ELEC 306
Problem Set 4
Due: September 26, 2014

Homework Problems.
Work the following problems in Sadiku:

H4.1 4.23

H4.2 5.11

H4.3 Let $\mathbf{E} = 2x\mathbf{a_x} + 6y\mathbf{a_y}$ V/m.

(a) Show that $\mathbf{E}$ is a genuine electrostatic field.

(b) Calculate the voltage between points $P(0,1,0)$ and $Q(1,0,0)$.

H4.4 A point charge Q is located at the center of a spherical dielectric ($\epsilon = \epsilon_r\epsilon_0$) shell of inner radius a and outer radius b. Determine $\mathbf{E}$, $\mathbf{D}$, $\mathbf{P}$, and V.

Real Problems.

R4.1 Figure 1 is the schematic diagram of a time domain reflectometer. The voltage step produced by the

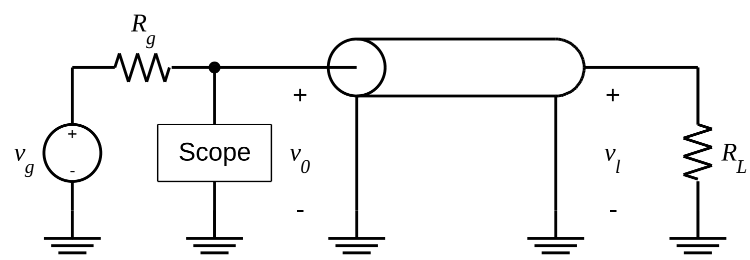

Figure 1: Time Domain Reflectometer

generator travels through the system from left to right. At any points where the impedance changes, reflections will occur and travel back to the left where they may be measured at v_0. Possible sources of reflections include:

- Improper termination at either or both ends of the line.
- Incorrect impedance of the line itself.
- A fault (short or open) at some point in the line.
- Damage (such as a kink) which causes a change in the impedance of the line.

By measuring the magnitude and timing of the reflections, the nature and location of the problem may be determined.

Like most schematics, this one hides some of the potential shortcomings of a physical realization.

1. It assumes that the source, the measurement of v_0, and the beginning of the line are all colocated, i.e. that the distance between them is zero. In a commercial TDR system, a high speed sampler is used ahead of the scope to improve system response. The pulse generator and sampler can be located directly adjacent to the connector, making this distance very small. If we want to build a TDR from equipment in the lab, we will have to use a function generator for the source and an oscilloscope for the measurement. These must be connected together with coax, adding an additional piece of transmission line to the system, as shown in Figure 2.

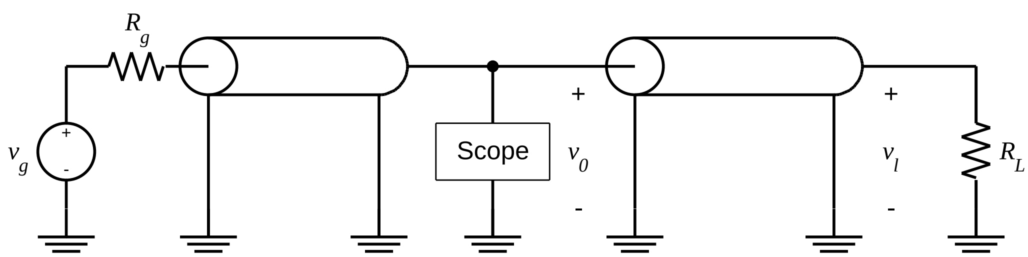

Figure 2: TDR with separate pulser and scope.

2. It assumes that the scope is ideal, i.e. introduces no load. Although the resistive component of the scope input impedance is high, there is a significant amount of capacitance. This will cause a discontinuity at the point of measurement, even if the line being measured is perfectly matched.
3. It assumes that the driving step input has zero rise time. In fact both the generator and the scope will have finite bandwidth, resulting in non-zero risetime for the measured signal and limiting the minimum time intervals we can accurately measure.

So much for the background. On to the problem:

(a) Devise and describe procedures for the following measurements:

1. Finding the length of a line of known type.
2. Finding the velocity factor and impedance of a line of unknown type.

(b) What effect will the cable between the generator and scope and the input capacitance of the scope have on measurements made by the system in Figure 2?

(c) What effect will a non-zero rise time have on the resolution and accuracy of the measurements? Be as quantitative as possible in your answer.

(d) Assuming the system has a rise time of 1 ns, sketch the response at v_0 if the following assembly is connected in series from left to right as the line under test (i.e. to the right of v_0 in Figure 2):

1. 2 m of 50Ω cable with a velocity factor of 66%
2. 2 m of 75Ω cable with a velocity factor of 75%
3. a 50Ω terminating resistor

Remember that the piece of coax to the left of v_0 is part of the measurement system. In this problem the single piece of coax between v_0 and v_l in Figure 2 is replaced with two pieces as described above.