國立台灣科技大學九十九學年度碩士班招生試題

系所組別： 電子工程系碩士班乙一組

科　　目： 通信系統

（總分為100分）

1. A box contains three red balls and seven blue balls. One ball is drawn at random and is discarded (i.e. removed) without its color being seen. Let us call this ball by the name of "Ball 1".

(a). (5%) A second ball, referred to as Ball 2, is then randomly drawn and observed to be red. What is the probability that Ball 1 was blue?

(b). (5%) Continued from (a), let us remove Ball 2 from the box. Then, a third ball is randomly drawn from the box. Let us call this third ball by the name of "Ball 3". What is the probability that Ball 3 is red?

2. A few candidate modulation schemes, listed below, are to be chosen for data transmission over an AWGN channel,

(i) coherent BFSK with $E_b/N_0 = 13$ dB,

(ii) BPSK with $E_b/N_0 = 12$ dB,

(iii) QPSK with $E_b/N_0 = 11$ dB,

where E_b is energy per bit and $N_0/2$ is the two-sided power spectral density of the AWGN channel.

(a). (4%) If the system's main performance criterion is the bit error rate, then which modulation scheme should be adopted ?

(b). (4%) If the system's main performance criterion is the bandwidth efficiency, then which modulation scheme should be adopted ?

3. Let us regard binary data transmission over an AWGN channel as a problem of binary hypothesis testing. The two hypotheses are

H_0: $z = A + w$

H_1: $z = -A + w$

where A is a positive constant, w is a zero-mean Gaussian noise whose variance is σ^2, and z is the observed signal at the receiver. Let $P(H_0)$ and $P(H_1)$ denote the a-priori probabilities of H_0 and H_1, respectively. The decision rule is:

Decide as H_0 if $z > \eta$.

The value of η should be chosen to minimize the probability of making an erroneous (i.e. incorrect) decision.

(a). (4%) If $P(H_0) = 0.6$ (and therefore $P(H_1) = 0.4$), then is η greater than 0 or less than 0? In other words, which choice is true: $\eta > 0$ or $\eta < 0$?

(b). (4%) If $P(H_0) = P(H_1)=0.5$, then η =?

(c). (4%) Continued from (b), what is the probability of making an erroneous decision? Please express your answer in terms of A, σ, and the Q function defined by

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$$Q(x)=\int_{x}^{+\infty}\frac{1}{\sqrt{2\pi}}e^{-\frac{t^2}{2}}dt$$

(d). (4%) The log-likelihood ratio of H_0 and H_1, denoted as L_{01}, is defined as $P(z|H_0)/P(z|H_1)$, where $P(z|H_0)$ and $P(z|H_1)$ are the conditional probability densities given H_0 and H_1, respectively, when the observed signal is z. Find the value of L_{01} for $A=1$, $\sigma=2$, and $z=0.84$.

(e). (4%) Assume $P(H_0)=P(H_1)=0.5$, $A=1$, $\sigma=2$, and $z=0.84$. Find the probability that the transmitter sent out A, instead of $-A$, to the receiver. In other words, what is the probability that H_0 is true?

4. Let us consider a binary (n,k) linear block code whose set of code-words is given by {000000, 110100, 011010, 101110, 101001, 011101, 110011, 000111}.

(a). (4%) n=? k=?

(b). (3%) Find the minimum distance of the code.

(c). (5%) Suppose that $[c_1\ c_2\ c_3\ c_4\ c_5\ c_6]$ is transmitted, and $[d_1\ d_2\ d_3\ d_4\ d_5\ d_6]=[c_1\ c_2\ c_3\ c_4\ c_5\ c_6]+[e_1\ e_2\ e_3\ e_4\ e_5\ e_6]$ is received, with $\mathrm{Prob}(e_k=1)=p$, for k=1,2,3,4,5,6. Let P(correct decoding) denote the probability that $[d_1\ d_2\ d_3\ d_4\ d_5\ d_6]$ can be correctly decoded. Then, P(correct decoding) can be written as

$$P(\text{correct decoding})=(a+bp)^m(1-p)^u\ .$$

Find the values of a, b, m and u.

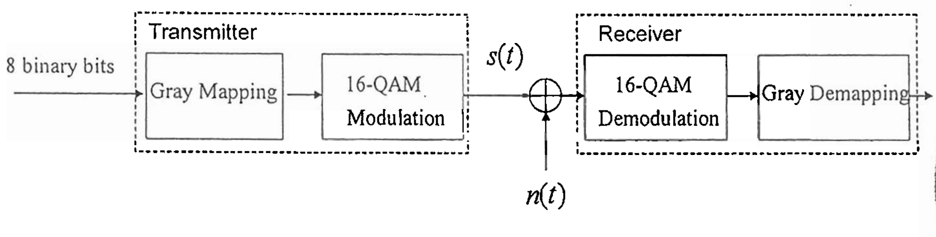
5.(5%)Prove that the power of a wide sense stationary process $X(t)$ is $E(X^2(t))$.

6. (5%) Find the power of the White Gaussian noise.

7.(5%) Find the minimum bit error rate of BPSK.

8.(5%) Find the minimum symbol error rate of QPSK.

9. The figure below shows the 16-QAM transmitter and receiver. At transmitter, 8 binary bits are Gray mapped and 16-QAM modulated with the pulse shaping filter $g(t)$, the symbol duration T and the central frequency f_c. The 16-QAM modulated signal $s(t)$ is transmitted over an AWGN channel. At receiver, the signal $s(t)+n(t)$ is 16-QAM demodulated and Gray demapped.



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(a). (5%) How many symbols does $s(t)$ carry?

(b). (10%) Find the orthogonal basis of $s(t)$ if

$$\int_{-\infty}^{+\infty} g(t-kT)g(t-mT)dt = 0, \quad \forall k \neq m, \quad k, m = \pm 1, \pm 2, ..$$

(c).(10%) Compute the minimum symbol error rate if binary bits are independently, identically and equally likely distributed.

(d). (5%) Based on the result of (c), find the minimum bit error rate.