

**Problem 9.5** 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,  $\lambda = c/f = (3 \times 10^8 \text{ m/s})/(10^6 \text{ Hz}) = 300 \text{ m}$ . As  $l/\lambda = (2 \text{ m})/(300 \text{ m}) = 6.7 \times 10^{-3}$ , this antenna is a short (Hertzian) dipole. Thus, from respectively Eqs. (9.35), (9.32), and (9.31),

$$R_{\text{rad}} = 80\pi^2 \left( \frac{l}{\lambda} \right)^2 = 80\pi^2 (6.7 \times 10^{-3})^2 = 35 \text{ (m}\Omega\text{)},$$

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

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

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

(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),

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


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