Fields and Waves I

Name ________________ ECSE-2100 Spring 2000 Section ____

Preparation Assignments for Homework #6

Due at the start of class.

Reading Assignments

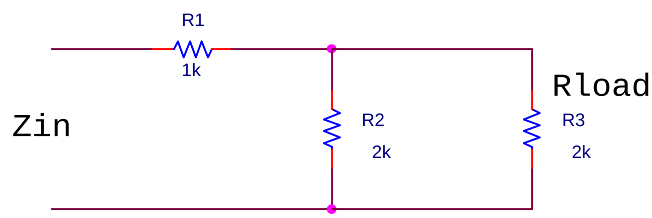
Please see the handouts for each lesson for the reading assignments.

20 March Lesson 4.1

Read over the notes for this lesson.

22 March Lessons 1.5 (Prob 1) and 4.3

a. Determine the input impedance of this circuit, with and without the load resistor R3 attached.



b. Write the expression for the input impedance of a short circuited lossless transmission line.

c. Write the expression for the input impedance of an open circuited lossless transmission line.

d. Show that the function $f = f\left(t - z/v\right)$ is a solution to the general wave equation

$\frac{\partial^2 f}{\partial z^2} - \frac{1}{v^2}\frac{\partial^2 f}{\partial t^2} = 0$. That is, show that any function of $t - z/v$ is a solution.

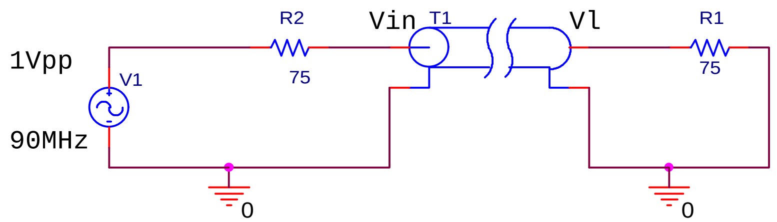
Class time 23, 24 March

Open shop to work on Homework 6. Due at 5 pm on 24 March.

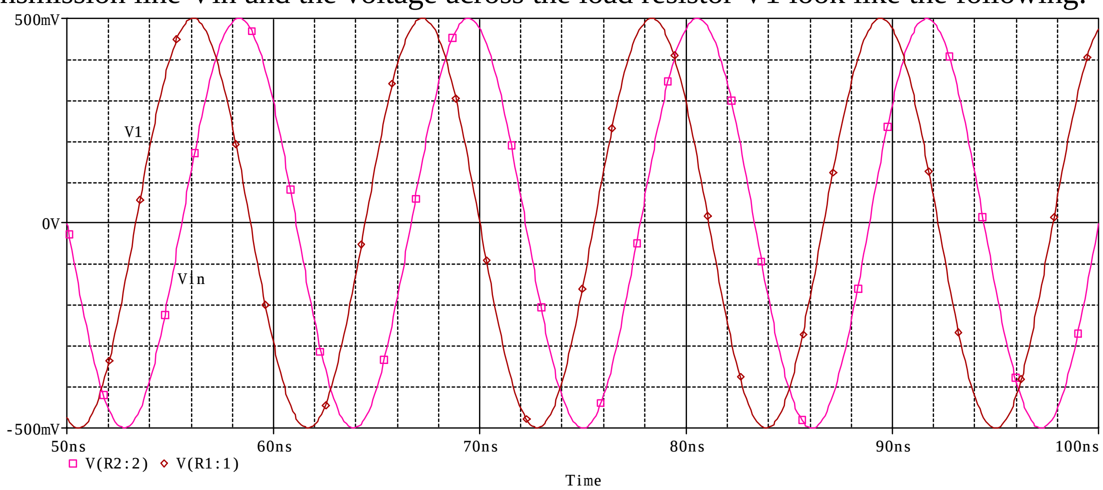
Homework #6

Problem 1. Transmission Line Parameters (10 Points)
A polystyrene* insulated transmission line has a characteristic impedance of 75 ohms and is 5 meters long.
a. What are the inductance and capacitance per unit length of this cable?
b. If the load is an open circuit, at what frequencies will the input impedance Z_{in} look like a short circuit?
c. How much time does it take for a voltage signal to propagate from the input to the output of the cable?

Problem 2. Waves on Transmission Lines (10 Points)
A polystyrene coaxial cable (length roughly 3.7-3.8 meters) for a cable television system (Z_o = 75 ohms) runs from an amplifier to a television set. The equivalent circuit for this configuration is:



where R1 is the input to the television set and R2 is the output impedance of the amplifier. The voltage level shown is arbitrary, not realistic. The voltage at the input to the transmission line Vin and the voltage across the load resistor V1 look like the following:

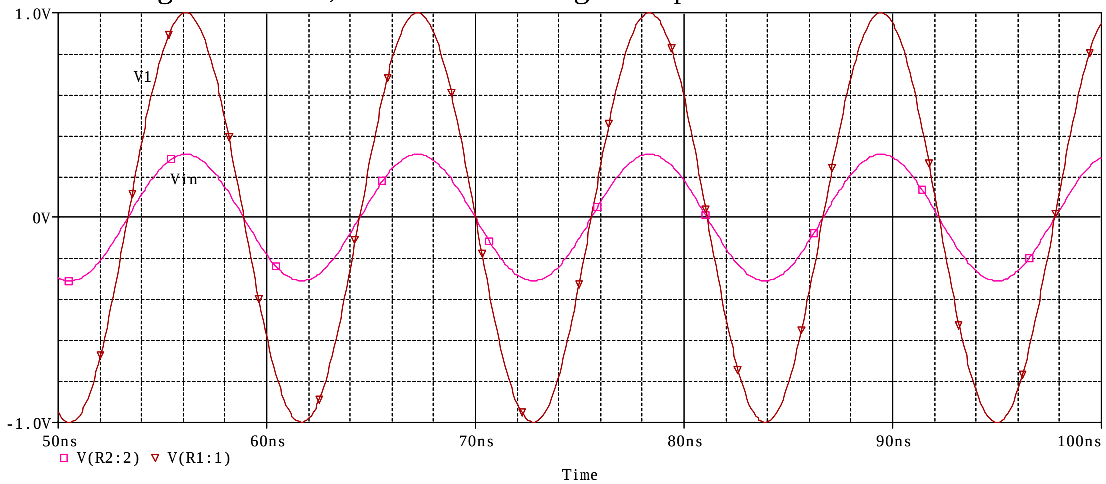


Note that the two voltages have the same amplitude and, thus, everything is matched.

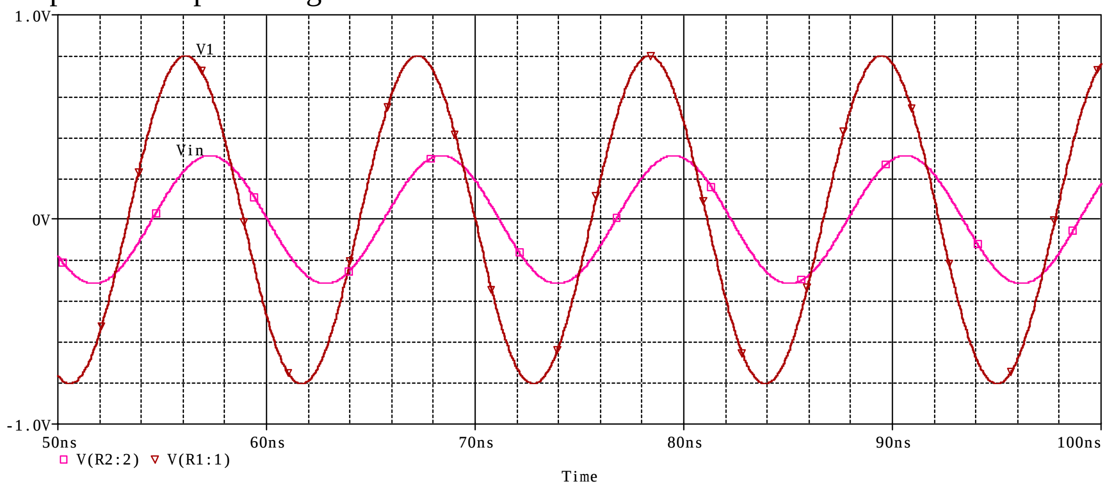
a. It appears in the above plot that the output voltage appears before the input voltage. Explain why this figure is correct. Also determine the exact length of this line.

b. Determine the reflection coefficient at the load Γ_L. Using the information on the amplitude of the voltage at the load, sketch the standing wave pattern. That is, plot the voltage amplitude as a function of position on the line. This should be a very simple sketch. Your horizontal scale should be the position on the line from the input to the output and the vertical scale should be volts.

c. Now assume that the television set is disconnected so that the load is now an open circuit. Again, determine the reflection coefficient at the load Γ_L. The input and output voltages are now as shown below. For this simulation (done with PSpice) the load is assumed to be 1Mohm, to correspond to an oscilloscope. Again, using the information about the voltage at the load, sketch the standing wave pattern for this case.



d. Finally, assume that four television sets are connected in series (people do very strange things, but probably not this) so that the load impedance is 300 ohms. Determine the reflection coefficient at the load Γ_L and sketch the standing wave pattern for this case. The input and output voltages for this case are:



* See http://hibp.ecse.rpi.edu/~connor/education/Fields/matl_prop.pdf which is also listed in the Supplementary Materials page.

Extra Credit (5 Points): Using the information given, determine the impedance at the input to the transmission line for each case.