國立台灣科技大學九十七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100分

Problem 1 In equations for the BER's (i.e. bit error rates) of many digital modulation schemes, the Q function and the erfc function are frequently encountered. They are defined by

$$Q(z) \triangleq \int_z^\infty \frac{1}{\sqrt{2\pi}} e^{-x^2/2}\, dx$$

$$erfc(z) \triangleq \int_z^\infty \frac{2}{\sqrt{\pi}} e^{-x^2}\, dx$$

(a) (3%) These two functions can be related to each other by Q(z) = A + B erfc(C z). What is the value of A+B+C?

(b) (3%) Let X be a Gaussian random variable with a mean of 3 and a variance of 4, what is the probability that X is greater than 4? Please express your answer in terms of the Q function.

(c) (4%) Assume that BPSK (binary phase shift keying) is adopted for data transmission in an AWGN channel with an E_b/N_0 of 6 dB, where E_b is the bit energy and N_0 is the two-sided power spectral density (PSD) of the Gaussian noise. What is the BER in this situation? Please express your answer in terms of the Q function. 14%

(d) (4%) Assume that coherent BFSK (binary frequency shift keying) is adopted for data transmission in an AWGN channel with an E_b/N_0 of 4.3 (N.B. this number is measured in regular dimension, not in dB), where E_b is the bit energy and N_0 is the two-sided PSD of the Gaussian noise. What is the BER in this situation? Please express your answer in terms of the Q function.

Problem 2 Answer the question below.

(a) (3%) Coherent detection and noncoherent detection differ in the requirement on the availability of one of the carrier information: (i) amplitude, (ii) frequency, and (iii) phase. Which one is the difference?

(b) (3%) In any communication system, one of the following operations is necessary while the others are optional: (i) encryption, (ii) channel coding, (iii) source coding, (iv) synchronization, and (v) multiplexing. Which one is the necessary operation?

(c) (3%) Of the functions listed below, which one does a phase-locked loop perform: (i) analogue-to-digital conversion, (ii) channel coding, (iii) source coding, (iv) synchronization, and (v) spectrum spreading. 19%

(d) (4%) A 4-ary information source sends out 4 different symbols with probabilities of 1/2, 1/4, 1/8, and 1/8, respectively. Find the entropy of this information source.

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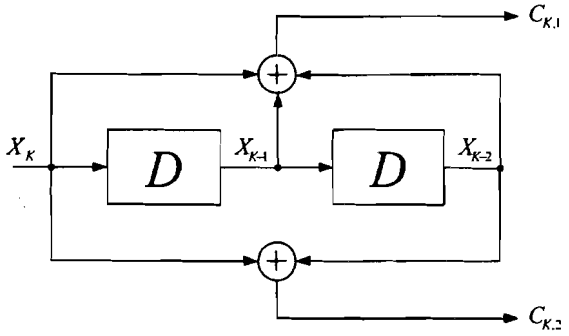
Please express your answer in term of bits.

(e) (3%) If coherent BFSK is adopted for data transmission at the rate of 100000 bits per second, what is the minimum tone spacing (measured in Hertz) for achieving orthogonal FSK signaling?

(f) (3%) If noncoherent BFSK is adopted for data transmission at the rate of 100000 bits per second, what is the minimum tone spacing for achieving orthogonal FSK signaling?

Problem 3 The encodeing circuit of a convolutional code is shown below, where X_K is the input message bit at time K, and $C_{K,1}$ and $C_{K,2}$ are the corresponding output code bits.



(a) (3%) What is the code rate of this convolutional code?

(b) (4%) Plot the state transition diagram of this convolutional code. Please denote the states in the form of (X_{K-1},X_{K-2}).

17%

(c) (4%) A message word $[X_1\ X_2\ X_3\ X_4]=[1101]$ (with X_1 fed into the encoder first, X_4 last) is encoded into a codeword $V=[C_{1,1}\ C_{1,2}\ C_{2,1}\ C_{2,2}\ C_{3,1}\ C_{3,2}\ C_{4,1}\ C_{4,2}]$, assuming that the encoding begins with both shift registers (i.e. the blocks labeled with "D") reset to 0. Write down the codeword V.

(d) (3%) Of the algorithms listed below, which one is the algorithm for convolutional decoding: (i) leaky bucket algorithm, (ii) Euclidean algorithm, (iii) Viterbi algorithm, (iv) water filling algorithm, and (v) Gram-Schmit algorithm?

(e) (3%) Of the estimation methods listed below, which one should the convolutional decoding algorithm in the previous subproblem be classified into: (i) maximum a-posteriori estimation, (ii) maximum likelihood sequence estimation, (iii) minimum mean square error estimation, and (iv) linear regression estimation

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Problem 4: Suppose a white Gaussian noise pass a band-pass filter, please answer following questions:

(a) (10%) Please prove and evaluate the noise after the band-pass can be expressed by $n_{bp}(t) = n_I(t)\cos(2\pi f_c t + \theta) - n_Q(t)\sin(2\pi f_c t + \theta)$, where $n_I(t)$ and $n_Q(t)$ are low-pass noise, f_c is center frequency of band-pass filter and $\theta \in [0, 2\pi]$ is uniformly distributed. 20%

(b) (10%) Based on results of (a), please prove and evaluate auto-correlation and cross-correlation of $n_I(t)$ and $n_Q(t)$.

Problem 5: (5%) Please prove and evaluate spectral efficiency of M-ary QAM. 5%

Problem6: Below figure shows a pair of signals $s_1(t)$ and $s_2(t)$ over the observation interval $0 \le t \le 3$. Suppose the received signal is defined by $x(t) = s_k(t) + n(t)$ $0 \le t \le 3$, $k = 1, 2$, where $n(t)$ is white Gaussian noise of zero mean and power spectral density $N_0/2$, please answer following questions:

(a)(20%) Please design the optimal receiver that decides in favor of signals $s_1(t)$ or $s_2(t)$ with minimum symbol error rates, assuming that these two signals are with probability mass function $p(s_1(t)) = 1/3$ and $p(s_2(t)) = 2/3$. 25%

(b)(5%) Based on results of (a), please calculate the minimum symbol error rates incurred by the optimal receiver.