國立臺灣科技大學
九十三學年度碩士班考試試題

系所組別：電子工程系乙一組
科　　目：通信系統

This examination includes 8 problems, which in turn consist of 23 subproblems. The total grade is 100 points. The grade points of each subproblem is indicated immediately following its problem number.

1. Let $g(t)$ denote a gate function defined as

$$g(t) = \begin{cases} 1 & 0 < t < T \\ 0 & \text{otherwise} \end{cases}$$

where T is a positive real constant. A deterministic signal $x(t)$ is defined as

$$x(t) = 1 + \sum_{k=-\infty}^{\infty} g(t - 2kT)$$

(a). (5%) Please compute and plot the Fourier transform of $x(t)$.

(b). (5%) Suppose the signal $x(t)$ is filtered by an ideal lowpass filter with bandwidth $\frac{1.2}{T}$ Hz. Please determine the filter output $y(t)$.

(c). (5%) Please find the expression for the Fourier transform of $\left(x(t)\cos(\frac{20\pi t}{T})\right)$.

2. Let $b[k]$ be a white random sequence with the property $P[b[k] = 1] = P[b[k] = -1] = 0.5$. Let τ be a uniform random variable distributed over [0, 1), and let Θ be a uniform random variable distributed over $[0, 2\pi)$. It is assumed that $b[k]$, τ, and Θ are mutually independent. Suppose $u(t)$ represnt the unit step funciton. Then, two continuous-time random signals $m(t)$ and $x(t)$ are defined as follows:

$$m(t) = \sum_{k=-\infty}^{\infty} b[k]\{u(t - k - \tau) - u(t - k - 1 - \tau)\}$$

and

$$x(t) = m(t)\cos(10\pi t + \Theta).$$

(a). (5%) Please determine the autocorrelation function of $m(t)$ using the ensemble average.

(b). (5%) Please compute the the autocorrelation function of $x(t)$ using the ensemble average.

(c). (5%) Is the random process $x(t)$ ergodic? Please justify your answer.

(d). (5%) Please determine the power spectral density of $x(t)$.

3. It is known that Costas loop can be employed to demodulate DSB-SC signals through the use of a coherent (synchronous) demodulation scheme.

(a). (7%) Please plot the block diagram of such a demodulation system.

(b). (8%) Please explain how the carrier synchronization is achieved and how the demodulation is accomplished.

4. With Prob(·) denoting the probability of an event, let us define the Q function to be $Q(x) = \text{Prob}(X_0 > x)$, where X_0 is a Gaussian random variable with mean = 0 and variance = 1. Let X be a Gaussian random variable with mean = μ and variance = σ^2. It ~~can~~ can be shown that $\text{Prob}(X > y) = Q(\alpha \cdot y + \beta)$, where α and β are constants.

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(a). (3%) $\alpha = ?$ Please express your answer in terms of μ and σ.

(b). (3%) $\beta = ?$ Please express your answer in terms of μ and σ.

5. In BPSK (binary phase shift keying) signal transmission, logical 0 and logical 1 are, respectively, mapped into waveforms $s_0(t) = A\cos 2\pi f_c t$ and $s_1(t) = -A\cos 2\pi f_c t$ for $0 < t < T$, where A is a positive constant. Assume that the communication is through an AWGN (additive white Gaussian noise) channel, where the two-sided power spectral density of the noise is $N_0/2$.

(a). (4%) Find the energy consumed by each bit. Please express your answer in terms of A and T.

(b). (4%) Plot a reception structure for the BPSK detection. You are required to use as few correlators as possible in it.

(c). (4%) What is the null-to-null bandwidth, which is equal to the width of the main lobe of the signal power spectrum, consumed by this BPSK transmission ? Please express your answer in terms of T.

(d). (4%) Can BPSK detection be performed noncoherently ?

(e). (4%) For $A = 4$, $T = 1$ and $N_0 = 3$, find the BER in the BPSK transmission. Please express your answer in terms of the Q function, which has been defined previously in Problem 4.

6. A (6,3) linear block code (referred to as $\mathcal{C}$) is generated by $\underline{c} = \underline{m}\,\underline{\underline{G}}$, where $\underline{m}$ is the message word, $\underline{c}$ is the codeword and the generator matrix $\underline{\underline{G}}$ is given by

$$\underline{\underline{G}} = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 \end{bmatrix}.$$

(a). (3%) List all codewords of $\mathcal{C}$.

(b). (3%) What is the minimum distance of $\mathcal{C}$?

(c). (3%) In $\mathcal{C}$, up to how many erroneous bits in one codeword can be detected ?

(d). (3%) In $\mathcal{C}$, up to how many erroneous bits in one codeword can be corrected ?

(e). (3%) Is $\mathcal{C}$ a cyclic code ?

7. (4%) Listed below are four circuit components : (a) correlator, (b) phase-locked loop, (c) A/D converter, (d) envelope detector. Among them, which one is the most essential part of a carrier synchronization circuit ?

8. (5%) In CDMA (code-division multiple access) communications, pseudo-noise sequences are needed. Here in this problem, let us consider a pseudo-noise sequence generated from a 16-stage linear feedback shift register circuit. What is the maximum period achievable of this sequence ?

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