Overview

One application of transmission lines is to connect a radio transmitter and antenna. The impedance of an antenna is typically a function of frequency and has both real and imaginary components. A typical transmitter works at a carrier frequency with some bandwidth. For this problem, I've chosen an AM radio frequency (1.4 MHz) with a bandwidth a little larger than the audio spectrum (± 50 kHz).

The radiation of waves looks to the rest of the circuit like a power loss and is therefore represented by the real part of the antenna impedance. Any reactive power in the circuit such as that due to the imaginary part of the antenna impedance or the oscillating power due to a standing wave is undesirable because in the event of a failure (such as a sudden short circuit) the stored energy can be suddenly released and damage components.

We will model a similar problem using the lumped L-C lines and equipment in the studio. We start with a circuit that is similar to the one used in homework 6.

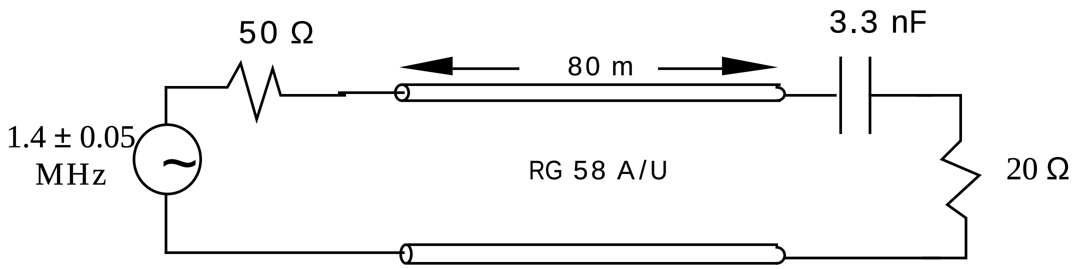


Figure 1

The load (representing an antenna) has a resistive and capacitive component. Some of our modeling and all of our experiments will be conducted with a lumped line replacing the coaxial cable as shown in the figure below.

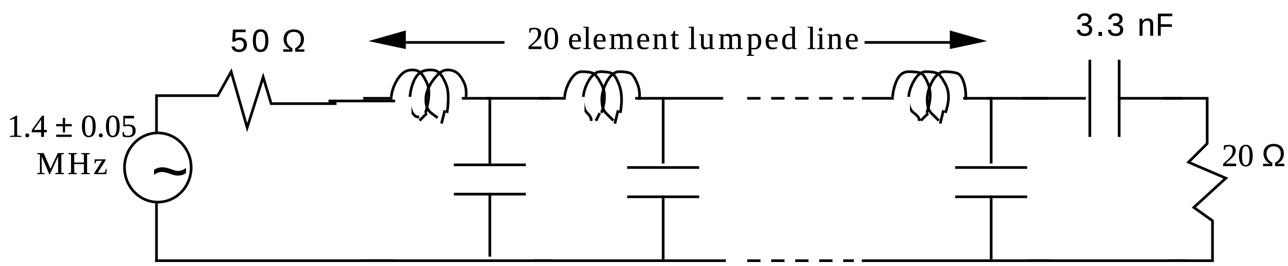


Figure 2

Part 1 of the assignment (due Friday April 2) will primarily be an analysis of the circuits shown in Figures 1 and 2. Part 2 of the assignment will be an experimental measurement of the circuit in Figure 2 and an improvement to the circuit that increases the radiated power and/or reduces the reactive power in the system.

In both parts of the assignment, the following restrictions are placed on parameters. The maximum source voltage is 20 Vpp (the limit of the function generators in the studio). The maximum node voltage allowed is 12 Vpp. (This models a dielectric breakdown limit).

Part 1 - DUE: April 2, 1999 5 PM

1. Analyze the circuit shown in Figure 2 using PSpice. An initial file for use is on the server in JEC 4107 if you want to use it.

a. Use the AC sweep analysis to determine the maximum source voltage allowed (subject to the limits stated at the bottom of the previous page). Set the source to this voltage. You should plot all node voltages using the AC sweep analysis to figure this out.

b. Use the results of the PSpice analysis to determine the node voltage and phase at 1.4 MHz. Plot the voltage magnitude and phase vs equivalent position on an RG58 cable. (The magnitude is the standing wave pattern). In addition, determine the voltage across the resistive part of the load and the power dissipated in the load.

2. Analyze the circuit in Figure 1 at 1.4 MHz. Plot the voltage magnitude and phase as a function of position along the line. Use the source voltage determined in 1a. Compare with your results from the SPICE analysis. (Ideally, the two are plotted together, but it isn't necessary). Use the computer software you prefer to handle the complex algebra.

3. Keep a copy of your codes for modification in part 2.

4. State at least one way you could modify the circuit to increase power to the load and/or reduce the standing wave ratio.

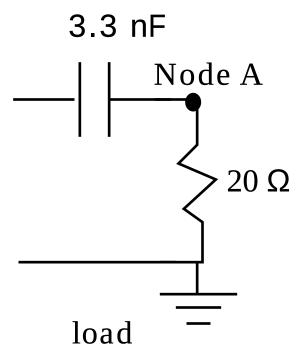
Part 2 - DUE: April 9, 1999 5 PM

Unmodified load

1. Measure the voltage magnitude and phase of the circuit in Figure 2 at 1.4 MHz. Plot them and compare with your predictions from Part 1. All parameters should be set as in Part 1. (The function generator should read 1/2 of the value in Part 1). Make a printout of the oscilloscope for a sample measurement. Use this plot to explain how you determined the phase.
Then, plot magnitude and phase of all nodes and compare with your results from Part 1.
2. Determine the power dissipated in the load.
3. Use the frequency sweep of the function generator to find the maximum voltage at any node and any frequency within the given bandwidth.

Modified load

4. Modify the circuit to achieve the following objectives:



· Maximize the power delivered to the load at 1.4 MHz. (This is determined by measuring the voltage at node A).

· Minimize the VSWR at 1.4 MHz.

The following constraints apply

· The maximum node voltage (at any frequency) is 12 Volts.

· The load must be treated as a unit (i.e. no component connections to node A).

· The 20 Ω resistor in the load must be grounded as shown.

a. Show a circuit diagram with your modifications. Briefly explain what improvements are made by the modification and why.
b. Measure the voltage magnitude and phase for all nodes at 1.4 MHz with the modified load. Plot the results vs position on the line. Measure the voltage at node A. Calculate the power dissipated in the load.
Have your measurements checked off by the course staff.
c. Analyze your modified circuit using PSpice and compare with the experimental results.

Rules on Group Work

The maximum number of people on a team is 3.
Each team turns in one report.
You may not simply copy computer codes from one team to another.
You may discuss the project with other teams.
Each team should take their own data. In the event that all experimental stations in the studio are taken, two teams may take data together (with approval of course staff).