9.27 The configuration shown in Fig. P9.27 depicts two vertically oriented half-wave dipole antennas pointed towards each other, with both positioned on 100 m tall towers separated by a distance of 5 km. If the transit antenna is driven by a 50 MHz current with amplitude $I_0 = 2$ A, determine:

(a) The power received by the receive antenna in the absence of the surface. (Assume both antennas to be lossless.)

(b) The power received by the receive antenna after incorporating reflection by the ground surface, assuming the surface to be flat and to have $\varepsilon_r = 9$ and conductivity $\sigma = 10^{-3}$ (S/m).

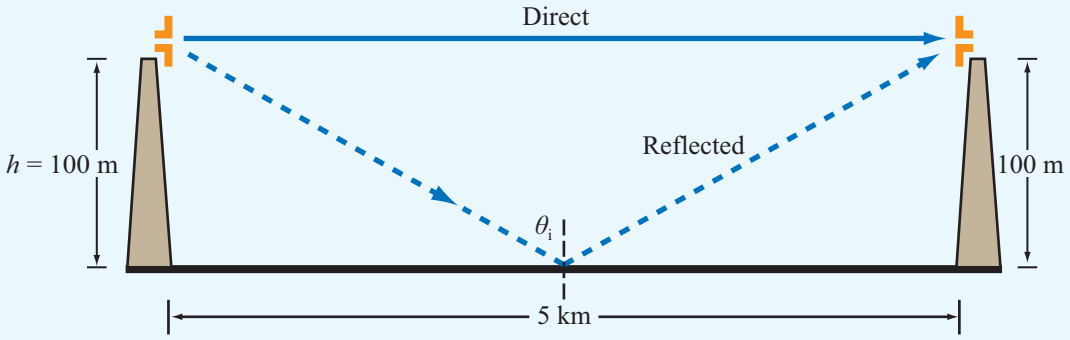

Figure P9.27 Problem 9.27.

Solution:

(a) Since both antennas are lossless,

$$P_{rec} = P_{int} = S_i A_{er}$$

where S_i is the incident power density and A_{er} is the effective area of the receive dipole. From Section 9-3,

$$S_i = S_0 = \frac{15 I_0^2}{\pi R^2},$$

and from (9.64) and (9.47),

$$A_{er} = \frac{\lambda^2 D}{4\pi} = \frac{\lambda^2}{4\pi} \times 1.64 = \frac{1.64\lambda^2}{4\pi}.$$

Hence,

$$P_{rec} = \frac{15 I_0^2}{\pi R^2} \times \frac{1.64\lambda^2}{4\pi} = 3.6 \times 10^{-6} \text{ W}.$$

From the geometry,

$$\cos\theta_{\rm i} = \frac{h}{(R'/2)} = \frac{100}{2502} = 0.04$$
$$\theta_{\rm i} = 87.71^\circ$$
$$\theta_{\rm t} = \sin^{-1}\left(\frac{\sin\theta_{\rm i}}{\sqrt{\varepsilon_{\rm r}}}\right) = 19.46^\circ$$
$$\eta_1 = \eta_0 \text{ (air)}$$
$$\eta_2 = \eta = \frac{\eta_0}{3}\,.$$

Hence,

$$\Gamma_{\parallel} = \frac{(\eta_0/3)\times 0.94 - \eta_0 \times 0.04}{(\eta_0/3)\times 0.94 + \eta_0 \times 0.04} = 0.77.$$

The reflected electric field is

$$E_{\rm r} = \left(\sqrt{\frac{30\eta_0}{\pi}}\,\frac{I_0}{R'}\,e^{-jkR'}\right)\Gamma$$
$$= 0.018e^{j0.6^\circ} \qquad \text{(V/m)}.$$

The total electric field is

$$E = E_{\rm d} + E_{\rm r}$$
$$= 0.024e^{-j120^\circ} + 0.018e^{j0.6^\circ}$$
$$= 0.02e^{-j73.3^\circ} \qquad \text{(V/m)}.$$

The received power is

$$P_{\rm rec} = S_{\rm i}A_{\rm er}$$
$$= \frac{|E|^2}{2\eta_0} \times \frac{1.64\lambda^2}{4\pi}$$
$$= 2.5\times 10^{-6}\ \text{W}.$$