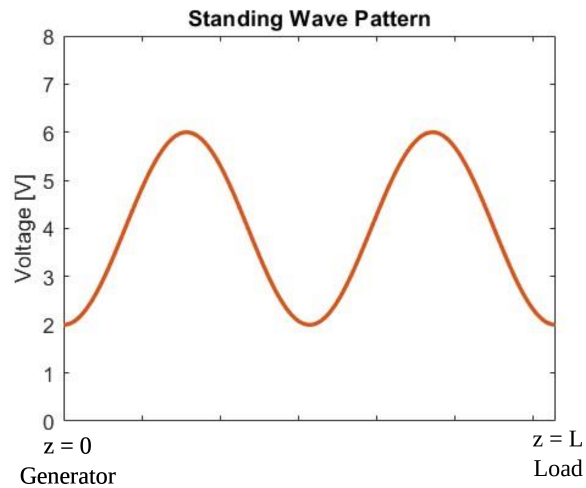
Homework 2

Due: 11:59pm September 20th

1. Standing Wave Patterns on Lossless Transmission Lines

All parts of Problem 1 refer to the standing wave pattern below. The characteristic impedance of the transmission line is $Z_0 = 50\Omega$.



a) Simply by inspecting the features of the standing wave pattern, determine if Z_L is purely real (resistive), purely imaginary (reactive), or a combination of both. How can you tell?

b) Again, simply by inspecting features of the standing wave pattern, determine the sign of Γ_L, the reflection coefficient at the load.

c) Calculate the standing wave ratio (SWR) for this standing wave pattern.

d) Keeping in mind your result from b), calculate Γ_L, the reflection coefficient at the load.

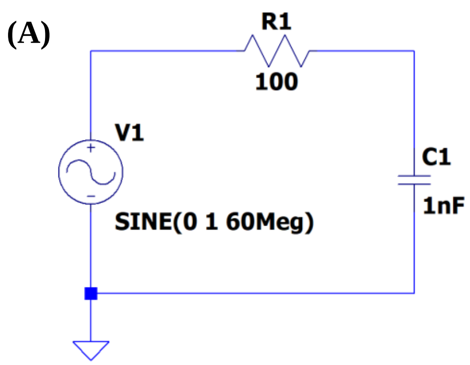
e) Calculate Z_L, the load impedance.

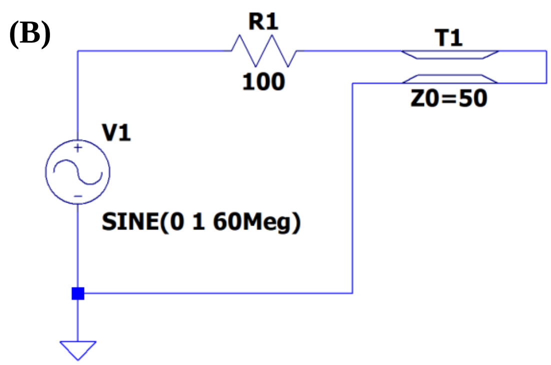
f) What is the value of V_0^+, the amplitude of the incident voltage wave?

2. Input Impedance of Lossless Transmission Lines

a) What is the wavelength of a 60 MHz voltage signal on a transmission line with a characteristic impedance $Z_0 = 50\Omega$ and velocity factor $v_f = 0.66$?

b) You are tasked with replacing the capacitor in circuit A below with a short-circuited transmission line, resulting in circuit B.

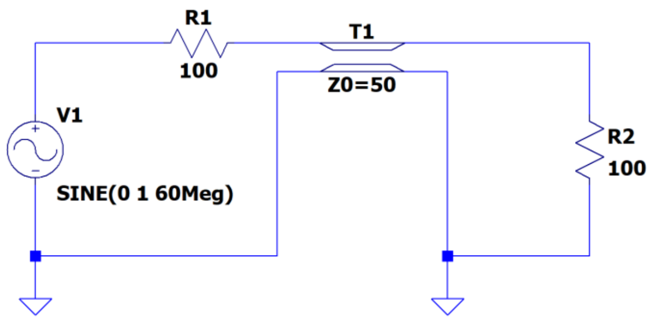




c) Using the same transmission line properties as in (a) and a source voltage frequency of 60MHz, what is the minimum length of the transmission line that would present the same input impedance to the generator circuit as the capacitor in circuit A?

d) Suppose instead that you were given an open-circuited transmission line with which to replace the capacitor in circuit A of part (b). What is the minimum length of the transmission line that would present the same input impedance as the capacitor in circuit A?

e) Given the circuit below, what is the minimum length of the transmission line T1 (same properties as in part a) that can be used to prevent reflection from occurring between the generator resistance R1 and the input of the transmission line? Will reflections still occur on the transmission line at the load?

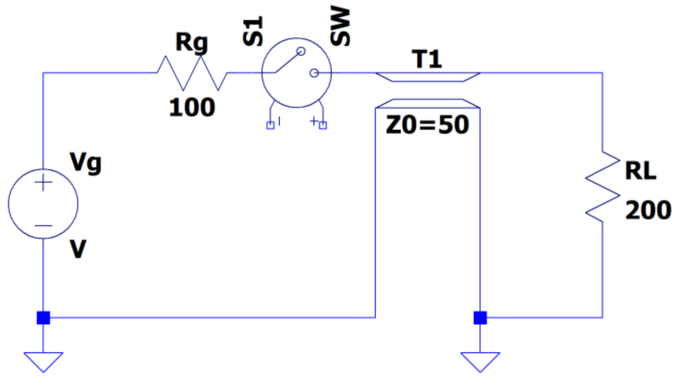


f) If R2 in the circuit above is instead 150Ω and transmission line T1 is a quarter wave transformer, what characteristic impedance Z_0 of T1 will ensure that no reflection occurs between the generator impedance R1 and the transmission line? Will reflections still occur on the transmission line at the load?

g) If the frequency of the source voltage in the circuit you designed in part f is changed, will the quarter wave transformer still ensure that no reflections occur between R1 and the input to the transmission line? Why or why not?

3. Transient Signals on Lossless Transmission Lines

All parts of Problem 3 refer to the circuit below. At time t=0, the switch S1 closes and a 3V DC source supplies voltage to the circuit. The transmission line has a characteristic impedance of Z_0 = 50Ω.



a) What is the amplitude of the forward-traveling voltage wave V_0^+ that enters the transmission line at t = 0?

b) What are Γ_L, the reflection coefficient at the load, and Γ_g, the reflection coefficient at the input to the transmission line?

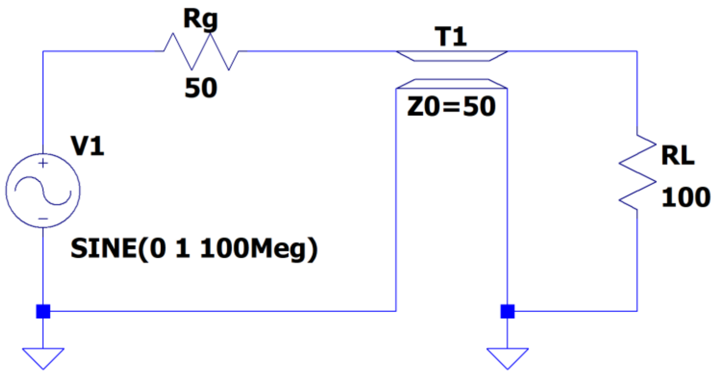
c) Draw a bounce diagram for the circuit above from t = 0 to t = 4T, where T is the time delay on the transmission line. Be sure to label both the time axis and distance axis, voltage wave amplitudes and directions of travel, and the voltages at the load and generator during reflection.

d) Sketch the voltage amplitude at the load vs. time for the timespan t = 0 to t = 4T. Be sure to label voltage amplitudes and critical times.

e) Assuming enough time has elapsed, what are the steady-state voltage and current on the line? Does this agree with the result you expect from DC circuit theory?

f) If you were to replace RL with a capacitor instead, what would you expect the steady-state voltage and current to be? Why?

4. Power on Lossless Transmission Lines



In the circuit above, the voltage source has a frequency of f = 100 MHz and the transmission line has a characteristic impedance $Z_0 = 50\Omega$ and velocity factor $v_f = 0.66$.

a) What is the instantaneous incident power on the transmission line? Express your answer in the time domain with numerical values for ω and β.

b) What is the instantaneous reflected power on the transmission line? Express your answer in the time domain with numerical values for ω and β.

c) What is the maximum net instantaneous power at the load?

d) What is the time-average net power delivered to the load? Does your result agree with what you would expect from circuit theory?

e) Why doesn't the time-average power depend on the frequency or wavelength of the signal?

f) If both the voltage and current waves have zero DC offset, why does the instantaneous power have a non-zero DC component (which is the time-average power)?