

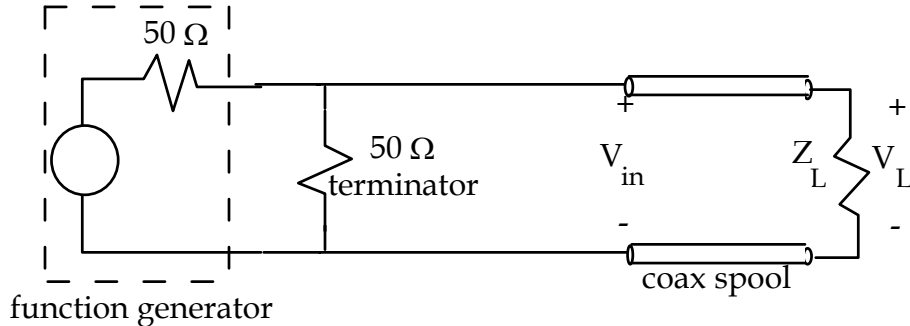
## Pulses and Transients on Transmission Lines

**Reading assignment**

Ulaby, 2-11

**Exercise 1 - Pulse signal with matched line**

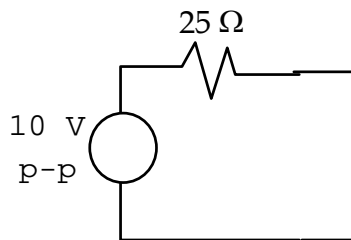
We will examine the circuit illustrated below.



- a. Experiment - Set up the experiment and measure the voltage at the input and output of the transmission line. You need two  $50\ \Omega$  terminators. One is used for  $Z_L$  and the other is placed on a tee at the function generator output. Use the following function generator parameters:  
 amplitude - 10 V P-P  
 square wave  
 1 MHz burst mode  
 (keep pulse length < 300 ns)

- b. Calculation -

The Thevenin equivalent of everything to the left of the transmission line is below.



- 1) The amplitude of the initial pulse traveling down a transmission line is obtained using the same relation as a voltage divider with impedances of  $R_C$  (from the transmission line) and  $Z_S$  (the source impedance). Determine the amplitude of the pulse down the line for this problem.
- 2) If you assume the cable is 80 m long, how long would it take a pulse to travel down the line? (You determined the propagation speed in Lesson 4.1).
- 3) The cable you used in the experiment probably has a slightly different length. Use the measured time delay to determine the length of the cable.

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4) Circuit analysis review. Show that the Thevenin equivalent given above is correct. Recall that the function generator amplitude readout applies when it sees a  $50 \Omega$  load. The voltage of the ideal source of our model is twice this value.

**Exercise 2 - Pulsed signal with unmatched line**

a. Experiment

Change  $Z_L$  to  $93 \Omega$  by using the appropriate terminator. How do you expect this to change the experiment?

(if time permits) - Use the Agilent software from the Start Menu to record your signal on the computer.

b. Calculation

- 1) What is the amplitude of the initial pulse down the line? (Hint: There is no communication yet with the load).
- 2) Find the reflection coefficients at the load and source.
- 3) What is the amplitude of the first reflected pulse? The second forward pulse?
- 4) Make a lattice diagram (also called a reflection diagram) and calculate the signal amplitudes for several bounces.
- 5) Calculate the voltage at the input and output as a function of time. For convenience, you can assume an 80 m cable if you don't know the length of your line. Compare with your measured values.

**Exercise 3 - Transient signal with open circuit / capacitive load**

- a. Experiment - Replace  $Z_L$  with an open circuit. Lower the frequency to about 1 kHz. Observe the response. Concentrate on the initial rise (i.e.,  $t < 3 \mu\text{s}$ ).
- b. Simulation - Run the Java applet listed on the course schedule for today. (with the appropriate parameters).
- c. Make a lattice diagram for this case.
- d. From your lattice diagram, determine  $V_L(t)$  and  $V_{in}(t)$  and compare with the simulation and experiment.
- e. Experiment - Replace  $Z_L$  with a capacitor of about  $0.1 \mu\text{F}$ . Remove the  $50 \Omega$  terminator on the function generator. Vary the frequency and observe the response.