

## Sinusoidal Circuits on Transmission Lines

**Reading assignment**

Ulaby, 2-6, 2-7

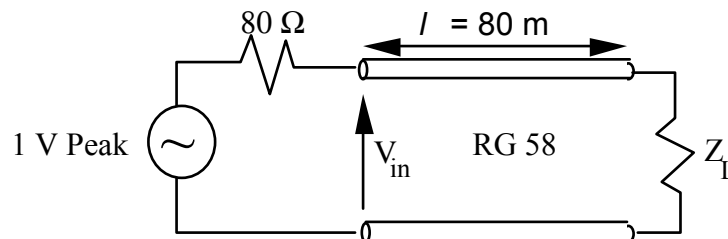
**Experiment 1 - Input impedance, coaxial cable**

Take a spool of coaxial cable. Short the output end of the spool. 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?

**Problem 1 -  $Z_{in}$  and transmission line circuit**

We will examine a very similar circuit to the one used in Lesson 4.3.  $\Gamma_L$  and VSWR are the same as in the previous lesson.



- For  $Z_L = \infty$  (i.e. open circuited),
  - calculate  $Z_{in}$  at  $z=0$  for a frequency of 400 kHz.
  - Sketch the real and imaginary parts of  $Z_{in}$  as a function of frequency.
- For  $Z_L = 93 \Omega$  and  $f = 400$  kHz,
  - What is  $Z_{in}$  at  $z=0$ ?
  - What is  $V_{in}$  in phasor form? The phase of the voltage source is 0.
  - What is the input power to the transmission line?
  - What is the voltage at the load?
  - What is the voltage in phasor form as a function of  $z$ ?

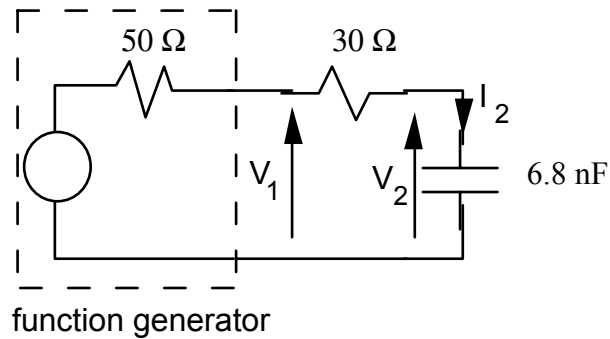
**Experiment 2 -  $Z_{in}$  measurements**

We will experimentally determine  $Z_{in}$  by measuring  $V_{in}/I_{in}$ . We can't use the multimeter to measure  $I_{in}$  since it is not accurate at high frequencies. Therefore, we will use a  $30 \Omega$  resistor and get the current using  $I_{in} = (V_1 - V_2)/30$ .

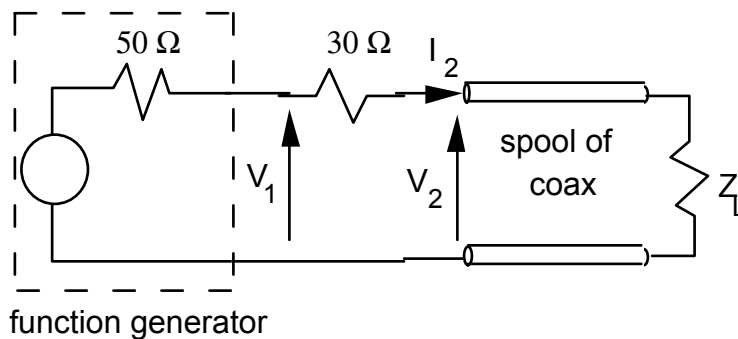
- One of the questions we will want to answer is whether the transmission line looks inductive, capacitive, or resistive. This section is just to familiarize you with those properties. Connect the circuit below and set up the oscilloscope to display  $V_2$  and  $(V_1 - V_2)$ . Does current lead or lag voltage?

What would you expect for the phase shift if the load was inductive? resistive?

## Sinusoidal Circuits on Transmission Lines



For the rest of the problem, we will use the following circuit with various  $Z_L$ .



- b. Open circuit. Set  $Z_L = \infty$
- 1) At what frequencies does the cable act like a capacitor? an inductor? Compare your result with Problem 1a.
  - 2) Determine  $Z_{in} = V_{in}/I_{in} = 30 V_2/(V_1 - V_2)$  when  $f = 400$  kHz.  
 $V_1$  and  $V_2$  must be treated as phasors in the equation above and you need to consider both amplitude and phase (or time delay). Therefore, you need to use the subtraction properties of the scope to get  $(V_1 - V_2)$ . (For example,  $|(V_1 - V_2)| \neq |V_1| - |V_2|$ ). To get the amplitude of  $Z_{in}$ , you can use  $|Z_{in}| = 30 |V_2| / |(V_1 - V_2)|$ . To determine the phase, use the time delay between  $|(V_1 - V_2)|$  and  $|V_2|$ . Compare with the result from problem 1a. 1). You probably have to redo the analytical calculation since your cable isn't exactly 80 m long. (Measure the cable length using the time delay of a pulse).
- c. (if time permits) Matched line case - Set  $Z_L = 50 \Omega$ .  
 Qualitatively determine whether  $Z_{in}$  is inductive, capacitive, or resistive. Is there any frequency dependence?
- d. Resistive load - Set  $Z_L$  to  $93 \Omega$ .
- 1) Qualitatively determine whether  $Z_{in}$  is inductive, capacitive, or resistive as a function of frequency. Does the pattern of the reactive component resemble the short or open circuit case more closely?
  - 2) How do you think the results for part 1) differ if  $Z_L = 25 \Omega$ ?