

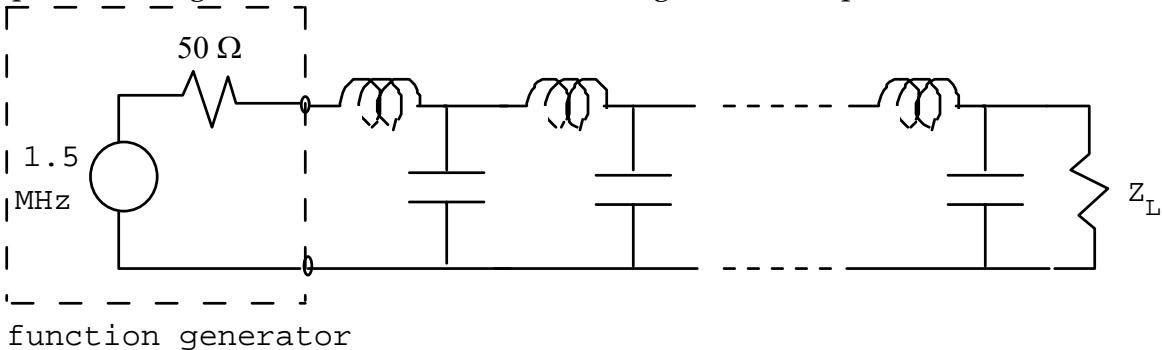
## Standing Wave Patterns

**Reading assignment**

Ulaby, 2-5.1, 2-5.2

**Experiment 1 - Standing wave pattern - lumped line**

Obtain a lumped model of a transmission line and connect it as shown. This lumped line models an 80 meter length of RG-58 A/U coaxial cable and each L-C section has an equivalent length of 4 meters. Set the function generator amplitude to 1 V P-P.

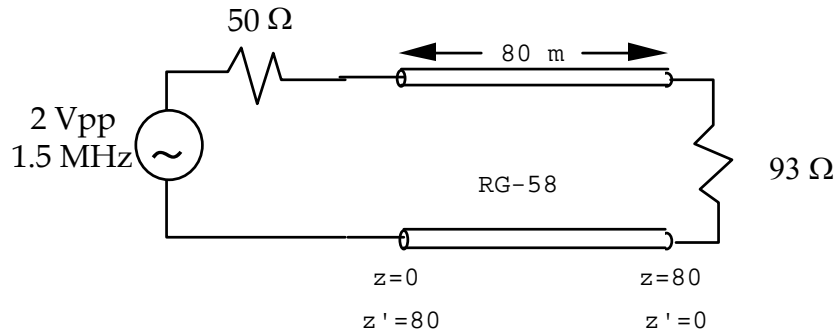


- a. Set  $Z_L = 93 \Omega$ .
  - 1) Measure the voltage magnitude as a function of node number and sketch the result. (Suggestion: first measure the even nodes, then the odd nodes).
  - 2) How many nodes separate  $V_{\max}$  and  $V_{\min}$  locations? Convert your answer to an equivalent length in the coaxial line.
  - 3) What is  $V_{\max}/V_{\min}$ ?
- b. Repeat part a. for  $Z_L = \infty$ ,  $Z_L = 50$ , and  $Z_L = 0$ . To save time, you don't need to record all values. Concentrate on finding  $V_{\max}$ ,  $V_{\min}$ , and their locations.
- c. Repeat part b. with a capacitor of 3.3 nF. What happens to the  $V_{\max}$  and  $V_{\min}$  locations?
- d. Run the `sing_bnd.m` code (Matlab file in the waves folder) which illustrates standing wave patterns.

## Standing Wave Patterns

**Problem 1 - Standing wave pattern - coaxial cable**

The equivalent coaxial cable circuit for Experiment 1 is shown below. You should compare answers with the experiment wherever you can.



RG 58 coaxial cables have the following parameters:  $a = 0.4 \text{ mm}$ ,  $b = 1.4 \text{ mm}$ ,  $R_C$  or  $Z_0 = 50 \Omega$ ,  $l = 2.5 \times 10^{-7} \text{ H/m}$ ,  $c = 1 \times 10^{-10} \text{ F/m}$ , and  $\epsilon_r = 2.3$ .

- Determine  $\beta$  and the wavelength  $\lambda$  at 1.5 MHz. Take your measurement of the distance between  $V_{\max}$  and  $V_{\min}$  from the experiment and express in terms of  $\lambda$ . What is the distance between two maxima?
- Determine the reflection coefficient at the load,  $\Gamma_L$  and the standing wave ratio, VSWR.
- Assume that the forward traveling wave has an amplitude of 1 Volt. Sketch the standing wave pattern for voltage and current. Include numbers for amplitudes and distances.
- Under what conditions do you get a voltage maximum at the load? a minimum?
- If the load is a 3.3 nF capacitor, what is the reflection coefficient at the load? Where is the location of the first minimum?

**Experiment 2 - Input impedance, lumped line**

Set  $Z_L = 0$  on the lumped line. Examine the signal at both the input and output of the lumped line.

- Set the frequency to 1 kHz. Does the input look like it is shorted?
- Increase the frequency to 400 kHz. Does the input look like it is shorted?