9.6 A 2 m long center-fed dipole antenna operates in the AM broadcast band at 1 MHz. The dipole is made of copper wire with a radius of 1 mm.

(a) Determine the radiation efficiency of the antenna.

(b) What is the antenna gain in decibels?

(c) What antenna current is required so that the antenna will radiate 80 W, and how much power will the generator have to supply to the antenna?

Solution:

(a) Following Example 9-3, $\lambda = c/f = \left(3\times10^8 \text{ m/s}\right)/\left(10^6 \text{ Hz}\right) = 300$ m. As $l/\lambda = (2 \text{ m})/(300 \text{ m}) = 6.7\times10^{-3}$, this antenna is a short (Hertzian) dipole. Thus, from respectively Eqs. (9.35), (9.32), and (9.31),

$$R_{\text{rad}} = 80\pi^2\left(\frac{l}{\lambda}\right)^2 = 80\pi^2\left(6.7\times10^{-3}\right)^2 = 35 \qquad (\text{m}\Omega),$$

$$R_{\text{loss}} = \frac{l}{2\pi a}\sqrt{\frac{\pi f\mu_c}{\sigma_c}} = \frac{2 \text{ m}}{2\pi\left(10^{-3} \text{ m}\right)}\sqrt{\frac{\pi\left(10^6 \text{ Hz}\right)\left(4\pi\times10^{-7} \text{ H/m}\right)}{5.8\times10^7 \text{ S/m}}} = 83 \qquad (\text{m}\Omega),$$

$$\xi = \frac{R_{\text{rad}}}{R_{\text{rad}}+R_{\text{loss}}} = \frac{35 \text{ m}\Omega}{35 \text{ m}\Omega + 83 \text{ m}\Omega} = 29.7\%.$$

(b) From Example 9-2, a Hertzian dipole has a directivity of 1.5. The gain, from Eq. (9.29), is $G = \xi D = 0.297\times1.5 = 0.44 = -3.5$ dB.

(c) From Eq. (9.30a),

$$I_0 = \sqrt{\frac{2P_{\text{rad}}}{R_{\text{rad}}}} = \sqrt{\frac{2(80 \text{ W})}{35 \text{ m}\Omega}} = 67.6 \text{ A}$$

and from Eq. (9.31),

$$P_t = \frac{P_{\text{rad}}}{\xi} = \frac{80 \text{ W}}{0.297} = 269 \text{ W}.$$