PHY 305F – ELECTRONICS LABORATORY I
Fall Semester 2003

EXPERIMENT 3
TRANSMISSION LINES
Lab notebook is due at 1 PM in MP238 on October 20

LEARNING OBJECTIVES:

(1) To become familiar with transmission of pulses down a cable.

(2) To understand what characteristic impedance and attenuation signify in a transmission line.

(3) To understand the effects of the termination on pulses travelling down a transmission line.

REFERENCES:

J.J. Brophy, Basic Electronics for Scientists, 5th Edition, pages 340-344.

P. Horowitz and W. Hill, The Art of Electronics, 2nd Edition, pages 879-882.

A.J. Diefenderfer and B.E. Holton, Principles of Electronic Instrumentation, 3rd Edition, pages 66-69.

INTRODUCTION:

In the transmission of electronic signals from one place to another, the medium used, which is the transmission line, has characteristics that must be taken into account in order that the information being transferred be reliably read. We here look at electrical transmission down configurations of wires (in contrast to light pulse transmission down optical fibres). In particular, (i) the finite speed of transmission can produce delays in the signals, (ii) terminations at either end of the line that don't match the characteristic impedance can produce reflections and thus multiple pulses, and (iii) attenuation in the line can produce loss of signal.

(In this experiment, you not be looking at noise pickup in the line, which is another source of degradation of the information being transmitted.)

The particular type of transmission line that you will be using is the RG-58/U coaxial cable. However, the theory of transmission lines also equally applies to other configurations of wires.

In order to be able to use the equipment currently on your bench, you will not be observing short square pulses, but rather will look at the square wave signals available from your Wavetek Function Generators. Although the short pulses would be easier to interpret, you should be able to figure out what the cable is doing to the square wave which starts with a fast rise and then maintains a steady voltage for half of the repetition time.

The basic apparatus that you will use is shown in Figure 1 below. You will be using the Function Generator set for square waves at around 10 kHz frequency (repetition rate). On the oscilloscope, you will be interested in the behaviour of the pulses for the first 0.1 μs at the least, to 10 μs at the most, following the transient change in the square wave. You will use two different output signals from the Function Generator. The "Hi – 50 Ω" output gives an output impedance (Thevenin equivalent resistance) of the Function Generator of 50 Ω. The "TTL Pulse Out" gives an output impedance (Thevenin equivalent resistance) of the Function Generator of less than 1 Ω on the low (close to 0 Volts) part of the pulse. The CRO has a very high input impedance (1 MΩ).

Note, that when you are looking at the 50 Ω output, it will be convenient for you to use the "TTL" output to trigger the CRO externally. Such an arrangement solves many of the triggering problems that arise when observing awkward signals.

Figure 1a

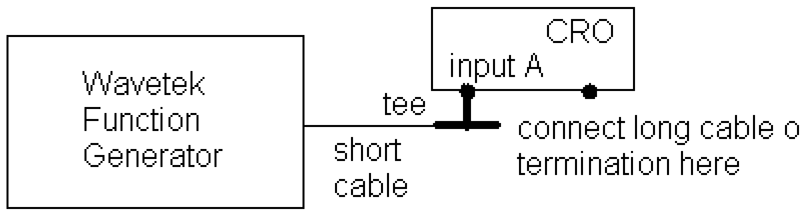
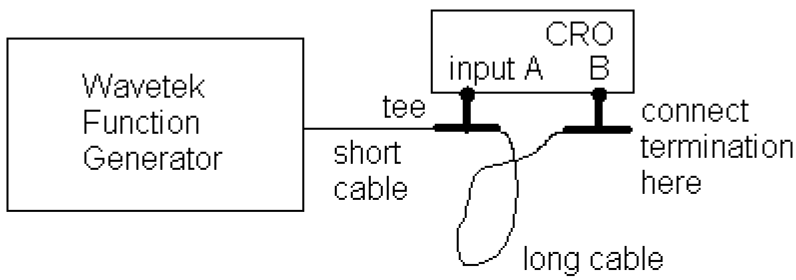


Figure 1b



<u>WHAT TO DO:</u>

(1) Observe the construction of a piece of RG-58/U cable.

(2) Using the 50 Ω source, with a 50 Ω termination directly on input 1 (or input A) of the CRO, observe the signal on input 1. (See Figure 1a.)

(3) Using the 50 Ω source, with the long cable connected to input 1, and the other end of the cable connected to a 50 Ω termination, observe the signal on input 1. (See Figure 1a.)

(4) Using the 50 Ω source, with the long cable connected to input 1, and the other end of the cable connected to a 0 Ω termination (short circuit stub), observe the signal on input 1. (See Figure 1a.)

(5) Using the 50 Ω source, with the long cable connected to input 1, and the other end of the cable connected to a ∞ Ω termination (open circuit – no termination attached), observe the signal on input 1. (See Figure 1a.)

(6) Repeat part 3, with the other end of the cable connected to a "tee" which is connected to input 2 (or input B) of the CRO. Observe simultaneously the forms of the signals on input 2 and input 1. (See Figure 1b.)

(7) Repeat part 5, with the other end of the cable connected to a "tee" which is connected to input 2 (or input B) of the CRO. Observe simultaneously the signals on input 2 and input 1. (See Figure 1b.)

(8) Repeat part 2 using the low impedance (TTL) source.

(9) Repeat part 8, with an ∞ Ω termination (open circuit – no termination attached) on input 1 of the CRO (i.e., the TTL source feeding a short cable 1.5 to 2 m long, to input 1 with nothing else attached).

(10) In order to get a rough idea of attenuation in the cable, using the setup of part 6, compare the heights of the signals on inputs 1 and 2. This should give a measure of attenuation, though the routing of signals in the tees may affect the observations.

(11) Using the setup of part 4, look at the height of the first step-down in the pulse observed at input 1. This should give you a measure of attenuation of the pulse as it travels up and back down the cable.

(12) Calculate the attenuation (in dB) per 100 metres of cable.

Note: At each step in this experiment, be sure that you understand the shapes of the pulses and what the cable and terminations are doing. If not, ask before proceeding on.