國立中央大學通訊工程學系 104 學年度碩士在職專班入學筆試

【通訊概論】試卷

考試地點：通訊館一樓 **E1-109** 室　　考試時間：**100** 分鐘　　試題總分：１００分

1. (**18 pt**) Consider a message signal $m(t)$:
   (a) (**6 pt**) Give the amplitude-modulated (AM) signal with an amplitude sensitivity constant k_a, if a sinusoidal carrier wave is given by $c(t) = A_c cos(2\pi f_c t)$.
   (b) (**6 pt**) Plot the spectrum of the AM wave in (a), if the spectrum of the message $m(t)$ is given by $\mathrm{M(f)} = \begin{cases} 1, -\mathrm{W} \leq \mathrm{f} \leq \mathrm{W} \\ 0, \quad \text{otherwise} \end{cases}$.
   (c) (**6 pt**) Give the frequency-modulated (FM) signal with a modulation index β, if $m(t) = A_m cos(2\pi f_m t)$

2. (**36 pt**) Consider optimum data detection for quadrature phase-shift keying (QPSK) with the constellation in Figure 1, where the signal vectors are given by $\mathbf{s}_1 = [+1, +1]^{\mathrm{T}}$, $\mathbf{s}_2 = [-1, +1]^{\mathrm{T}}$, $\mathbf{s}_3 = [-1, -1]^{\mathrm{T}}$, and $\mathbf{s}_4 = [+1, -1]^{\mathrm{T}}$. Let $\mathbf{x} = \mathbf{s}_\mathrm{i} + \mathbf{w}$ be the observation signals, for $i = 1, \ldots, 4$, where $\mathbf{w}$ is the zero-mean additive white Gaussian noise with covariance $(\mathrm{N}_0/2)\mathbf{I}$.
   (a) (**6 pt**) Label the QPSK constellation with Gray mapping.
   (b) (**6 pt**) Describe the maximum likelihood (ML) decision rule.
   (c) (**6 pt**) Show that the ML decision rule is equivalent to a minimum distance decision rule.
   (d) (**6 pt**) Draw the optimum decision regions for QPSK.
   (e) (**6 pt**) Describe the maximum a posteriori probability (MAP) decision rule.
   (f) (**6 pt**) Explain why the MAP decision rule is usually a better choice than the ML decision rule, and under what condition the two decision rules are equivalent.

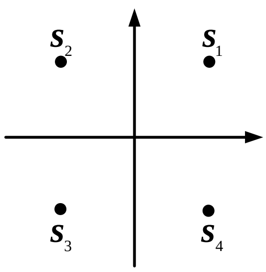

Figure 1: QPSK constellation

3. (**18 pt**) Consider a sinusoidal signal with random phase, defined as
$$x(t) = A \cdot cos(2\pi f_c t + \Theta)$$
where A and f_c are constants and Θ is a uniformly distributed random variable over the interval $[-\pi,\ \pi]$, given by

背面尚有試題

$$f_\Theta(\theta)=\begin{cases}\frac{1}{2\pi}, -\pi\le\theta\le\pi\\ 0, \quad elsewhere\end{cases}$$

(a) (**6 pt**) Give the definition of the autocorrelation function and the power spectral density.

(b) (**6 pt**) Find the autocorrelation function of $x(t)$.

(c) (**6 pt**) Find the power spectral density of $x(t)$.

4. (**14 pt**) Consider the waveforms of four signals $s_1(t), s_2(t), s_3(t)$ and $s_4(t)$ in Figure 2.
   (a) (**8 pt**) Use the Gram-Schmidt orthogonalization procedure to find the orthonormal basis for this set of signals.
   (b) (**6 pt**) Express each of these signals in terms of the set of basis functions found in (a).

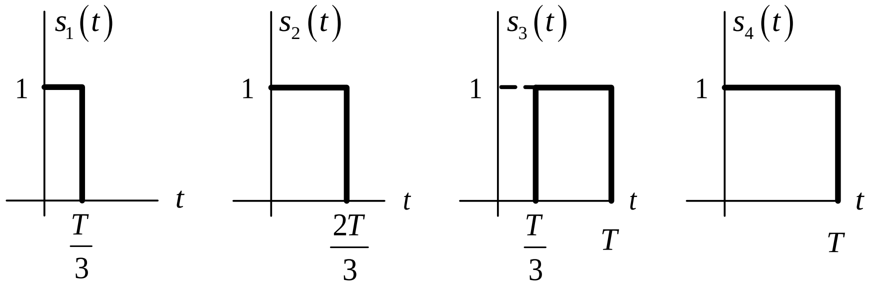

Figure 2: Four waveforems

5. (**14 pt**) Consider the following four passband signals, and determine which one is phase-shift keying (PSK), differential phase-shift keying (DPSK), quadrature amplitude modulation (QAM) and frequency-shit keying (FSK).

(i) $$s_i(t)=\begin{cases}\sqrt{\frac{2E_b}{T_b}}a_i cos(2\pi f_c t)-\sqrt{\frac{2E}{T}}b_i sin(2\pi f_c t), & 0\le t\le T_b\\ 0, \ elsewhere\end{cases}, \ i=0,\pm1,\pm2,\dots$$

(ii) $$s_i(t)=\begin{cases}\sqrt{\frac{2E_b}{T_b}}cos\left(2\pi f_c t+(i-1)\frac{2\pi}{M}\right), & 0\le t\le T_b\\ 0, \ elsewhere\end{cases}, \ i=1,\dots,M$$

(iii) $$s_i(t)=\begin{cases}\sqrt{\frac{2E_b}{T_b}}cos\left(2\pi\left(\frac{n_c+i}{T_b}\right)t\right), & 0\le t\le T_b\\ 0, \ elsewhere\end{cases}$$, for a fixed integer n_c, $i=1,2,\dots$

(iv) $$s_1(t)=\begin{cases}\sqrt{\frac{E_b}{2T_b}}cos(2\pi f_c t), & 0\le t\le T_b\\ \sqrt{\frac{E_b}{2T_b}}cos(2\pi f_c t), & T_b\le t\le 2T_b\end{cases}; \ s_2(t)=\begin{cases}\sqrt{\frac{E_b}{2T_b}}cos(2\pi f_c t), & 0\le t\le T_b\\ \sqrt{\frac{E_b}{2T_b}}cos(2\pi f_c t+\pi), & T_b\le t\le 2T_b\end{cases}$$