California State University, Bakersfield

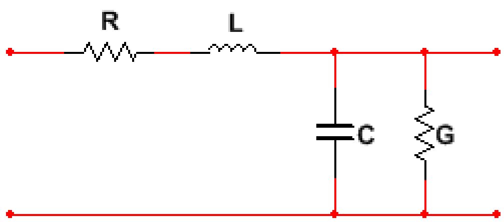
ECE 3320 – Fields and Waves

Lab 6 - Transmission Lines

Introduction:

In this lab, we will go over the basics of transmission lines and simulate transmission lines using Multisim. A transmission line is a two port network connecting a source to a load. Coaxial cables are usually represented as transmission lines. In low frequency and short distance models, transmission lines have little effect on the overall performance of a circuit. However, as length of the transmission line increases and the frequency of the source increases, the transmission line can distort the source signal on the load end.

Using a lumped-element model transmission line, we will observe the effects of length and source frequency on signal distortion. Transmission lines can be represented as a series of the following circuit.

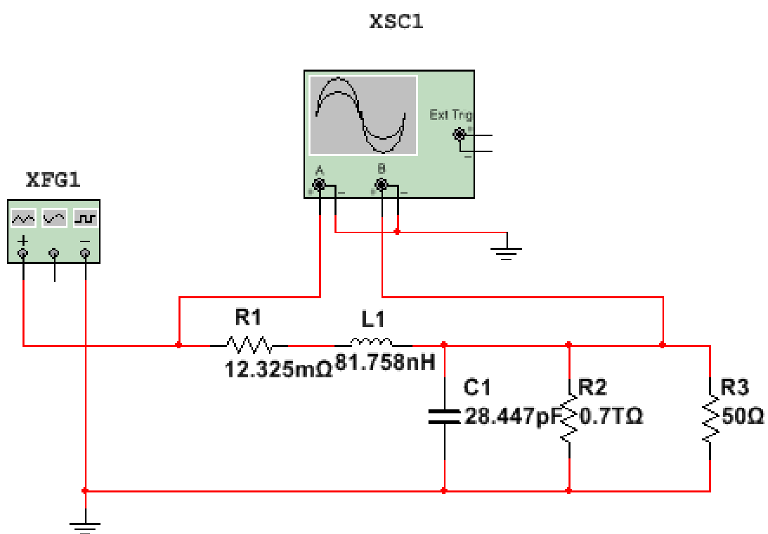


R represents the resistivity of the line (Ω/m), L represents the inductance of the line (H/m), C represents the capacitance of the line (F/m) and G represents the conductance of the line(S/m). These values are represented as per unit length. In order to find the total values of the line, you simply multiply the per unit length value with the total length of the line. Therefore, as the length of the line increases, so do each of the total values.

Procedure:

1. Open Multisim. This can be done by pressing the start button and searching for it.

2. After Multisim has loaded, construct the following circuit.



The R, L, and C components can be found by right clicking and clicking “Place component.” Then on the left side, under group, select the “Basic.” group. Resistors, capacitors and inductors can be found under the family section on the left hand side. Since we will be changing the values of each element, it doesn't matter which value you initially choose. Additionally, the ground component can be found under the “Sources” group and the “POWER_SOURCES” family with the title “GROUND.”

After you have placed your components, double click on the value you wish to change to open the properties window under the value tab. Change the current value to the desired value and click “OK”. If you need to add a prefix, just add the letter prefix after the number. For example, for the inductor we want 81.758nH, so we enter “81.758n” in the value box and click “OK”.

After your component values are set, you will need to add a function generator and an oscilloscope. Both of these can be found on the right hand side. After these are placed, wire you circuit accordingly.

3. Change the function generator settings to:

Waveform: Square wave

Frequency: 10 MHz

Duty Cycle: 50%

Amplitude: 2 Vp

Offset: 0 V

To open the function generator options, simply double click on it.

4. Change the oscilloscope values to the following:

Timebase Scale: 100 ns/Div

Channel A Scale: 5 V/Div

Channel A Y pos.: 1

Channel B Scale: 5 V/Div

Channel B Y pos.: 2

To open the oscilloscope, simply double click on it. You will want to keep this open.

5. Now that our circuit is ready to simulate, press the green button to start the simulation. Make sure that your oscilloscope is open. If you are getting a strange signal, open up the function generator, click the triangle waveform, then click the square wave again to reset the waveform.

You should see the input waveform on the top and a slightly distorted waveform on the bottom. This distortion is caused by the transmission line characteristics.

6. Stop the simulation and increase all values on the transmission line by a factor by 10, except for the 50 Ω resistor. Run the simulation again and observe your results. What happened to the output waveform?

7. Set the components back to the original values. Increase the frequency to 100 MHz and change the timebase on the oscilloscope to 10 ns/Div. Observe your results.

Problems:

1. Using the per unit length values provided in the circuit above, calculate the propagation constant γ, characteristic impedance Z_0 at f=10 MHz and 100 MHz.

$$\gamma = \sqrt{(R' + j\omega L')(G' + j\omega C')} \quad Z_0 = \sqrt{\frac{(R' + j\omega L')}{(G' + j\omega C')}}$$

2. What effect does frequency have on the propagation constant and characteristic impedance? Do these results agree with your findings in the lab?

3. As length of the transmission line increases, what happens to the output waveform? Why?

Please include graphs of simulation results for each configuration in your results.