國立中山大學114學年度
碩士班考試入學招生考試試題

科目名稱：通訊理論【電機系碩士班戊組選考、通訊所碩士班甲組、乙組選考、電波聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

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※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

一、選擇題(單選，計分方式:不倒扣，答對得該題全部分數，答錯及未作答得零分)

1. (5%) The sum of two or more sinusoids may or may not be periodic. Which of the following signal is not periodic?
   (A) $x_1(t) = 2cos(2t) + 4sin(6\pi t)$
   (B) $x_2(t) = cos(6\pi t) + 7cos(30\pi t)$
   (C) $x_3(t) = cos(4\pi t) + 9sin(21\pi t)$
   (D) $x_4(t) = 3sin(4\pi t) + 5cos(7\pi t) + 6sin(11\pi t)$
   (E) None of these

2. (5%) Which of the following signals is a power signal?
   Note that α is a positive constant and $u(t) \triangleq \begin{cases} 0, & t < 0 \\ 1, & t > 0 \\ undefined, & t = 0 \end{cases}$.
   (A) $x_1(t) = e^{-\alpha t}u(t)$
   (B) $x_2(t) = (\alpha^2 + t^2)^{-\frac{1}{2}}$
   (C) $x_3(t) = 2cos(4\pi t + 2\pi/3)$
   (D) $x_4(t) = e^{-\alpha|t|}$
   (E) None of these

3. (5%) Which of the filters with impulse responses given below is not BIBO stable? (α and f_0 are positive constants.)
   (A) $h_1(t) = \exp(-\alpha|t|)cos(2\pi f_0 t)$
   (B) $h_2(t) = e^{-t}u(t) - e^{-(t-1)}u(t-1)$
   (C) $h_3(t) = t^{-2}u(t-1)$
   (D) $h_4(t) = cos(2\pi f_0 t)u(t)$
   (E) None of these

4. (5%) An FM modulator has output $x_c(t) = 100cos\left[2\pi f_c t + 2\pi f_d \int_0^t m(\alpha)d\alpha\right]$, where $f_d = 20$ Hz/V. Assume that $m(t)$ is the rectangular pulse $m(t) = 4\Pi\left[\frac{1}{8}(t-4)\right]$, where $\Pi(t) = \begin{cases} 1, & |t| \le \frac{1}{2} \\ 0, & otherwise \end{cases}$. Which of the following is correct?
   (A) For $0 < t < 8$, the phase deviation is $80\pi t$.
   (B) For $0 < t < 8$, the frequency deviation is 40 Hz
   (C) The peak frequency deviation is 40 Hz.
   (D) The peak phase deviation is 1280π radians.
   (E) None of these

5. (5%) In an AM modulator, efficiency is defined as the ratio of the power of the information-bearing signal to the total power of the transmitted signal. Determine the efficiency of the AM modulator having the output
   $$x(t) = 40cos[2\pi(200)t] + 5cos[2\pi(180)t] + 5cos[2\pi(220)t].$$
   (A) 50%
   (B) 25%
   (C) 13%

(D) 2%
(E) None of these

6. (5%) For the following signal, please determine the largest sampling interval T_s such that aliasing does not occur.

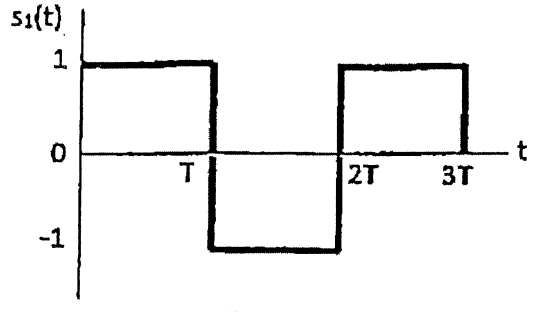
$$x_2(t) = \frac{1}{t}\sin(3\pi t)\cos(2\pi t)$$

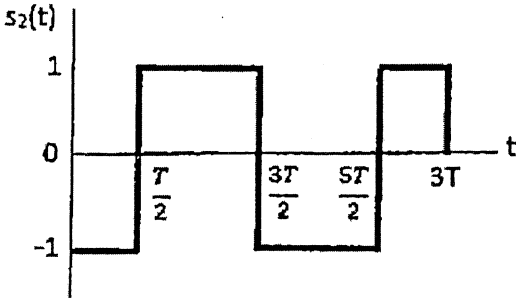
(A) $T_s \leq \frac{1}{2}$
(B) $T_s \leq \frac{1}{5}$
(C) $T_s \leq \frac{1}{6}$
(D) $T_s \leq \frac{1}{3}$
(E) None of these

7. (5%) Which descending order of the minimum bit-error-rate P_b for the following modulation schemes to send messages through the AWGN channel with $\frac{E_b}{N_0} = 10\text{dB}$ is correct? (1) BPSK; (2) QPSK; (3) OQPSK; (4)16PSK; (5)8FSK; (6) BFSK; (7) MSK; (8)16QAM.

(A) (1) = (2) = (3) = (7) < (5) < (6) < (8) < (4)
(B) (1) = (2) = (3) = (7) < (6) < (5) < (8) < (4)
(C) (1) < (2) = (3) < (7) < (5) < (6) < (8) < (4)
(D) (1) = (2) = (3) = (7) > (6) > (5) > (8) > (4)
(E) (1) = (2) = (3) = (7) < (8) < (5) < (6) < (4)

8. (5%) The following figure shows a pair of signals $s_1(t)$ and $s_2(t)$ that are orthogonal to each other over the observation interval $0 \leq t \leq 3T$. The received signal is defined by $X(t) = s_k(t) + w(t), k = 1, 2$, where $w(t)$ is white Gaussian noise of zero mean and a noise power spectral density (PSD) of $N_0/2$. Please calculate the average probability of symbol error for $E_s/N_0 = 4$, where E_s is defined as the signal energy.





(A) $\frac{1}{2}erfc(\frac{\sqrt{2}}{2})$
(B) $\frac{1}{2}erfc(\sqrt{2})$
(C) $erfc(\frac{\sqrt{2}}{2})$
(D) $erfc(\sqrt{2})$
(E) $erfc(2\sqrt{2})$

9. (5%) Three signals are transmitted over AWGN channel with a noise PSD of $N_0/2$. Three signals are

$$s_1(t) = \begin{cases} 1, & 0 \le t \le T \\ 0, & otherwise. \end{cases} \quad s_2(t) = -s_3(t) = \begin{cases} 1, & 0 \le t \le \frac{T}{2} \\ -1, & \frac{T}{2} < t < T \\ 0, & otherwise. \end{cases}$$

Which of the following statements is correct?

(A) The dimensionality of the signal space is 3

(B) $P(error|s_2\ transmitted) > P(error|s_3\ transmitted)$

(C) $P(error|s_1\ transmitted) = P(error|s_2\ transmitted)$

(D) $P(error|s_1\ transmitted) < P(error|s_3\ transmitted)$

(E) None of these is correct

二、問答計算題:

1. (15%) An SSB-AM signal is generated by modulating an 800 kHZ carrier by the signal $m(t) = cos(2000\pi t) + 2sin(2000\pi t)$. The amplitude of the carrier is $A_c = 100$.

(A) (5%) Determine the signal $\hat{m}(t)$, the Hilbert transform of $m(t)$.

(B) (5%) Determine the time-domain expression for the lower sideband of the SSB-AM signal.

(C) (5%) Determine the magnitude spectrum of the lower-sideband-SSB signal.

2. (10%) Over an interval $|t| \le 1$, an angle modulated signal is given by

$$\varphi_{EM}(t) = 10cos(13000t).$$

It is known that the carrier frequency $\omega_c = 10000$.

(A) (5%) If this were a PM signal with $k_p = 1000$, determine the message signal $m(t)$ over the interval $|t| \le 1$.

(B) (5%) If this were a FM signal with $k_f = 1000$, determine the message signal $m(t)$ over the interval $|t| \le 1$.

3. (15%) In an AWGN channel with a noise PSD of $N_0/2$, two equiprobable messages are transmitted using $S_1(t)$ and $S_2(t)$ defined in $0 \le t \le T$ with energies E_1 and E_2, respectively. If $\rho_{12} = \frac{\int_0^T S_1(t)S_2(t)dt}{\sqrt{E_1}\sqrt{E_2}}$, find:

(A) (5%) The structure of the optimal receiver, including the threshold expressed as functions of E_1, E_2, ρ_{12} and N_0.

(B) (4%) An expression for the average error probability.

(C) (3%) An expression for the average error probability if the signals are orthogonal.

(D) (3%) An expression for the average error probability if the signals are antipodal.

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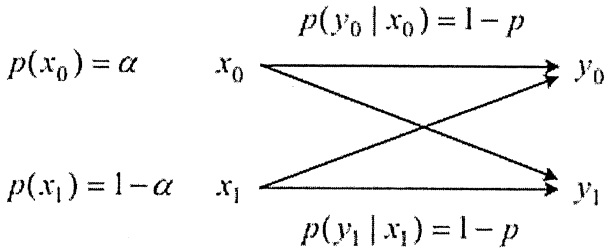
4. (15%) Consider a binary symmetric channel (BSC) as follows:



Determine the channel capacity C_s.