

Sinusoidal Circuits on Transmission Lines

Reading assignment

Ulaby, 2-6, 2-7

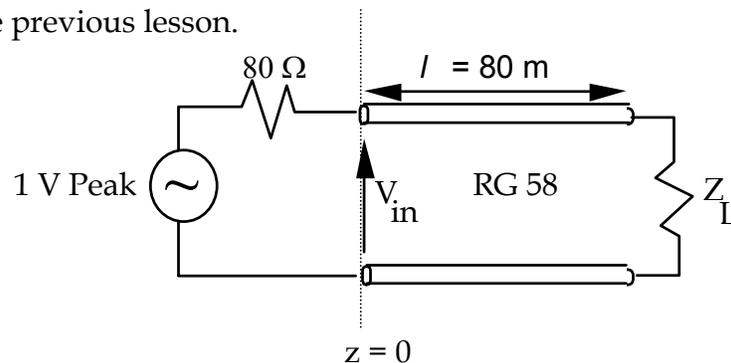
Experiment 1 - Input impedance, coaxial cable

Take a spool of coaxial cable. Short the output end of the spool ($Z_L = 0$). 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 1.2. Γ_L and VSWR are the same as in the previous lesson.



- For $Z_L = \infty$ (i.e. open circuited),
 - calculate Z_{in} at $z=0$, the input to the spool, (the dashed line in the above figure) 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 ?

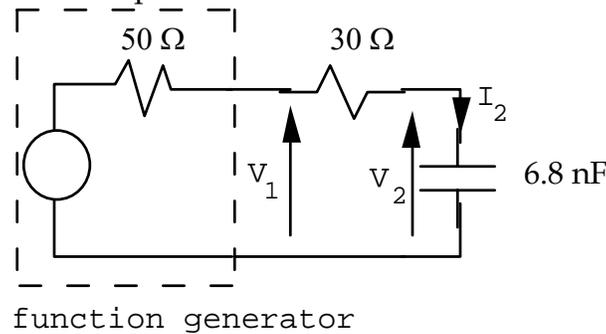
Experiment 2 - Z_{in} measurements

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 30Ω resistor and get the current using $I_{in} = (V_1 - V_2)/30$.

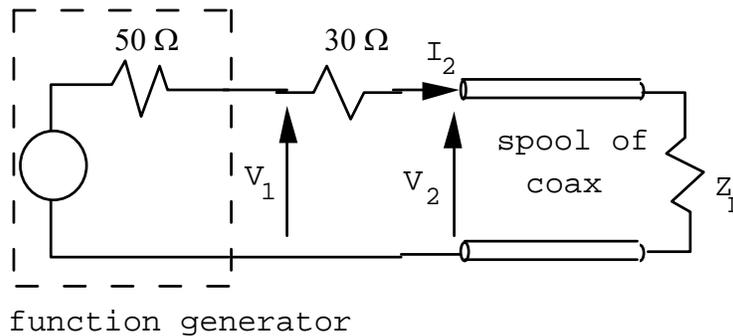
- One of the questions we will want to answer is whether the transmission line looks inductive, capacitive, or resistive. This section is just to familiarize you with those properties. Connect the circuit below and set up the oscilloscope to display V_2 and $(V_1 - V_2)$. Does current lead or lag voltage?

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



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 $Z_{in} = \frac{V_{in}}{I_{in}} = V_2 \frac{30}{(V_2 - V_1)}$ 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). The input voltage and input current will most likely be out of phase. 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 93Ω .

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- 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 $Z_L = 25 \Omega$?