CSE 4214 :: Problem Set 3

1. A computer generates binary data at the rate of 56 kbit/s. The data is transmitted using 4-ary raised-cosine pulses. What is the total bandwidth (counting positive frequencies only) required for excess bandwidth of 0.33, 0.67, and 1?

2. Suppose u(t) and v(t) satisfy the Nyquist criterion. Let w(t) = u(t) * v(t), where the * operation represents convolution. Either show that w(t) satisfies the Nyquist criterion, or find a counterexample showing that it does not (hint: try solving this problem in the frequency domain).

3. Show that:

   a. $\sin(2\pi f_c t) + \cos(2\pi f_c t) = k \sin(2\pi f_c t + \pi/4)$;
   b. $\sin(2\pi f_c t) - \cos(2\pi f_c t) = k \sin(2\pi f_c t + 3\pi/4)$;
   c. $-\sin(2\pi f_c t) - \cos(2\pi f_c t) = k \sin(2\pi f_c t + 5\pi/4)$; and
   d. $-\sin(2\pi f_c t) + \cos(2\pi f_c t) = k \sin(2\pi f_c t + 7\pi/4)$;

   where $k = \sqrt{2}$. Using these results, explain why transmitting a bit simultaneously with sin and cos is called "quadrature phase shift keying" (QPSK).

4. Using QPSK, let p_i and p_q represent the probability of bit error on the in-phase and quadrature bits, respectively. Show that the probability of symbol error is given by $p_i + p_q - p_i p_q$.

5. Consider a ternary system with three symbols: 0, 1, and 2, with the following modulation functions:

$s_0(t) = 0$	$s_1(t) = \begin{cases} 1, & 0 \le t \le T \\ 0, & t < 0, t > T \end{cases}$	$s_2(t) = \begin{cases} -1 & 0 \le t \le T \\ 0, & t < 0, t > T \end{cases}$

5. Suppose the filter is matched to $s_1(t)$. Find the probability of symbol error in terms of erfc, using the optimal decision regions, and find the average energy per symbol.

6. Consider the feedback shift register in the diagram below. Determine whether it produces a maximum length (ML) sequence.