UNIVERSITY OF TORONTO

Department of Electrical and Computer Engineering

ECE320F/ECE357S

III Year

WAVES ON TRANSMISSION LINES

1. Object:

This is an investigation of the fundamental properties of travelling waves using a coaxial transmission line.

2. References:

(1) Your lecture notes.
(2) Cheng, "Field and Wave Electromagnetics", Chapter 9
(3) Thomas, "Engineering Electromagnetics," Chapter 11.
(4) Ramo, Whinnery, Van Duzer, "Fields and Waves in Communication Electronics," Chap. 5.

3. Experimental Procedure:

We study the fundamental behaviour of travelling waves on a transmission line using the configuration of Fig. 1. The coaxial line has several test points where the voltage can be monitored, namely points A, B, C, D, E, and F.

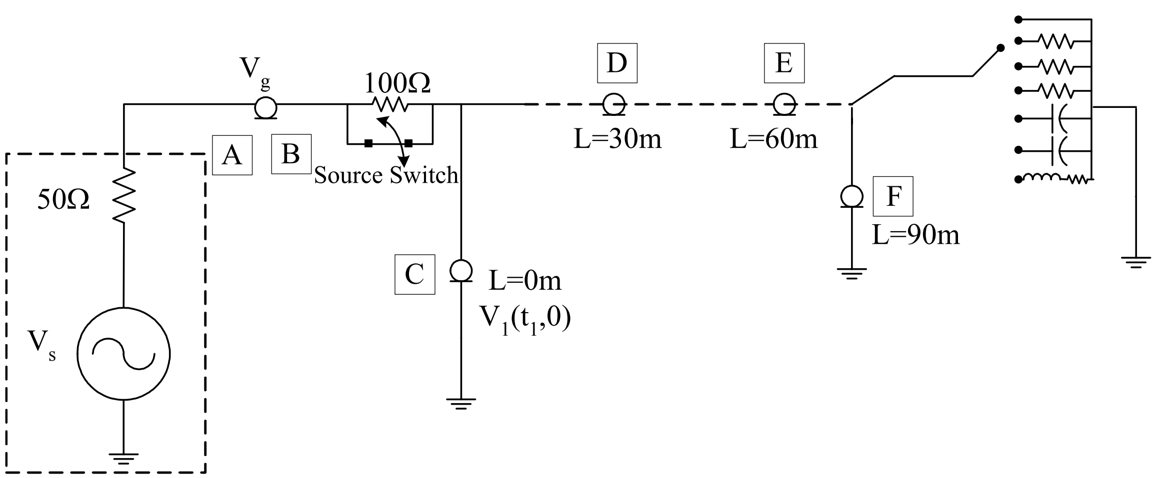

Fig. 1

A. Determination of the characteristic impedance Z_0:

Use a pulse generator and set up a suitable pulse train without the transmission line connected. Connect the transmission line and observe the input waveform. At point C, when the terminating resistance is equal to the characteristic impedance of the line there will be no reflection at the far end. The waveform at the input of the line will be the same as the generator waveform except for a change in amplitude. Vary the terminating resistance and find the value for no reflection. This is the characteristic impedance of the line and will be used for the remainder of the experiment. With this termination only one travelling wave will be excited.

B. Determination of $V_1(t, 0)/i_1(t, 0)$:

For a wave in $+z$ direction $v_1(t, z)/i_1(t, z) = Z_0$. $v_1(t, 0)$ can be observed directly in the experimental set-up at point C. To determine $i_1(t, 0)$, observe the generator voltage $V_g(t)$ and the value of the series resistor R. The resulting Z_0 should be the same as that of part A.

C. Observation of travelling waves:

With a pulse train drive observe the voltage waveforms at various test points on the line. Be sure to synchronize the oscilloscope to the waveform at the input end of the line so that time delay down the line can be observed. Plot the voltage waveform as functions of time for the different position using the same time base. Plot the waveform as functions of positions for selected values of time using the same position origin.

D. Determination of velocity of propagation:

From the data of part C and the physical length of the line, determine the velocity of propagation. Compare this velocity with the velocity of light in free space and determine the dielectric constant of the insulating medium used in the line.

E. Simple Reflection

Use a pulse generator with 50 Ω internal impedance to excite the line such that no multiple reflections occur at the source end. Also use a pulse width approximately equal to the total delay of the transmission line. Observe the voltage waveforms at the end points with R_L = 0 Ω, 20 Ω, 100 Ω and ∞. Compare the reflection coefficient with the expected value for each case. Observe and plot waveforms at other test points for R_L = 20 Ω as functions of time and as functions of position for selected values of time.

F Multiple Reflection:

Move the source switch to the up position to put the 100Ω resistor in series with the source and a load resistor of 20 Ω. Using the same pulse width, observe and plot the voltage at all test points. Compare the waveform at the load with expected amplitudes of each of the waves. Repeat with a pulse width approximately 10 times the delay time of the line.

G Input Impedance:

Terminate the coaxial line in a short circuit. Drive the line with a sine wave generator through the series 100 Ω resistor. Vary the frequency and observe the voltage waveform at the input of the line V_1, and at the generator terminal V_g on the same time base. Find frequencies at which the V_1 is a minimum. Determine the length of the line in terms of wavelengths at these frequencies. Observe the amplitude of V_g at these frequencies. Evaluate the input current of the line at one of these frequencies and show that it is a maximum. Terminate the line in a .01 µf capacitor. Observe V_1 versus frequency and note the frequencies for minimum values. Compare with those of the short circuit case and explain.