



Due 2 June 2010 (Wednesday's class)

We want to consider an RG58U lossless transmission line used in different applications. We will also be using only the lossy transmission line model from PSpice but will mostly input only lossless parameters. That is we will choose the resistance and conductance per unit length to be zero. Note that their default value is 1. The length of the line is *440 meters*. The excitation frequency is $f = 200kHz$.

1. Transmission Line Characteristics

Since you will need them later, write down the following characteristics of the line and waves on the line.

The inductance per unit length $l =$

The capacitance per unit length $c =$

The characteristic impedance $Z_o =$

The propagation velocity $u =$

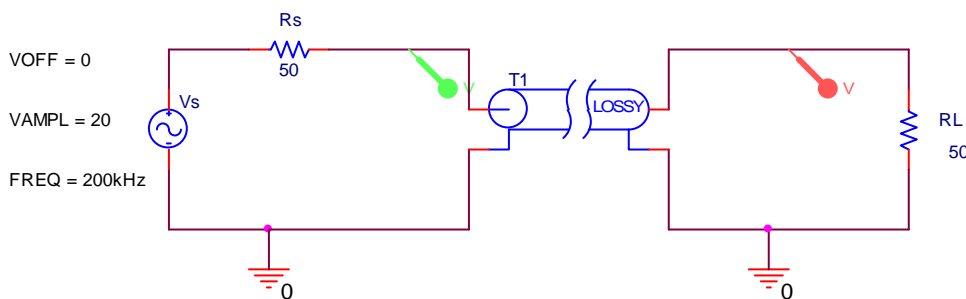
The delay time for the line $T =$

The angular frequency $\omega =$

The propagation constant $\beta =$

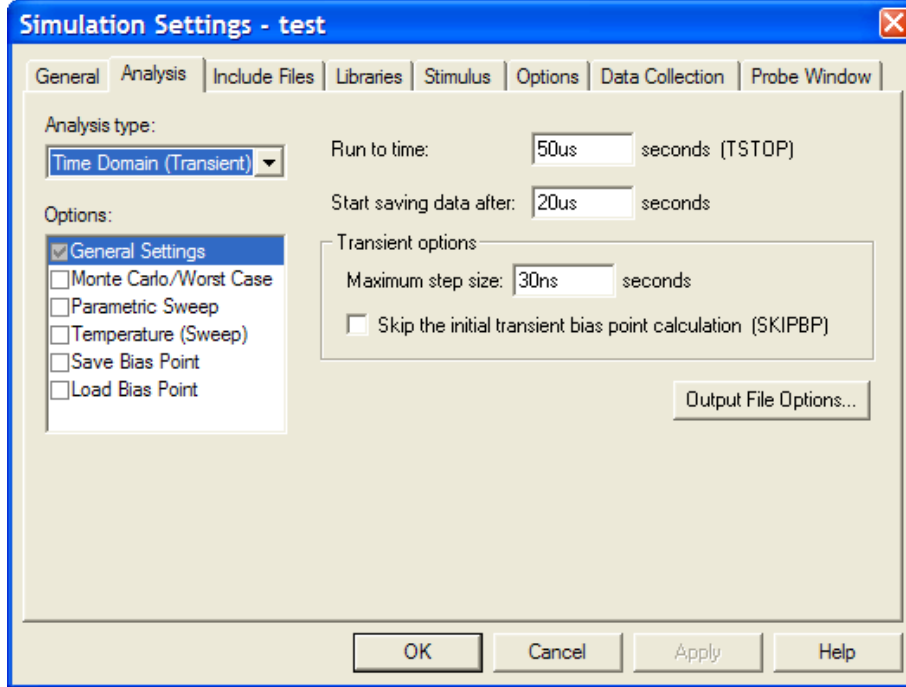
2. PSpice Simulation of the Transmission Line with Sinusoidal Input Voltage

First we will consider how the line behaves with the sinusoidal input voltage $V(t) = 20\cos\omega t$ where the frequency $f = 200kHz$. The voltage source and the load are both matched to the line. Set up the following representation.



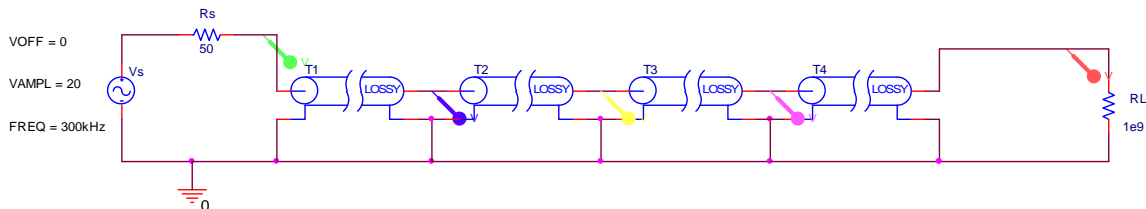


When setting up your simulation profile, use the following as your first guess. You may want to adjust it when you address pulsed sources. Run this simulation and save the output plots for your report. Be sure to include the voltage probes at the input and output of the line. Also run this for the cases where the load resistance is 93Ω , 25Ω , an open circuit and a short circuit. The delay is not necessary, but it is good to see how it works.



3. PSpice Simulation of several Transmission Lines

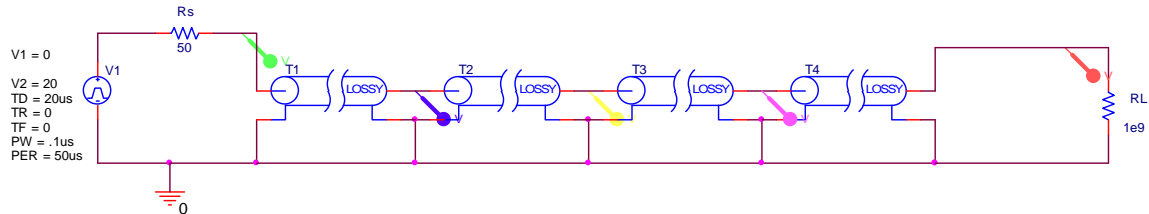
Set up the following configuration. Again, use the lossy line model. Note that in this case, we have replaced the transmission line connected to the load with four transmission lines. We have done this to obtain information at intermediate points in the line in addition to at the input and output ends of the line. PSpice does not give us any information at the interior of lines, just like we cannot obtain such information from real transmission lines. However, we are able to create a long transmission line by stringing together several shorter lines, as we did in class, when we connected 6 lines in a loop. The student version of PSpice allows us only 4 such lines, so set the length of the lines to be 74, 80, 158 and 128 for a total length of 440 meters. You should analyze and obtain the information at all five locations. While we took measurements at 10 different frequencies, you only have to do the case for $200kHz$. Compare your answers at the input and output ends for the five different loads with your solution to the previous problem.





4. PSpice Simulation of the Transmission Line with a Pulsed Source

Now, replace the constant frequency source with a pulsed source (you should create a separate simulation since you may want to re-visit both cases), as shown. The pulsed source produces 20V, 0.1 μ s pulses after a delay of 20 μ s.



Now, if necessary, adjust the simulation profile until your plot demonstrates that you are observing the full signal while it settles into its steady state conditions. Change the simulation conditions only enough to show this. Carefully label all pulses, noting where they are observed (input or output end or at the connection between the two lines) and their amplitude (since this is not always easy to read from the plots).

5. Input Impedance of a Line

This question relates to the sinusoidal voltage.

- Determine the input impedance of the line.
- From the input impedance, determine the input power to the line.
- From the input power to the line, determine the power delivered to the load.
- From the power delivered to the load, determine the voltage observed at the load.
This should allow you to explain the magnitude of the observed voltages.
- Qualitatively explain why the phase difference between the two voltages observed in your plots also makes sense. Only an approximate answer is necessary.

6. Pulses on a Transmission Line

This question relates to the pulsed voltage.

- Determine the voltage input to the line from the voltage divider relationship that characterizes the initial line voltage.
- Determine the reflection coefficients at the load and source end for both loads.
- Generate the bounce diagram for both loads, showing the voltages observed until the changes in level are under .1V.
- From the information in your bounce diagram, sketch the voltages observed at the input and output ends and the intermediate points of the line.

7. Comparison Between Modeling and Theory

- Use your results for problem 5 to explain the voltages observed for the sinusoidal source.
- Use your results for problem 6 to explain the voltages observed for the pulsed source.



8. Experimental Verification

The experiment to be done in the studio classroom requires the cooperation of all students. One student is to provide the source voltage to their coil of wire. Then each student, in turn, is to connect their coil of wire in series with the others until the last student provides the terminated loads.

Each student must also set up the pulsed experiment with their individual cable. However, the only measurement you each need to make is the transit time to go from one end of the cable to the other. You can do this any way you wish. From the transit time and your knowledge of the propagation velocity, determine the actual length of your cable. As an additional confirmation of the length, use the LCZ Bridge to measure the capacitance of the cable with no load (open circuit). Using the known capacitance per unit length of the cable, determine its length. Compare your results to those obtained in the spring term. You should have approximately the same answer.

Compare your experimental results with those from your analysis. That is, identify what is the same and what is different and why.

9. Lossy Lines

Using the experimental information obtained for the matched load at 200kHz , determine the decay constant and the corresponding resistance per unit length at this frequency. Add this resistance to your PSpice simulation of the four linked lines and repeat problem 3. Compare with your experimental results again. Do you see better agreement?

10. Extra Credit

Repeat problem 5 for the lossy cable case. The steps are somewhat different since we can no longer assume that the power at the input end equals the power at the output end.

- Determine the input impedance of the line.
- From the input impedance, determine the input voltage to the line. Because the input impedance is complex, the input voltage will also be complex.
- Write the general expression for the voltage at all points on the line in phasor form. From the given information, you should be able to determine the propagation constant, decay constant, reflection coefficient. However, you will need to then evaluate the general expression at the input end of the line and set this equal to the input voltage to find the complex amplitude of the voltage wave.
- Use Matlab to plot the absolute value of the total voltage wave (this gives the standing wave pattern) and compare your results to the measurements made in class. Do this for all loads at 200kHz .