

考生注意：1. 依次序作答，只要標明題號，不必抄題。

2. 答案必須寫在答案卷上，否則不予計分，並限以藍黑色筆作答。

3. 試題隨卷繳回。(餘請詳閱試場規則)

1. Consider two i.i.d. random variables X and Y with probability density functions (pdf's)

$$f_X(x) = f_Y(x) = \frac{1}{a} \Pi\left(\frac{x}{a}\right),$$

where $\Pi(y)$ denotes the rectangular function which is 1 for $|y| < \frac{1}{2}$, and 0 otherwise.

Compute the pdf of $Z = X + Y$ using characteristic functions. (10%)

2. Let $\mathbf{X} = (X_1, X_2, X_3)^T$ be a random vector with mean vector $\boldsymbol{\mu} = E\{\mathbf{X}\}$ given by

$$\boldsymbol{\mu} = (5, 5, 6)^T$$

and covariance given by

$$\mathbf{K} = \begin{bmatrix} 5 & 2 & -1 \\ 2 & 5 & 0 \\ -1 & 0 & 4 \end{bmatrix}$$

Calculate the mean and variance of $Y = \mathbf{A}^T \mathbf{X} + B$, where $\mathbf{A} = (2, -1, 2)^T$ and $B = 5$. (20%)

3. Consider M -ary coherent FSK in terms of signal space. The transmitted signal set is

$$s_i(t) = A \cos \{2\pi [f_c + (i-1)\Delta f] t\}, \quad 0 \leq t \leq T_s$$

where

$$\Delta f = \frac{m}{2T_s}, \quad m \text{ is an integer, } i = 1, 2, \dots, M$$

It is assumed that $f_c T_s$ is an integer. Find an orthonormal basis set and the optimum receiver. Please explain your answer. (20%)

4. A channel of bandwidth 100 kHz is available. Using null-to-null RF bandwidths, what data rates may be supported by: (a) BPSK? (b) Coherent FSK (tone spacing = $1/2T$)? (c) DPSK? (d) Noncoherent FSK (tone spacing = $2/T$)? (20%)

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5. A DSSS system employing BPSK data modulation operates with a data rate of 1Mbps. A processing gain of 20 dB is desired.

- (a) Find the required chip rate. (5%)
(b) What is the RF transmission bandwidth required (null-to-null)? (5%)

6. Consider the set of three finite-energy signals

$$s_1(t) = 1, \quad 0 \leq t \leq 1$$

$$s_2(t) = \cos(2\pi t), \quad 0 \leq t \leq 1$$

$$s_3(t) = 1 - \sin^2(\pi t), \quad 0 \leq t \leq 1$$

Find an orthonormal basis for the signal space spanned by these three signals. (15%)

7. For a binary source, $p(1) = \alpha$ and $p(0) = 1 - \alpha = \beta$. Derive the entropy of the source as a function of α . (5%)

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