Fields and Waves I

Name _______________ ECSE-2100 Fall 2002 Section ____________

Homework 1

Due Thursday September, 2002

1) Lumped Parameters-Lossless Lines

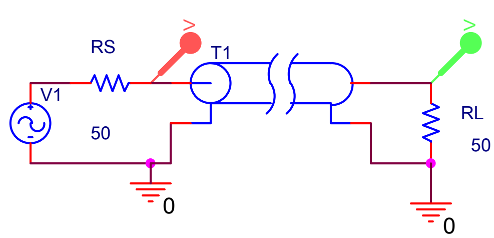
A twisted pair transmission line has a characteristic impedance of 300Ω and a propagation velocity of 3E8 m/s (the insulating material is assumed to have the same permittivity as free space). Design a lumped parameter circuit to simulate 10 meters of line. You need to determine the inductor and capacitor for each section and how many sections to use for the circuit. Your design must have a transfer function that is greater than 0.95 in the frequency range, $f \in [0,10 \text{ Mhz}]$. A transfer function is defined as the magnitude of the ratio, $\left| \frac{V_{out}}{V_{in}} \right|$. In this equation, V_{in} is the voltage at the input to the transmission line, not the source voltage and V_{out} is the voltage across the load. (It is not necessary to determine the transfer function. The simulation results will be sufficient.) The circuit should include a matched source impedance and a matched load impedance.

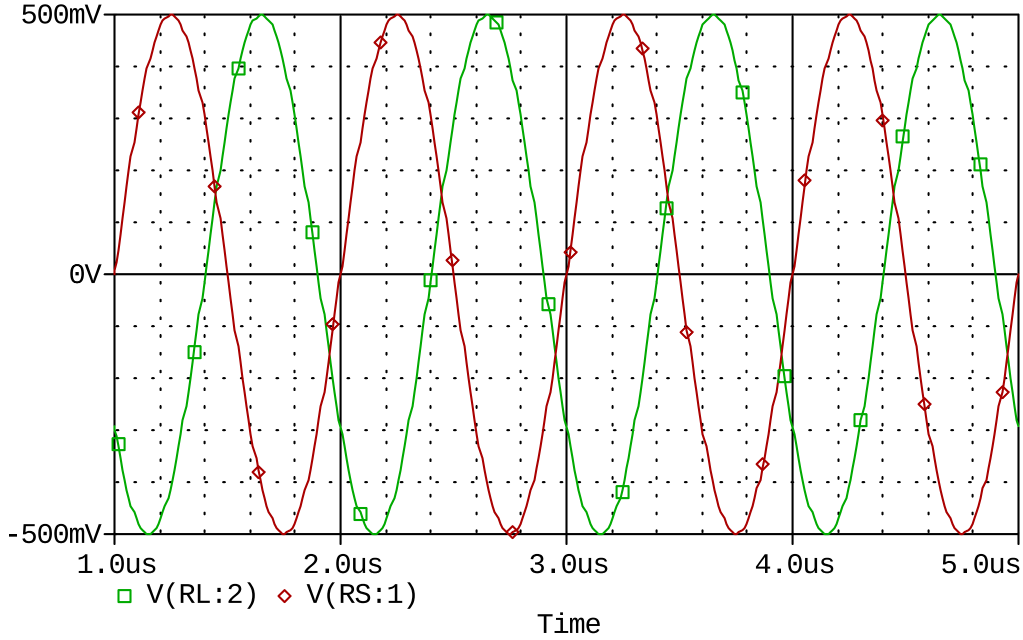
Plot the frequency results (AC sweep) of a SPICE simulation of your circuit. Include both the plot and schematic in your homework. Make sure your plot includes the frequency range at which the lumped parameter model becomes inaccurate. Is this frequency consistent with what you would expect? Why?

Obtain SPICE: You may download SPICE from the course web pages. A link ("Design with PSpice") is present on the "Projects" page, near the top. The link is present in a pdf file that contains all the information you will need for simulations in this course.

2) Wave Propagation and Measurements

A simple matched transmission line circuit is shown below. The voltages at the input to the transmission line and across the load are shown on the following page.





1) What is the period of the wave?

2) What is the frequency? What is the radial frequency?

3) What is the shortest length of the transmission line if the velocity is 2E8 m/s? What is the second shortest length?

For the rest of the questions, used the above velocity with the shortest length of line.

4) What is the wavelength?

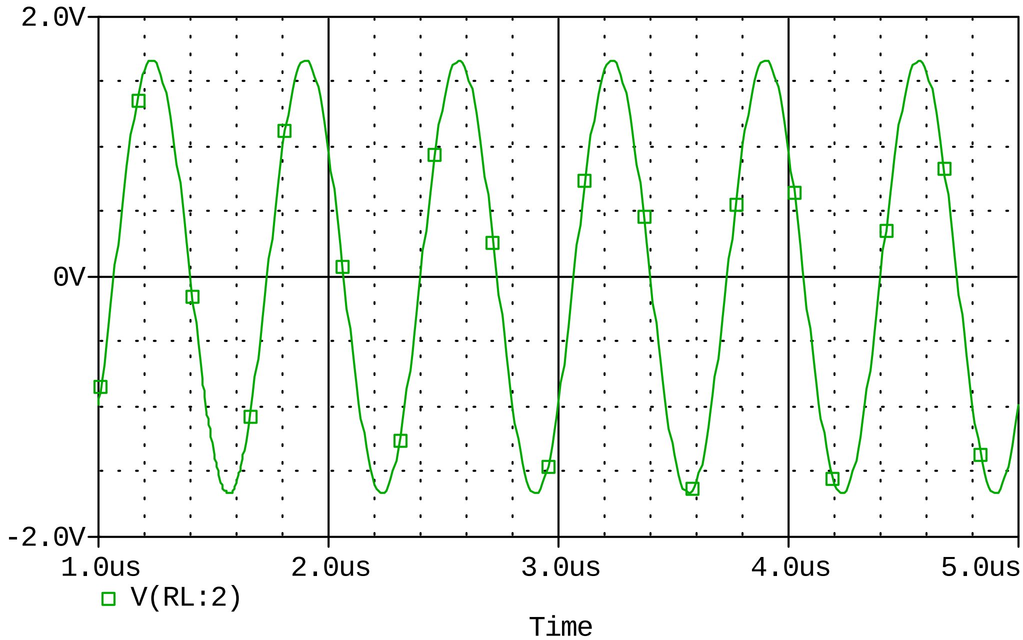
5) What is the spatial frequency?

6) Express the forward propagating voltage wave and current wave in time domain form.

7) Express the forward propagating voltage wave and current wave in phasor form.

8) What is the reflection coefficient?

3) Wave Reflection and Standing Wave Pattern



The above plot is the load voltage of a transmission line circuit. The line is 50 Ω and the load is resistive, but mismatched. The incident wave has a 2 V amplitude and the line has a velocity of 0.5c.

1) Determine the reflection coefficient at the load.

2) Determine the load impedance(s).

If you think there is more than one possible load impedance, choose the larger value for the following parts.

3) Determine the standing wave ratio.

4) Determine the total voltage on the line in both phasor and time domain form.

5) Sketch the standing wave pattern. Label your axis and the locations of minima and maxima.

Extra Credit:

Replace the resistive load with a 1nF capacitor. Determine the location of the first standing wave minimum.