SC/CSE 4215 Mobile Communications Winter 2014

Quiz #1, Tue. Feb. 4, 2014 Name: ____________________

1. (*5 points*) An isotropic antenna radiates 3.33 W and its signal is picked up by an antenna 2.1 km away with an aperture area of 350 cm^2 and an efficiency of 0.8. We wish to receive the same amount of power with a second antenna that has an aperture of 120 cm^2 and an efficiency of 0.95. What is the maximum distance we can place the second antenna from the isotropic radiator? Assume the communication is at 900 MHz.

$$P_{r\,large} = P_{r\,small}$$

$$\frac{P_t G_t \eta_1 A_{e1}}{4\pi d_1^2} = \frac{P_t G_t \eta_2 A_{e2}}{4\pi d_2^2}$$

$$\frac{0.8 \times 350 \times 10^{-4}}{(2.1 \times 10^3)^2} = \frac{0.95 \times 120 \times 10^{-4}}{d_2^2}$$

$$d_2 = 1.34\ km$$

2. (*5 points*) A transmitter operates with an effective isotropic radiated power of 3 W and has a transmit gain of 1.2-dBd. It communicates with a receiver antenna 0.7 km away that has a gain of 4.1-dBi. If the communication occurs at 2.4 GHz what is the power at the output of the receive antenna in dBm?

$$P_r = \frac{P_t G_t G_r}{(4\pi d/\lambda)^2}$$

$$P_r|_{dBm} = P_t|_{dBm} + G_t|_{dB} + G_r|_{dB} - 20\cdot\log\left(\frac{4\pi d}{\lambda}\right)$$

$$= 34.77 + 3.35 + 4.1 - 20\cdot\log\left(\frac{4\pi\, 700}{0.125}\right)$$

$$= -54.7\ dBm$$

3. (*5 points*) A receiver has a noise figure of 7-dB and a power gain of 47-dB. It has a 400-kHz bandwidth and is attached to a 100-K antenna. What is the noise power coming out of the receiver (in Watts)? What is the total noise power contributed by the receiver electronics at the output (in Watts)?

$P_{out} = k(T_{ant} + T_e) \cdot G_o \cdot B$

$= k(501) \cdot 10^{4.7} \cdot 400 \times 10^3$

$= 1.39 \times 10^{-10}$ W

$T_e = T_{ant}(F - 1)$

$= 100(10^{0.7} - 1)$

$= 401$ K

$P_{out}|_{electronics} = k T_e G_o \cdot B$

$= 1.11 \times 10^{-10}$ W

$h = 6.625 \times 10^{-34}$ J·s, $q = 1.6 \times 10^{-19}$ C, $k = 1.38 \times 10^{-23}$ J/K, $c = 3 \times 10^8$ m/s
1 nW $= 10^{-9}$ W, 1 μ W $= 10^{-6}$ W

$$E = hf, \quad f = c/\lambda, \quad d = v \cdot t$$

$$Q\ [\mathrm{dB}] = 10\log(Q), \quad \log(A \cdot B/C) = \log(A) + \log(B) - \log(C)$$

$$P = V \cdot I, \quad V = R \cdot I$$

$$p = \frac{P_t}{4\pi d^2}, \quad P_r = p \cdot A_{er} = \frac{(EIRP)A_{er}}{4\pi d^2}$$

$$\text{beamwidth} = \frac{k\lambda}{L}$$

$$G = 4\pi\eta\frac{A_e}{\lambda^2}, \quad P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2}$$

$$P = kTB, \quad S(f) = \frac{N_0}{2}, \quad S_y(f) = |H(f)|^2 S_x(f), \quad P_y = \int_{-\infty}^{\infty} S_y(f)\mathrm{d}f$$

$$< v^2 >= \lim_{T\to\infty}\frac{1}{T}\int_{T/2}^{T/2} v^2(t)\mathrm{d}t, \quad v_{rms} = \sqrt{< v^2 >}, \quad kTB =< v^2 > /4R, \quad < v^2 >= 4kTRB = 4N_0RB$$

$$P_{ao} = G_0 \cdot N_0 \cdot B = \frac{N_0}{2}\int_{-\infty}^{\infty} G(f)\mathrm{d}f, \quad G(f) = \frac{1}{1 + (f/f_{3dB})^{2n}}, \quad B = \frac{\frac{\pi}{2}f_{3dB}}{n\sin(\frac{\pi}{2n})}$$

$$P_{ao} = G_0N_0BF = kTBG_0F = k(T_0 + T_e)BG_0, \quad F = 1 + \frac{T_e}{T_0}, \quad T_e = T_0(F - 1)$$

$$F = F_1 + \frac{F_2 - 1}{G_{01}} + \frac{F_3 - 1}{G_{01}G_{02}}, \quad T_e = T_{e1} + \frac{T_{e1}}{G_{01}} + \frac{T_{e3}}{G_{01}G_{02}}$$

$$P_r \approx \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 L_{sys}}\left(\frac{4\pi h_t h_r}{\lambda}\right)^2 \frac{1}{d^4}$$