國立中正大學
109學年度碩士班招生考試
試 題
[第1節]

科目名稱	通訊原理
系所組別	電機工程學系-信號與媒體通訊組
	通訊工程學系-通訊甲組

—作答注意事項—

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

1. 預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
2. 考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
3. 入場後於考試開始40分鐘內不得離場。
4. 全部答題均須在試卷（答案卷）作答區內完成。
5. 試卷作答限用藍色或黑色筆（含鉛筆）書寫。
6. 試題須隨試卷繳還。

國立中正大學 109 學年度碩士班招生考試試題

科目名稱：通訊原理　　　　　　　　　　　　本科目共 5 頁　第 1 頁
系所組別：電機工程學系-信號與媒體通訊組
　　　　　通訊工程學系-通訊甲組

I. Short Questions

Answer the questions below by providing the most appropriate choice. Write down the correct answer on your answer sheet. No explanations will be considered in grading this portion of the exam. Each correct answer is worth 5 points (5%).

1) Which of the following functions can be the autocorrelation of a real-valued wide-sense stationary random process?
   a) $f(\tau) = \tau^2$
   b) $f(\tau) = \sin(\tau)$
   c) $f(\tau) = \tau^3$
   d) $f(\tau) = \cos(2\pi\tau)$
   e) None of the above.

2) Consider a set of four binary codewords given by $\mathbf{c}_1 = [1, 1, 1, 1]$, $\mathbf{c}_2 = [1, -1, 1, -1]$, $\mathbf{c}_3 = [1, 1, -1, -1]$, and $\mathbf{c}_4 = [1, -1, -1, 1]$. Assume that the received signal of a receiver is given by $\mathbf{r} = -\mathbf{c}_m + \mathbf{z}$ where $\mathbf{z}$ is a 1×4 zero-mean real-valued Gaussian random vector with $E[\mathbf{z}^T\mathbf{z}] = \sigma^2\mathbf{I}$. Given $\mathbf{r} = [-0.3, 0.3, 0.1, 0.2]$, find the maximum-likelihood codeword.
   a) $\mathbf{c}_1$
   b) $\mathbf{c}_2$
   c) $\mathbf{c}_3$
   d) $\mathbf{c}_4$
   e) $\mathbf{c}_1$ and $\mathbf{c}_2$

3) Let $s_1(t) = \cos(2\pi f_c t)$ and $s_2(t) = \cos(2\pi(f_c + \Delta f)t)$. Define $\rho = \int_0^T s_1(t)s_2(t)dt$, where $T = n/f_c$ for some fixed integer n. Determine the minimum Δf so that $\rho = 0$.
   a) $\Delta f = 1/T$
   b) $\Delta f = 1/(2T)$
   c) $\Delta f = 2/T$
   d) $\Delta f = \cos(T)$
   e) None of the above.

4) The equivalent baseband transmitted signal for a digital communication system is given by $V(t) = \sum_{n=-\infty}^{\infty} A_n g(t - nT)$, where A_n is the complex-valued wide-sense stationary random information sequence and $g(t)$ is the impulse response of the transmission filter. Let $E[A_n] = 0$ and $E[A_m^* A_{n+m}] = 1$ if $n = 0$ and zero otherwise. Let $G(f)$ be the Fourier transform of $g(t)$. Determine the power-spectral density of $V(t)$.
   a) $S_V(f) = \frac{1}{T}|G(f)|^2$
   b) $S_V(f) = \frac{T}{2}|G(f)|^2$
   c) $S_V(f) = \frac{1}{T}G(f)$

d) $S_V(f) = \frac{T}{2}G(f)$

e) None of the above.

5) Regarding the binary modulation techniques, BPSK, BFSK and on-off keying, which of the following statements is true?

a) Under the coherent detection, BPSK and BFSK have the same performance under the same SNR.

b) Under the coherent detection, BFSK and on-off keying have the same performance under the same SNR.

c) Under the coherent detection, BPSK has the best performance under the same SNR.

d) Under the coherent detection, BFSK has the best performance under the same SNR.

e) None of the above.

6) Which of the following statements is correct?

a) An FM modulator is equivalent to a differentiator followed by a PM modulator.

b) A PM modulator is equivalent to an integrator followed by an FM modulator.

c) An FM modulator is equivalent to an integrator followed by a PM modulator.

d) An FM modulator is equivalent to a limiter followed by a PM modulator.

e) None of the above.

7) Regarding to the anti-aliasing filter, which of the following statements is correct?

a) The anti-aliasing filter is a high pass filter to remove the in-band noise.

b) The anti-aliasing filter is a combination of non-aliasing high-pass and low-pass filters.

c) The anti-aliasing filter is a low-pass filter to prevent aliasing effect after sampling.

d) The anti-aliasing filter is a combination of two non-aliasing high-pass filters.

e) None of the above.

8) To reconstruct the original signal $g(t)$ from the sampled signal $g_\delta(t) = \sum_{n=-\infty}^{\infty} g(nT_s)\delta(t-nT_s)$, which of the following statements is correct?

a) The original signal may be reconstructed by passing the sampled signal through an envelope detector.

b) No matter how fast of the sampling rate is, the original signal cannot be reconstructed from the sampled signal.

c) The original signal may be reconstructed by passing the sampled signal through a low pass filter.

d) The original signal may be reconstructed by passing the sampled signal through a delta demodulator.

e) None of the above.

9) Assume that a stationary random process $X_1, X_2, \ldots$ has zero mean and variance σ^2. The correlation between two adjacent signal point is $E[X_n X_{n-1}] = a > 0$. Determine the

variance of the sequence $Y_n = X_n + X_{n-1}$.

a) $2\sigma^2 + 2a$
b) $\sigma^2 - a$
c) $2\sigma^2 - 2a$
d) $a\sigma^2$
e) None of the above.

10) A PAM system produces the signal $s(t) = \sum_{n=-\infty}^{\infty} m(nT_s)h(t - nT_s)$, where T_s is the sampling period and $m(t)$ is the message signal. Let $H(f)$ be the Fourier transform of $h(t)$ and $M(f)$ be the Fourier transform of $m(t)$. Determine the Fourier transform of $s(t)$.

a) $S(f) = \frac{1}{T}\sum_{k=-\infty}^{\infty} M(f - \frac{k}{T_s}) \otimes H(f)$, where $\otimes$ denotes the convolution operator.
b) $S(f) = \frac{1}{T}\sum_{k=-\infty}^{\infty} M(f - \frac{k}{T_s})H(f)$
c) $S(f) = \frac{1}{T}\sum_{k=-\infty}^{\infty} H(f - \frac{k}{T_s})M(f)$
d) $S(f) = \frac{1}{T}\sum_{k=-\infty}^{\infty} M(f - \frac{k}{T_s})H(f)\exp(j2\pi kfT_s)$
e) None of the above.

國立中正大學 109 學年度碩士班招生考試試題

科目名稱：通訊原理

系所組別：電機工程學系-信號與媒體通訊組
通訊工程學系-通訊甲組

II. Long Questions

Give detailed derivations on the following questions. The grade of this portion depends not only on the correct answers but also on the explanations and derivations. Therefore, explain every detail as possible as you can.

1) (25%) A binary communication system uses two signals $s_1(t)$ and $s_2(t)$, for $0 \le t < T$, to represent equal probable information bit "0" and "1", respectively. The energies for both signals are equal with $E = \int_0^T |s_1(t)|^2 dt = \int_0^T |s_2(t)|^2 dt$. Let the received signal be $r(t) = s_i(t) + n(t)$, where $n(t)$ is a zero-mean white Gaussian noise with power spectral density of $N_0/2$.
   a) (10 %) Design an optimal receiver for the system.
   b) (10 %) Determine the bit error rate for the optimal receiver.
   c) (5 %) Given E and N_0, under what conditions, the receiver has the best performance.

2) (25 %) Consider a quaternary digital modulation system with $M = 4$ signals

$$s_1(t) = \phi_1(t) + \phi_2(t) \qquad s_2(t) = -\phi_1(t) + \phi_2(t)$$
$$s_3(t) = -\phi_1(t) - \phi_2(t) \qquad s_4(t) = \phi_1(t) - \phi_2(t)$$

where $\phi_1(t)$ and $\phi_2(t)$ are shown in Figure 1. The signal received at the demodulator is given by

$$x(t) = s_m(t) + n(t)$$

where $s_m(t)$ is the signal transmitted by the modulator, $m \in \{1, 2, 3, 4\}$, and $n(t)$ is a white Gaussian noise with the probability density function

$$f(w) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{w^2}{2\sigma^2}}$$

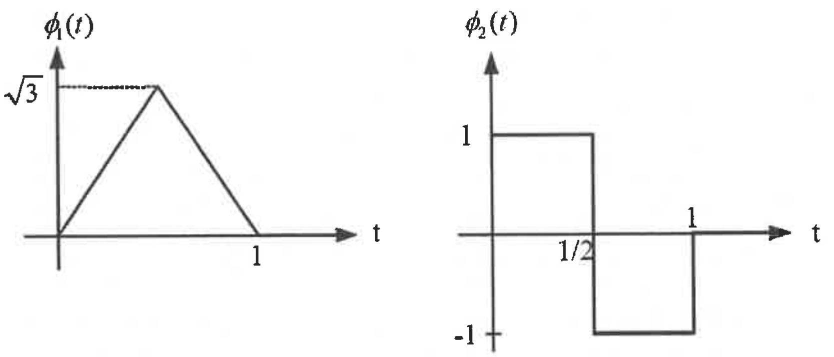

Fig. 1.

a) (5 %) Find a set of orthogonal basis functions for the signal space in terms of $\phi_1(t)$ and $\phi_2(t)$. Sketch the signal constellation.

b) (10 %)Find and sketch the maximum likelihood (ML) detector and sketch its decision regions in the signal space.

c) (10 %) Compute the error probability P_e of the ML detector, assuming the signals $s_1(t)$, $s_2(t)$, $s_3(t)$, and $s_4(t)$ are equally likely to be transmitted.