ECE230X-D07 Quiz 2

Your Name: Solution Your box #: _____

March 27, 2007

1. 60 points total. Suppose you have a NetFlix movie subscription and that NetFlix ships two DVDs to your home each week. Assume that each DVD contains 8 gigabytes of data. **Definitions:** one gigabyte = 10^9 bytes and one byte = 8 bits

   (a) 20 points. What is the average data rate, in bits per second, from NetFlix to your home?

   $$\frac{8 \text{ gigabytes} \times 2}{\text{week}} = \frac{16 \times 8 \times 10^9 \text{ bits}}{7 \times 24 \times 60 \times 60 \text{ seconds}} = 211.6 \times 10^3 \text{ bits/sec}$$

   or 211.6 kbits/sec

   (b) 40 points. A manager at NetFlix suggests that, instead of shipping the DVDs to customers by mail, NetFlix should "beam" the movies to customers all over the world via satellite links. Assume that the DVD data is not compressed and that NetFlix leased enough bandwidth so that each customer has a 50kHz dedicated link to the satellite. What is the minimum SNR (in dB) needed in the 50kHz satellite link for NetFlix to be able to reliably deliver two DVDs per week to your home? Use your result from part (a) and explain.

   $C = B\log_2(1+\sigma)$ Shannon's capacity formula

   Can't have a data rate higher than C and have reliable communication.

   $B = 50\text{kHz}$

   $C = 211.6$ kbits/sec

   Solve for SNR σ

   $$1+\sigma = 2^{C/B} \Rightarrow \sigma = 2^{C/B} - 1$$

   $$\sigma = 2^{211.6/50} - 1 = 17.79$$

   Convert to dB $\Rightarrow$ SNR(dB) = 12.50dB

   This is the absolute minimum SNR for these idea to even be possible.

2. 40 points. Suppose you have two space ships floating in deep space separated by a distance of d meters with no nearby planets or other celestial objects. These space ships communicate with each other at frequency $f_c = 900\text{MHz}$. The transmit and receive antennas on each space ship are isotropic. If one space ship transmits a signal with power of -10dBm and the received power at the the other space ship is -100dBm. what is the distance d?

Hint: You know two equations for attenuation in wireless links, each based on a different propagation model. Make sure you use the correct one to solve this problem.

$$\text{attenuation(dB)} = 10\log_{10}\left(\frac{(4\pi d)^2}{\lambda^2 G_r G_t}\right)$$

$$\text{attenuation(dB)} = 10\log_{10}\left(\frac{(4\pi d)^2}{\lambda^2 G_r G_t} \cdot \frac{1}{4\sin^2\left(\frac{2\pi h_t h_r}{\lambda d}\right)}\right)$$

this is the free-space model which applies here. (no reflecting objects nearby)

$\lambda = c/f_c = \frac{3\times10^8}{900\times10^6} = 0.333$

-10dBm → attenuation (90dB) → -100dBm

$G_r = 1 = G_t$ (isotropic)

$$90\text{dB} = 10\log_{10}\left(\frac{(4\pi d)^2}{0.333^2 \cdot 1 \cdot 1}\right)$$

$$\left(\frac{4\pi d}{0.333}\right)^2 = 10^9, \text{ solve for } d$$

$$\boxed{d = 838\text{m}}$$

3. BONUS: 10 points, no partial credit. What is the name of the scientific instrument that shows the power of signals as a function of frequency? Hint: We looked at the power and bandwidth of wireless LAN signals in class using this instrument on Friday.

"spectrum analyzer"