類組：電機類　科目：通訊系統(通訊原理)(300E)　※請在答案卷內作答

一、 (30%) Answer the following questions (there might be multiple choices for each question). No explanation is needed. Just write down your choices on the answer sheet. You will get the credit for each question only when all the correct answers are selected.

(一) (3%) Consider spread spectrum communication, which of the following statements are true?

(1) A direct sequence spread spectrum BPSK system has better error performance than a conventional BPSK system in an AWGN channel.
(2) A direct sequence spread spectrum BPSK system has better error performance than a conventional BPSK system in a multipath channel.
(3) A direct sequence spread spectrum BPSK system has better error performance than a conventional BPSK system in a single-tone interference channel.
(4) A direct sequence spread spectrum BPSK system has the following relationship: $(\text{Jamming margin})_{dB} = (\text{Processing gain})_{dB} + 10 \log (Eb/No)_{dB}$.
(5) None of the above.

(二) (3%) Consider radio communication, which of the following statements are true?

(1) An RF bandpass filter can be used to reduce the noise figure of the system.
(2) An RF bandpass filter can be used to reduce the image interference.
(3) Free space propagation loss is linearly proportional to the distance.
(4) Free space propagation loss is linearly proportional to the carrier frequency.
(5) None of the above.

(三) (3%) Consider cellular communication, which of the following statements are true?

(1) The GSM system uses $\pi/4$-shift DQPSK modulation.
(2) The GSM system is a TDMA system.
(3) The GSM system needs adaptive equalization.
(4) The GSM system uses a RAKE receiver.
(5) None of the above.

(四) (3%) A discrete memoryless source has an alphabet $\{s_1, s_2, s_3, s_4\}$ with symbol probabilities 0.2, 0.2, 0.2, and 0.4, respectively. Which of the following statements are true? [Note that $\log_2 5=2.3220$]

(1) The entropy of this source is greater than 1.9 (bits).
(2) The entropy of this source is smaller than 1.8 (bits).
(3) If a Huffman code with minimum code length variation is constructed, its average code-length is smaller than 1.9 (bits).
(4) The coding efficiency of the Huffman code in (3) is greater than 95%.
(5) None of the above.

(五) (3%) Consider a binary symmetric channel whose conditional probability of error is p, $0 \le p \le 0.5$. Denote its channel capacity as C. Which of the following statements are true?

(1) The channel capacity is the minimum mutual information between the input and output data of the channel.
(2) $C=1-p \log_2 p -(1-p) \log_2 (1-p) \ge 0$.
(3) This channel capacity C attains its minimum value of zero when $p=0.5$.
(4) This channel capacity C attains its maximum value of 1 when $p=0$.
(5) If two of such binary symmetric channels are cascaded, denote D as the channel capacity of the cascaded channel, then $D \ge C$.

參考用

注意：背面有試題

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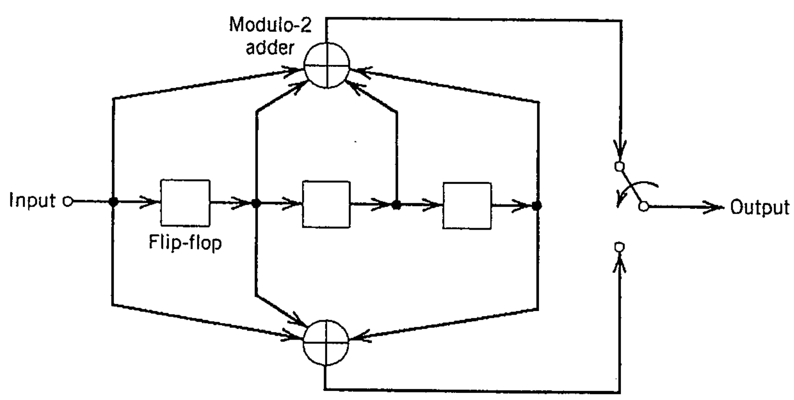
(六) (3%) Consider a (n,k) linear block code. Which of the following statements are true?
(1) Its code rate is k/n.
(2) There are $(n-k)$ parity check bits in a codeword.
(3) Its minimum distance is the largest Hamming distance between any pair of codewords.
(4) The minimum distance for a (7,4) Hamming code is equal to 3.
(5) If the minimum distance of this code is equal to 6, then it is able to correct 3 errors.

(七) (3%) Consider a systematic $(7,3)$ cyclic code with generator polynomial $g(X)=1+X+X^2+X^4$. Denote $h(X)$ as its parity-check polynomial. The code polynomial of a codeword $[c_0, c_1, \dots, c_6]$ is denoted as $c(X)= c_0 + c_1 X + \cdots + c_6 X^6$. Which of the following statements are true?
(1) The encoder of this code can be implemented by a linear feedback shift register with 4 stages.
(2) Its parity-check polynomial is $h(X)=1+X+X^2+X^3$.
(3) The codeword of the message word 100 is $1110\ 100$.
(4) For any code polynomial $c(X)$, we have $[c(X)\ h(X)]\ mod\ (X^7+1)=0$.
(5) The generator polynomial of its dual code is $1+X+X^2+X^3$.

(八) (3%) [Continued from (七)] If the received data polynomial is $r(X)=X+X^4+X^6$, which one is its syndrome polynomial $s(X)$?
(1) X^2+X+1
(2) X^3+X^2+X
(3) $X^4+X^3+X^2$
(4) $X^4+X^3+X^2+X+1$
(5) None of the above

(九) (3%) Consider the encoder of a binary convolutional code shown below.



Which of the following statements are true?
(1) Its code rate is $r=1/3$.
(2) Its constraint length is $K=3$.
(3) There are 8 states in its state transition diagram.
(4) The generator polynomial of the upper path is $g_1(D)=1+D+D^2$.
(5) The generator polynomial of the lower path is $g_2(D)=1+D+D^3$.

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(十) (3%) Suppose the transfer function of a binary convolutional encoder is

$$T(D,L)=\frac{D^3L^3}{1-DL-D^3L^2}$$

The free distance of this code is
(1) 1
(2) 2
(3) 3
(4) 4
(5) 5

二、 (14%) Assume $X(t)$ is a real-valued wide-sense stationary (WSS) random process with autocorrelation function $R_X(\tau)=E\{X(t+\tau)X(t)\}$, where $E\{\cdot\}$ denotes the expectation, and power spectral density $S_X(f)$ is band-limited to W Hertz. Consider the modulated process $Y(t)=X(t)\cos(2\pi f_c t+\Theta)$, where Θ is uniformly distributed over $[0,2\pi)$ and is independent of $X(t)$. Assume that the carrier frequency $f_c >> 2W$.

(一) (3%) Find the autocorrelation function of $Y(t)$.

(二) (5%) $Y(t)$ is passed through an ideal low-pass filter with frequency response

$$H(f)=\begin{cases}1, & |f|\le f_c\\ 0, & |f|>f_c\end{cases}$$

and $\tilde{Y}(t)$ is the filter output. Compute $E\{\tilde{Y}^2(t)\}$.

(三) (6%) A double-sideband suppressed-carrier signal $s(t)\cos(2\pi f_c t)$ is transmitted and is interfered by a sample function $y(t)=x(t)\cos(2\pi f_c t+\pi/4)$ of the process $Y(t)$. Given the received signal $r(t)=s(t)\cos(2\pi f_c t)+y(t)$ and assuming that both $x(t)$ and $s(t)$ are band-limited to W Hz, is it possible to perfectly demodulate $s(t)$ based on $r(t)$? Justify your answer.

三、 (16%) Let $x(t)$ be a low-pass signal band-limited to W Hz, and define $T=1/(2W)$.

(一) (8%) Show that $\sum_{k=-\infty}^{\infty}|x(kT)|^2=\frac{1}{T}\int_{-\infty}^{\infty}|X(f)|^2\,df$, where $X(f)$ is the Fourier transform of $x(t)$.

(二) (3%) Assume that $x(t)$ is a realization of a WSS process $X(t)$ with autocorrelation coefficients $R_X(0)=1$, $R_X(T)=1/2$, and $R_X(2T)=1/5$. Determine the coefficients $\{c_1,c_2\}$ of the second-order linear predictor $\hat{X}(kT)=c_1X((k-1)T)+c_2X((k-2)T)$ via minimization of the mean square error $E\{|e(kT)|^2\}$, where $e(kT)=X(kT)-\hat{X}(kT)$.

(三) (3%) The sampled sequence $\{x(kT)\}$ is to be transmitted through a differential pulse coded modulation (DPCM) system. Draw the system block diagram (including both the transmitter and the receiver).

(四) (2%) Assume that the prediction filter obtained in problem (二) is used in the DPCM system. Compute the processing gain, namely, $E\{|X(kT)|^2\}/E\{|e(kT)|^2\}$, achieved by this predictor (assume that the quantization error is sufficiently small and can be neglected).

參考用

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四、 (15%) Consider a binary baseband digital communication system operating on an AWGN channel with noise PSD $N_o/2$. Two equiprobable transmitted symbols are

$$s_0(t)=\begin{cases}A, & 0<t<0.5T\\ 0, & \text{otherwise}\end{cases} \quad \text{and} \quad s_1(t)=\begin{cases}A, & 0.5T<t<T\\ 0, & \text{otherwise}\end{cases}$$

(一) (2%) Draw the block diagram of the optimum receiver using only one matched filter.

(二) (3%) Suppose the receiver has a filter with the following impulse response

$$g(t)=\begin{cases}1/\sqrt{T}, & 0<t<0.25T\\ 0, & \text{otherwise}\end{cases}$$

Use this filter and a sampler to implement the optimum receiver in (一).

(三) (5%) Suppose the baseband channel has an impulse response $h(t)=\delta(t)+0.5\,\delta(t-0.5T)$. Propose an optimal detection scheme if the same receiver filter obtained in (一) is used.

(四) (5%) Find the average probabilities of symbol error in (一) and (三), respectively.

五、 (12%) Consider DPSK modulation in an additive white Gaussian noise channel with noise power spectral density $S_N(f)=N_o/2$, and assume the receiver does not have the carrier phase information.

(一) (4%) Explain why DPSK modulation is not sensitive to carrier phase offset for data detection.

(二) (4%) Explain why DPSK modulation can be regarded as a kind of orthogonal signaling.

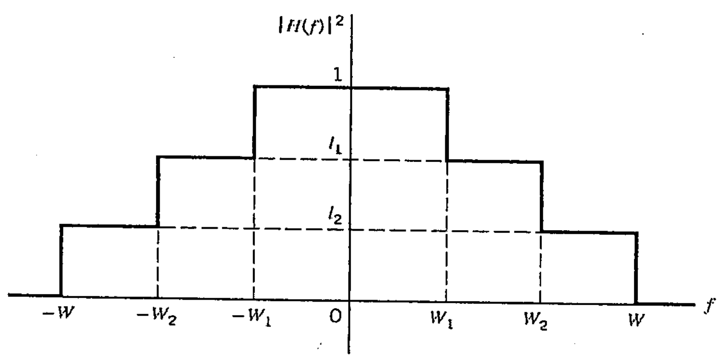
(三) (4%) If you already know the bit error probability of noncoherent BFSK modulation in an additive white Gaussian noise channel is $1/2\ e^{-Eb/2No}$ (E_b is the bit energy), guess what the bit error probability of DPSK modulation will be. You must describe the reasoning behind your guess.

六、 (13%) Consider multichannel modulation in a channel with linear distortion and additive white Gaussian noise with noise power spectral density $S_N(f)=N_o/2$, $N_o=0.001$ $Watt/Hz$.

(一) (4%) Explain the basic motivation behind using multichannel modulation.

(二) (4%) Explain how orthogonal frequency division multiplexing (OFDM) functions as a special case of multichannel modulation.

(三) (5%) Given the squared magnitude response of a channel with three subchannels as shown below ($l_1=1/3$, $l_2=1/5$, *and note that the plot is not to the scale)*, and the total transmit power $P=7$ $Watt$, find the optimum power loading for the three subchannels to maximize the overall theoretical channel capacity (assuming $W_1=2000$ Hz, $W_2=3000$ Hz, $W=4000$ Hz, and the signal to noise ratio gap $\Gamma=1$).



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