line).

Answer the following questions for each of the three frequencies: f = 1k [Hz], f = 1M [Hz], f = 1G [Hz]

What is the load impedance (you may use reasonable approximations)?

What is the reflection coefficient (you may use reasonable approximations)?

What is the standing wave ratio, *SWR*?

Where is the location of the first maximum in [m] for each frequency?

Plot the standing wave pattern for all three frequencies. I recommend using Maple or Matlab to generate your plots. If you are more familiar with another mathematical software package, you may use it instead. Include your code/commands for one of the plots. Label the horizontal axis in both [m] and [λ]. Assume a 1 [V] amplitude of the forward propagating wave.

For the frequency of 1M [Hz], using PSpice, measure V_{pp} at several locations (< λ from the load) and verify that is consistent with the previous plot of the standing wave pattern. Include one of the plots and indicate its location relative to the node.