國立臺灣科技大學
115學年度碩士班招生

試題

系所組別：0761電機工程系碩士班己一組

科　　目：通訊系統

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（總分為100分；所有試題務必於答案卷內頁依序作答）

1. （48 ％）選擇題

   (1) (8%) The average transmitted power of the following modulation is independent of the baseband signal.
      A.   Amplitude modulation.
      B.   Single sideband modulation.
      C.   Frequency modulation.
      D.   Double sideband modulation.

   (2) (8%) For a wide-sense stationary random process $X(t)$, find the correct statement.
      A.   The mean of $X(t)$ is a constant.
      B.   The autocorrelation function of $X(t)$ is a constant.
      C.   The power spectral density of $X(t)$ is a constant.
      D. $X(t)$ is strictly stationary.

   (3) (8%) For a zero-mean white Gaussian noise $W(t)$, find the correct statement.
      A.   The average power of $W(t)$ is zero.
      B.   Two different samples of $W(t)$ is uncorrelated.
      C.   The average power of $W(t)$ is Gaussian distributed.
      D.   The power spectral density of $W(t)$ is zero.

   (4) (8%) A real continuous-time signal $x(t)$ has a spectrum that satisfies
   $$X(f) = \begin{cases} 1, & 30\ kHz \leq |f| \leq 50\ kHz, \\ 0, & otherwise. \end{cases}$$
   You uniformly sample $x(t)$ at sampling frequency f_s and reconstruct it using an ideal reconstruction filter. What is the minimum sampling frequency f_s that guarantees perfect reconstruction of $x(t)$ from its samples?
      A.   20 kHz.
      B.   50 kHz.
      C.   100 kHz.
      D.   The sampling frequency depends on the quantization bit depth, so it cannot be determined.

   (5) (8%) A QPSK system uses Gray-coded mapping. The bit rate is R_b. Which statement is correct?
      A.   The QPSK symbol rate is $R_s = R_b$.
      B.   The QPSK symbol rate is $R_s = R_b/2$.
      C.   Each QPSK symbol carries 4 bits.
      D.   Gray coding means the two farthest constellation points differ by 1 bit.

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(6) (8%) A real-valued analog signal $x(t)$ is uniformly quantized using an $N = 3$-bit uniform quantizer whose input voltage range is $[-1V, +1V]$. Assume all the quantization levels span the full-scale range. Which option correctly gives **(i)** the number of quantization levels and **(ii)** the quantization step size Δ?
  A. 8 levels, $\Delta = 0.25\ V$.
  B. 8 levels, $\Delta = 0.125\ V$.
  C. 16 levels, $\Delta = 0.25\ V$.
  D. 16 levels, $\Delta = 0.125\ V$.

2. (26%) Let the carrier and message (single-tone) signals be $c(t) = A_c \cos(2\pi f_c t)$ and $m(t) = A_m \cos(2\pi f_m t)$, respectively. A conventional AM waveform is given by $s(t) = [A_c + k_a m(t)] \cos(2\pi f_c t)$, where $A_c = 1V$, $f_c = 2MHz$ and $A_m = 0.2V$, $f_m = 10kHz$.

  (1) (8%) Find the range of k_a for distortion-free envelope detection.

  (2) (18%) Let $k_a = 3$

    A. (10%) Sketch the AM spectrum and state the frequency components.

    B. (8%) Assume $s(t)$ is delivered to a 1-ohm resistor. Find the average power ratio of the upper sideband power to the carrier power.

3. (26%) Consider coherent BPSK transmission over an additive white Gaussian noise (AWGN) channel. Over one bit interval $0 \le t \le T_b$, the transmitted waveforms is
$$s(t) = \begin{cases} +\sqrt{E_b}\, p(t), & \text{if bit } b = 1 \text{ is transmitted,} \\ -\sqrt{E_b}\, p(t), & \text{if bit } b = 0 \text{ is transmitted,} \end{cases}$$
with equal probability, where $p(t)$ is a raised-cosine pulse with roll-off factor $\alpha = 0.25$ and its spectrum satisfies
$$|P(f)| = 0 \text{ for } |f| > 1.25\ MHz.$$
The received signal-to-noise ratio (SNR) is $E_b/N_0 = 5\ \text{dB}$, where N_0 is the (one-sided) noise power spectral density of the AWGN. Assume ideal carrier and timing synchronization.
  (1) (6%) Sketch the magnitude spectrum $|P(f)|$ of the raised-cosine pulse (shape only; no need to draw exact values). Clearly label the zero breakpoints in frequency in terms of bit rate R_b and roll-off α, i.e., indicate where the spectrum transitions from flat to roll-off and where it becomes zero.
  (2) (8%) What is the minimum sampling rate f_s (samples/second) at the receiver decision device that satisfies the Nyquist zero-ISI condition? Justify your answer by sketching the result in frequency domain.
  (3) (4%) Specify the receiver filter $h(t)$ (impulse response) that maximizes the output SNR at the decision instant.

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(4) (8%) State the optimal sampling time and the decision rule (threshold) that achieves minimum bit error probability. Also write the resulting BER in terms of the $Q(\cdot)$ function, where the $Q(\cdot)$ function is defined as

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-t^2/2}\, dt.$$