國立中正大學
109學年度碩士班招生考試
試題
[第3節]

科目名稱	通訊原理
系所組別	通訊工程學系-通訊乙組

—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。

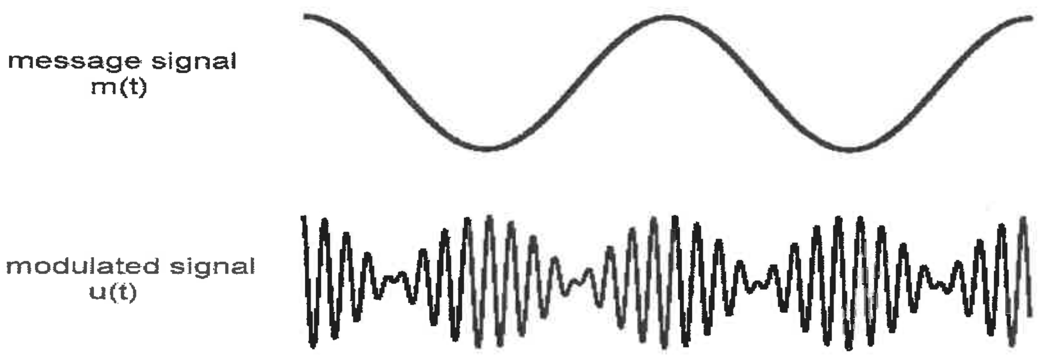
1. 預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
2. 考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
3. 入場後於考試開始40分鐘內不得離場。
4. 全部答題均須在試卷（答案卷）作答區內完成。
5. 試卷作答限用藍色或黑色筆（含鉛筆）書寫。
6. 試題須隨試卷繳還。

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) In AM radio broadcast, the information signal that is transmitted is contained in which part of the carrier signal
   a) Frequency
   b) Phase
   c) Amplitude
   d) Frequency and phase
   e) None of the above.

2) The message signal $m(t)$ is used to generate the modulated signal $u(t)$. The signals $m(t)$ and $u(t)$ are illustrated in the following figure. What is the modulation scheme used in this modulator?



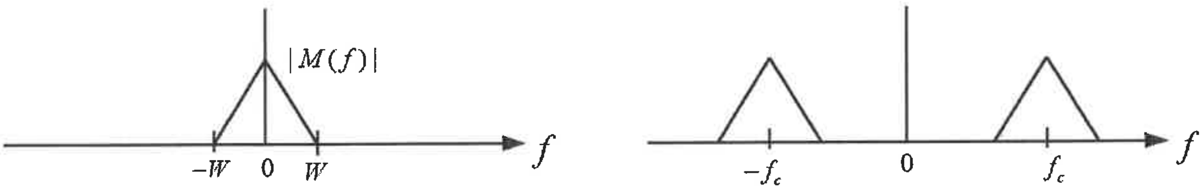
   a) FM modulation.
   b) PM modulation.
   c) DSB-SC AM modulation.
   d) SSB-AM modulation.
   e) None of the above.

3) Regarding to SSB-AM, which of the following statements is true?
   a) The required transmission bandwidth of SSB-AM is larger than that of conventional AM.
   b) The SSB-AM can be demodulated by using an envelope detector.
   c) No carrier recovery circuit is required to demodulate the SSB-AM signal.

d) The required transmission bandwidth of SSB-AM is smaller than that of DSB-SC AM.

e) None of the above.

4) The spectrum $M(f)$ of a message signal $m(t)$ is given in the left part of the following figure. The right part of the figure represents the spectrum of the modulated signal. Which type of modulation is used?



a) SSB-SC AM
b) DSB-SC AM
c) FM
d) PM
e) None of the above.

5) A conventional AM signal is expressed as $u(t) = A_c(1+am_n(t))\cos(2\pi f_c t)$, where $m_n(t)$ is the message signal and is normalized such that its minimum value is -1. Determine the condition for this signal that makes it easy to be demodulated by an envelope detector.

a) $a \geq 1$
b) $a > 1$
c) $a > 2$
d) $a < 1$
e) None of the above.

6) A quadrature-carrier multiplexing allows us to transmit two message signals $m_1(t)$ and $m_2(t)$ on the same frequency. The transmitted signal can be expressed as

$$s(t) = m_1(t)\cos(2\pi f_c t) + m_2(t)\sin(2\pi f_c t).$$

Describe how to demodulate $m_1(t)$ from $u(t)$.

a) Use an envelope detector followed by a low-pass filter.

b) Multiply the received signal by $\sin(2\pi f_c t)$ and then pass the signal through a low-pass filter.

c) Multiply the received signal by $\cos(2\pi f_c t)$ and then pass the signal through a low-pass filter.

d) Multiply the received signal by $\cos(2\pi f_c t)$ and then pass the signal through an envelope detector.
e) None of the above.

7) Let $S_x(f)$ be the power-spectral density of a random process $X(t)$. Passing $X(t)$ through a linear system with frequency response $H(f)$ results the output random process $Y(t)$. What is the power-spectral density of $Y(t)$?
a) $X(t)H(f)$
b) $X(t)|H(f)|^2$
c) $S_X(f)|H(f)|^2$
d) $|S_X(f)|^2 H(f)$
e) None of the above.

8) Assume that a random process $X(t)$ has a power spectral density of $S_X(f) = A \times \text{rect}\left(\frac{f}{W}\right)$. Determine the power of $X(t)$.
a) AW
b) A^2W
c) AW^2
d) A^2W^2
e) None of the above.

9) Assume that the power-spectral density of a white noise $N(t)$ is $N_0/2$. The signal $N(t)$ is passed through an ideal low-pass filter with frequency response

$$H(f) = \begin{cases} 1 & |f| < W \\ 0 & \text{otherwise} \end{cases}$$

Denote $W(t)$ as the resulting noise output. Determine the autocorrelation function of $W(t)$.
a) $2WN_0\text{sinc}(2W\tau)$
b) $WN_0\text{sinc}(2W\tau)$
c) $WN_0\text{rect}(2W\tau)$
d) $WN_0 \sin(2W\tau)$
e) None of the above.

10) Let the power-spectral density of the random process $M(t)$ be $S_M(f)$. Determine the power-spectral of the random process $U(t) = A_c M(t)\cos(2\pi f_c t)$.
a) $\frac{A_c^2}{2}\left[S_M(f-f_c) - S_M(f+f_c)\right]$
b) $\frac{A_c^2}{4}\left[S_M(f-f_c) + S_M(f+f_c)\right]$
c) $A_c^2\left[S_M(f-f_c) - S_M(f+f_c)\right]$
d) $\frac{A_c}{4}\left[S_M(f-f_c) + S_M(f+f_c)\right]$
e) None of the above.

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) (10 %) Comparison of M-ary FSK and M-ary PSK: Consider two digital communication systems, the M-ary FSK and the M-ary PSK. Under the same data rate and E_b/N_0. Describe how the bit error rate and bandwidth changed by increasing M.

2) (15 %) Let $x(t)$ be a signal given by

$$x(t) = \begin{cases} a\cos(2\pi n f_0 t) + b\sin(2\pi n f_0 t) & 0 < t < T_0 \\ 0 & \text{otherwise} \end{cases}$$

where $T_0 = 1/f_0$, n is a positive integer, and a, b are arbitrary real numbers.

   a) (10 %) Show that $\cos(2\pi n f_0 t)$ and $\sin(2\pi n f_0 t)$ for $0 < t < T_0$ are orthogonal.

   b) (5 %) Assume n and f_0 are known. Given $x(t)$, how to find the parameters a and b?

3) (25 %) Consider binary PAM signals. The signal waveforms are $s_1(t) = g_T(t)$ and $s_2(t) = -g_T(t)$, where $g_T(t)$ is an arbitrary pulse which is nonzero in the interval $0 \le t \le T_b$ and zero elsewhere. In addition, the energy of $g_T(t)$ is $E_b = \int_0^{T_b} |g_T(t)|^2 dt$. Let the received signal be

$$r(t) = s_i(t) + n(t) \quad \text{for } i = 1, 2$$

where $n(t)$ is a zero mean white Gaussian noise with power-spectral density of $N_0/2$.

   a) (5 %) Find the basis functions and sketch the signal points (signal constellation).

   b) (5 %) Design a Correlation-Type demodulator for the system.

   c) (5 %) Determine the maximum likelihood detection rule.

   d) (10 %) Determine the average bit error probability for the system.