Exercise 1 in SSY135 Wireless Communications

January 28, 2020

1. [G-2.1] Under a free space path loss model, find the transmit power required to obtain a received power of 0 dBm for a wireless system with isotropic antennas ($G_{TX} = 1$, $G_{RX} = 1$) and a carrier frequency $f = 5$ GHz, assuming a distance $d = 10$ m. Repeat for $d = 100$ m.

2. Consider a cell with log-distance path loss, log-normal shadowing, and Rayleigh fading. The base station uses 16-QAM modulation with 1 Mbit/s bit rate and transmits with the power 10 W and carrier frequency is 900 MHz. The path loss exponent is 3.7 and path gain at the reference distance $d_0 = 1$ km is 18 dB below the free space path gain. Assume that the transmit and receive antennas are omnidirectional.
   Find the cell radius if an average received power of -100 dBm is to be maintained at cell boundary.

3. (a) For a two-ray model according to Figure 1, show how a Taylor series approximation of

$$x + x' - l = \sqrt{(h_t + h_r)^2 + d^2} - \sqrt{(h_t - h_r)^2 + d^2}$$

   results in the following:

$$\Delta\phi = \frac{2\pi(x + x' - l)}{\lambda} \approx \frac{4\pi h_t h_r}{\lambda d}$$

   Hint: $\sqrt[n]{1 + x^n} \simeq 1 + x^n/n$ for small x

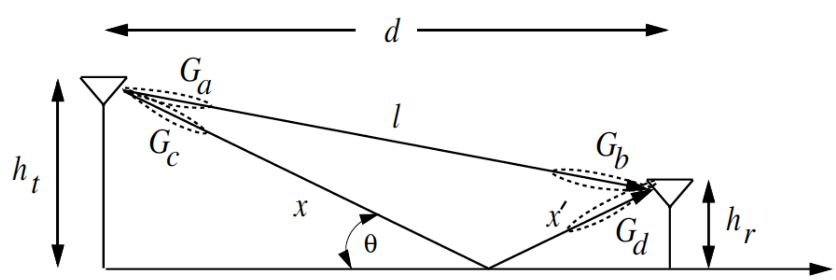

Figure 1: Two-ray model

   (b) For the two-ray model, derive an approximation expression for the distance values below the critical distance d_c at which signal nulls occur.

   (c) Consider a two-path channel with impulse response $h(t) = \alpha_1(t - \tau) + \alpha_2(t - (\tau - 0.022\ \mu\text{sec}))$. Find the distance separating transmitter and receiver, as well as α_1 and α_2, assuming free space path loss on each path with a reflection coefficient of -1. Assume the transmitter and receiver are located 8 meter above the ground and the carrier frequency is 900 Mhz.