EE 7620 **Problem Set # 6** **Due: 12,1,08**

1) Please attempt each problem on a new page.

2) Show all your work clearly.

1. The following code is used to transmit a binary source with rate R_b across an AWGN channel with noise power spectral density of $\frac{N_0}{2}$.

$$\begin{aligned}
\mathbf{s}_1 &= \sqrt{E_c}(+1,+1,+1,+1), \quad \mathbf{s}_2 = \sqrt{E_c}(-1,-1,-1,-1) \\
\mathbf{s}_3 &= \sqrt{E_c}(+1,+1,-1,-1), \quad \mathbf{s}_4 = \sqrt{E_c}(-1,-1,+1,+1) \\
\mathbf{s}_5 &= \sqrt{E_c}(+1,-1,+1,-1), \quad \mathbf{s}_6 = \sqrt{E_c}(-1,+1,-1,+1) \\
\mathbf{s}_7 &= \sqrt{E_c}(+1,-1,-1,+1), \quad \mathbf{s}_8 = \sqrt{E_c}(-1,+1,+1,-1)
\end{aligned}$$

   (a) Find the input blocklength K, output blocklength L and the code rate.

   (b) Diagram a complete communication system that uses this code to transmit over the AWGN channel. Your system should include an optimum receiver. Be sure to specify the operation of each block.

   (c) Use the union bound to obtain an upper bound to block error probability.

   (d) Find an expression for the block error probability (what kind of signal set is this?)

   (e) Find the $\frac{E_b}{N_0}$ needed to get block error probability of 10^{-5} (you can use the results from the book).

   (f) Repeat part (1e) using the upper bound in part (1c).

   (g) Find R_b/W assuming assuming a baseband rectangular pulse $\phi(t)$ is used.

   (h) Diagram an optimum hard decision receiver. Be sure to give the optimum vector decision rule.

   (i) Find $d_{\min}$ and the error correcting capability of this code.

   (j) Find an upper bound to the block error probability of the hard decision receiver.

   (k) Compute $\frac{E_b}{N_0}$ needed to get block error probability of 10^{-5} for the hard decision receiver (use the upper bound above).

   (l) Compare the results of parts (1c), (1e) and (1f).

2. A binary *Golay* code has $L = 23$, $K = 12$ and $d_{\min} = 7$.

   (a) Compute the $\frac{E_b}{N_0}$ needed to get $P(E) \leq 10^{-5}$ for both the soft decision and the hard decision receivers (use upper bounds for $P(E)$).

   (b) Compute R_b/W assuming a baseband rectangular pulse $\phi(t)$ is used.