EE 483/583 Antennas for Wireless Communications
Quiz #4 (Spring 2017)

Name Key

Instructions: Open book & notes. Place answers in indicated spaces and show all work for credit.

A 20 cm long dipole, oriented and centered on the z-axis, is driven by a phasor input current of $3.6\angle 30^\circ$ A at 749.5 MHz. Calculate length of this antenna as a fraction of a wavelength l/λ and the wavenumber k. Is this antenna infinitesimal, small, finite, or half-wavelength? At the point $(r = 1.6\text{m}, \theta = 60^\circ, \phi = 45^\circ)$ are we in the near-field, intermediate, or far-field region? Why? Find the radiation resistance and loss resistance of the dipole if it is made with a 2 mm diameter lead rod ($\sigma = 5\times10^6$ S/m). Calculate the radiated power, loss power, and total input power as well as the antenna efficiency. Assume $c = 2.998\times10^8$ m/s.

$$\lambda = \frac{c}{f} = \frac{2.998\times10^8}{749.5\times10^6} = 0.4\text{ m} = 40\text{cm}$$

$$l/\lambda = \frac{20\text{cm}}{40\text{cm}} = 0.5 \qquad k = \frac{2\pi}{\lambda} = \frac{2\pi}{0.4} = 15.708\ \frac{\text{rad}}{\text{m}}$$

$$r = 1.6\text{m} > \frac{2D^2}{\lambda} = \frac{2(0.2)^2}{0.4} = 0.2\text{m}\ ?\ \text{Yes!}$$

Per (4-93), $R_r \approx 73\,\Omega$. Per $R_r = \frac{1}{2\pi}\int_0^{\pi} \frac{\cos^2(\frac{\pi}{2}\cos\theta)}{\sin\theta}\,d\theta$

$$= 73.07901\,\Omega$$

Per (2-906) $R_{hf} = \frac{l}{2\pi a}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{0.2}{2\pi(1\times10^{-3})}\sqrt{\frac{2\pi(749.5\times10^6)4\pi\times10^{-7}}{2(5\times10^6)}}$

$$= 0.7743384\,\Omega$$

For a $\lambda/2$ dipole w/ sinusoidal current distribution $R_L = \frac{R_{hf}}{2}$

(2-90) efficiency $= e_{cd} = \frac{R_r}{R_r + R_L} = \frac{73.07901}{73.07901 + 0.38717} = 0.99473$

$P_{rad} = \frac{1}{2}|I_0|^2 R_r = \frac{1}{2}(3.6)^2 73.08 = 473.55\,\Omega$

$P_{loss} = \frac{1}{2}|I_0|^2 R_L = \frac{1}{2}(3.6)^2 0.387 = 2.509\,\Omega$

$l/\lambda =$ 0.5 $k =$ 15.708 rad/m infinitesimal, small, finite, or (half-wavelength) (circle correct)

near-field, intermediate, or (far-field) region? (circle correct) Why? $r = 1.6\text{m} > \frac{2D^2}{\lambda} = 0.2\text{m}$

$R_{rad} =$ 73.07901 Ω $R_{loss} =$ 0.38717 Ω efficiency = 99.473 %

$P_{rad} =$ 473.55 W $P_{loss} =$ 2.509 W $P_{in} =$ 476.061 W $= P_{rad} + P_{loss}$