

## Lossy Transmission Lines

**Reading assignment**

Paul, Whites, and Nasar, 7.4, 7.5

**Problem 1 - resistance and attenuation of coaxial cables**

In the waves section of the course, we will learn that waves penetrate into a material a distance known as a skin depth,  $\delta = (\frac{1}{f\mu})^{-0.5}$ .

- a. Calculate the skin depth in copper at 1 kHz and 15 MHz.
- b. An RG-58 cable has a polyethylene dielectric ( $\epsilon_r = 2.3$  and  $\mu = 10^{-13}$ /ohm m) and copper conductors. The inner conductor extends from  $r = 0$  to  $r = a = 0.4$  mm and the outer conductor extends from  $r = b = 1.4$  mm to 1.53 mm. (Note the numbers here are slightly different than in the book).
  - 1) Calculate the resistance per unit length  $r$ , and conductance per unit length  $g$  at 1 kHz. Use  $\mu = 10^{-13}$  for the polyethylene.
  - 2) Repeat for 15 MHz.
- c. The inductance and capacitance per unit length,  $l$  and  $c$  have already been calculated. They are  $0.25 \mu\text{H}/\text{m}$  and  $100 \text{ pF}/\text{m}$  respectively. At 15 MHz,
  - 1) determine the characteristic impedance,  $Z_C$ ,
  - 2) the propagation constant,  $\gamma = \alpha + j\beta$
  - 3) the distance a wave travels before the voltage is attenuated to  $1/e$  of its original value.
  - 4) The reflection coefficient for a  $93 \Omega$  load.
- d. What parameters are essentially the same for low-loss and lossless lines? What is new?