Reading Assignment: Chapters 8-9 of Cheng

Homework #2 **Due: Friday, 27 January 2006**

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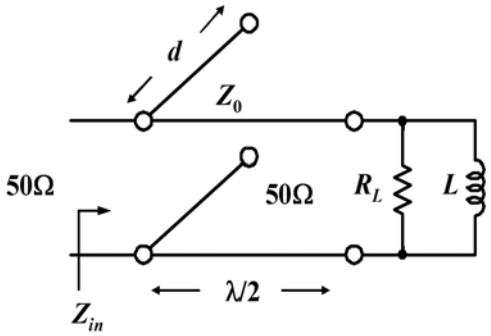
1) In the single-stub matching problem below, a load impedance with $R_L = 50\,\Omega$ and L=10 nH terminates a 50 Ω transmission line. It is desired to match this load to a 50 Ω generator. An open-circuited stub placed $\lambda/2$ from the load can be used to cancel the inductive reactance. Do the following



   a) Using the impedance transformation formula, numerically calculate the required stub length d that is required to match the load at a freqency of f=1 GHz. Assuming that the stub impedance is $Z_0 = 50\,\Omega$.
   b) Repeat (a) using a Smith chart, and turn in your annotated Smith chart with this assignment.

2) Do problem P.9-48 in Cheng. Turn in your annotated Smith chart with this assignment.

3) Do problem P.8-21 in Cheng

4) Aluminum has $\epsilon = \epsilon_0$, $\mu = \mu_0$, and $\sigma = 3.54 \times 10^7$ S/m. Suppose we want to make an antenna for UHF reception out of a wood dowel coated with a thin layer of aluminum. The thickness of this aluminum layer should several skin depths ($\sim 3\delta$) at that frequency. What thickness should be used? Is ordinary aluminum foil thick enough for this purpose? (Aluminum foil is about 1 mil, or 0.001 inch thick). Assume a typical UHF frequency of $f = 1.0$ GHz.

5) Measurements on a plane wave of frequency 3.0 GHz travelling through a non-magnetic material yield a wavelength of $\lambda = 5.00$ cm and an attenuation of 0.4 dB/cm.
   a) Find β and α.
   b) Is this medium a low-loss dielectric or a good conductor?
   c) Find the dielectric constant, ϵ_r.
   d) Find the conductivity, σ, in Siemens/meter.
   e) Suppose the frequency were changed to 10 MHz. In what distance would the wave's field strength attenuate by 10 dB?

(turn over)

6) After watching a sensationalist CNN program on the perils of human exposure to high levels of electromagnetic radiation, a concerned young engineering student measured an electric field of approximately 1.0 V/m at 2.45 GHz leaking from her microwave oven. In the library she found that the IEEE and U.S. Government recommend limiting human exposure to microwaves to an average power of less than 10 mW/cm^2 for a duration of less than six minutes. Should she stop using her microwave oven?

7) A 10 GHz radar produces an electromagnetic wave which is normally incident upon a still ocean. Assuming it is a plane wave, find the magnitude and phase of reflection coefficient and percent of incident energy reflected. The electrical properties of seawater are approximately $\sigma = 4\,\mathrm{S/m}$ and $\epsilon_r = 81$.

8) A wire grid is a polarization-sensitive device. When a plane wave is normally incident on a wire grid, the part of the wave with an electric field parallel to the wires is reflected, and the part with the electric field perpendicular to the wires gets transmitted. Consider the wire grid shown below, which has closely spaced wires that run vertically ($\hat{x}$ direction). Determine the reflected and transmitted waves and their polarization if the incident field is circularly polarized,

$$\overline{E}_{inc} = E_0(\hat{x} + \jmath\hat{y})e^{-\jmath k_0 z}$$

What fraction of incident power gets reflected and transmitted?