

# 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）

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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)  $x_1(t) = 2\cos(2t) + 4\sin(6\pi t)$
- (B)  $x_2(t) = \cos(6\pi t) + 7\cos(30\pi t)$
- (C)  $x_3(t) = \cos(4\pi t) + 9\sin(21\pi t)$
- (D)  $x_4(t) = 3\sin(4\pi t) + 5\cos(7\pi t) + 6\sin(11\pi t)$
- (E) None of these

2. (5%) Which of the following signals is a power signal?

Note that  $\alpha$  is a positive constant and  $u(t) \triangleq \begin{cases} 0, & t < 0 \\ 1, & t > 0 \\ \text{undefined}, & t = 0 \end{cases}$ .

- (A)  $x_1(t) = e^{-\alpha t}u(t)$
- (B)  $x_2(t) = (\alpha^2 + t^2)^{-\frac{1}{2}}$
- (C)  $x_3(t) = 2\cos(4\pi t + 2\pi/3)$
- (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? ( $\alpha$  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  $x_c(t) = 100\cos\left[2\pi f_c t + 2\pi f_d \int_0^t m(\alpha)d\alpha\right]$ , 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  $\Pi(t) =$

$\begin{cases} 1, & |t| \leq \frac{1}{2} \\ 0, & \text{otherwise} \end{cases}$ . 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  $1280\pi$  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

$$x(t) = 40\cos[2\pi(200)t] + 5\cos[2\pi(180)t] + 5\cos[2\pi(220)t].$$

- (A) 50%
- (B) 25%
- (C) 13%

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- (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.

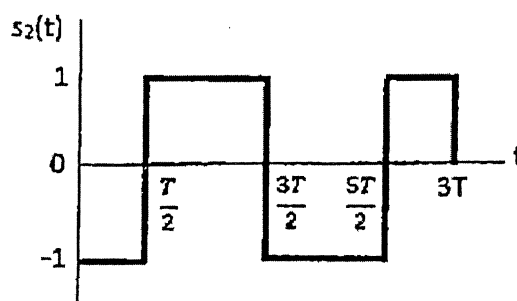
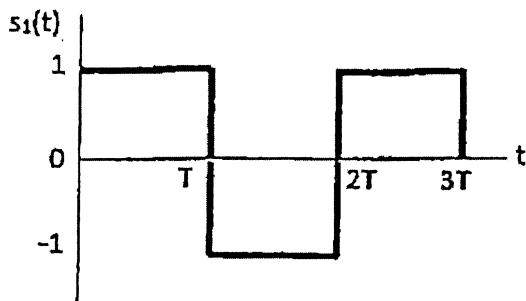
$$x_2(t) = \frac{1}{t} \sin(3\pi t) \cos(2\pi t)$$

- (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)  $\frac{1}{2} \text{erfc}\left(\frac{\sqrt{2}}{2}\right)$   
(B)  $\frac{1}{2} \text{erfc}(\sqrt{2})$   
(C)  $\text{erfc}\left(\frac{\sqrt{2}}{2}\right)$   
(D)  $\text{erfc}(\sqrt{2})$   
(E)  $\text{erfc}(2\sqrt{2})$

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

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

Which of the following statements is correct?

- (A) The dimensionality of the signal space is 3
- (B)  $P(\text{error}|s_2 \text{ transmitted}) > P(\text{error}|s_3 \text{ transmitted})$
- (C)  $P(\text{error}|s_1 \text{ transmitted}) = P(\text{error}|s_2 \text{ transmitted})$
- (D)  $P(\text{error}|s_1 \text{ transmitted}) < P(\text{error}|s_3 \text{ transmitted})$
- (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  $m(t) = \cos(2000\pi t) + 2\sin(2000\pi t)$ . 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  $|t| \leq 1$ , an angle modulated signal is given by

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

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

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  $0 \leq t \leq T$  with energies  $E_1$  and  $E_2$ , respectively. If  $\rho_{12} =$

$$\frac{\int_0^T S_1(t)S_2(t)dt}{\sqrt{E_1}\sqrt{E_2}}, \text{ find:}$$

- (A) (5%) The structure of the optimal receiver, including the threshold expressed as functions of  $E_1, E_2, \rho_{12}$  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.

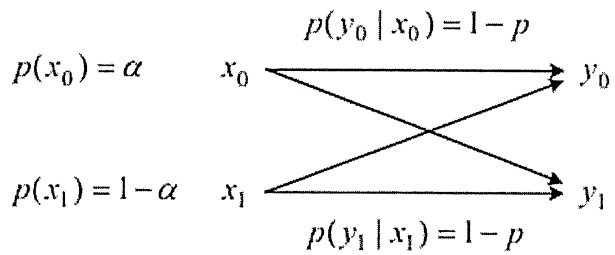
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4. (15%) Consider a binary symmetric channel (BSC) as follows:



Determine the channel capacity  $C_s$ .