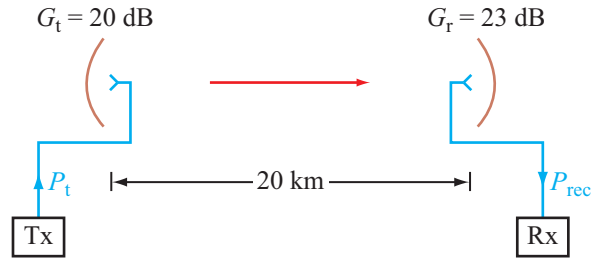


**Problem 9.23** Consider the communication system shown in Fig. P9.23, with all components properly matched. If  $P_t = 10$  W and  $f = 6$  GHz:

- (a) What is the power density at the receiving antenna (assuming proper alignment of antennas)?
- (b) What is the received power?
- (c) If  $T_{\text{sys}} = 1,000$  K and the receiver bandwidth is 20 MHz, what is the signal-to-noise ratio in decibels?



**Figure P9.23:** Communication system of Problem 9.23.

**Solution:**

- (a)  $G_t = 20$  dB = 100,  $G_r = 23$  dB = 200, and  $\lambda = c/f = 5$  cm. From Eq. (9.72),

$$S_r = G_t \frac{P_t}{4\pi R^2} = \frac{10^2 \times 10}{4\pi \times (2 \times 10^4)^2} = 2 \times 10^{-7} \text{ (W/m}^2\text{)}.$$

- (b)

$$P_{\text{rec}} = P_t G_t G_r \left( \frac{\lambda}{4\pi R} \right)^2 = 10 \times 100 \times 200 \times \left( \frac{5 \times 10^{-2}}{4\pi \times 2 \times 10^4} \right)^2 = 7.92 \times 10^{-9} \text{ W}.$$

- (c)

$$P_n = K T_{\text{sys}} B = 1.38 \times 10^{-23} \times 10^3 \times 2 \times 10^7 = 2.76 \times 10^{-13} \text{ W},$$

$$S_n = \frac{P_{\text{rec}}}{P_n} = \frac{7.92 \times 10^{-9}}{2.76 \times 10^{-13}} = 2.87 \times 10^4 = 44.6 \text{ dB}.$$


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