2.103 A one-way communication system, operating at 100 MHz, uses two identical $\lambda/2$ vertical, resonant, and lossless dipole antennas as transmitting and receiving elements separated by 10 km. In order for the signal to be detected by the receiver, the power level at the receiver terminals must be at least 1 μW. Each antenna is connected to the transmitter and receiver by a lossless 50-Ω transmission line. Assuming the antennas are polarization-matched and are aligned so that the maximum intensity of one is directed toward the maximum radiation intensity of the other, determine the minimum power that must be generated by the transmitter so that the signal will be detected by the receiver. Account for the proper losses from the transmitter to the receiver.

- Hint: The term 'resonant' implies that the reactance of the dipole has been eliminated, i.e., $X_A = 0$.

$$(4\text{-}93)\quad Z_{ant} = 73 + j\cancel{42.5}\ \Omega \longrightarrow \text{@ resonance } X_{ant} = 0$$

$$|\Gamma| = \left|\frac{Z_{ant} - Z_c}{Z_{ant} + Z_c}\right| = \left|\frac{73 - 50}{73 + 50}\right| = \underline{0.186992}$$

$$\lambda = c/f = \frac{2.998 \times 10^8}{100 \times 10^6} = \underline{2.998\,m}$$

$$(4\text{-}91)\quad D_{ant}\big|_{max} = 1.643$$

$$(2\text{-}118)\quad \frac{P_r}{P_t} = \underbrace{e_{cd_t}}_{\to 1}\,\underbrace{e_{cd_r}}_{\to 1}(1 - |\Gamma_t|^2)(1 - |\Gamma_r|^2)\left(\frac{\lambda}{4\pi R}\right)^2 D_t\big|_{max} D_r\big|_{max} \underbrace{|\hat{\rho}_t \cdot \hat{\rho}_r|^2}_{\to 1}$$

$$= (1 - 0.187^2)(1 - 0.187^2)\left(\frac{2.998}{4\pi\, 10 \times 10^3}\right)^2 (1.643)(1.643)$$

$$\frac{1\,\mu W}{P_t} = 1.4309 \times 10^{-9}$$

$$P_t\big|_{min} = \frac{1\,\mu W}{1.4309 \times 10^{-9}} = \underline{\underline{698.86\,W}}$$