國立中山大學100學年度碩士班招生考試試題

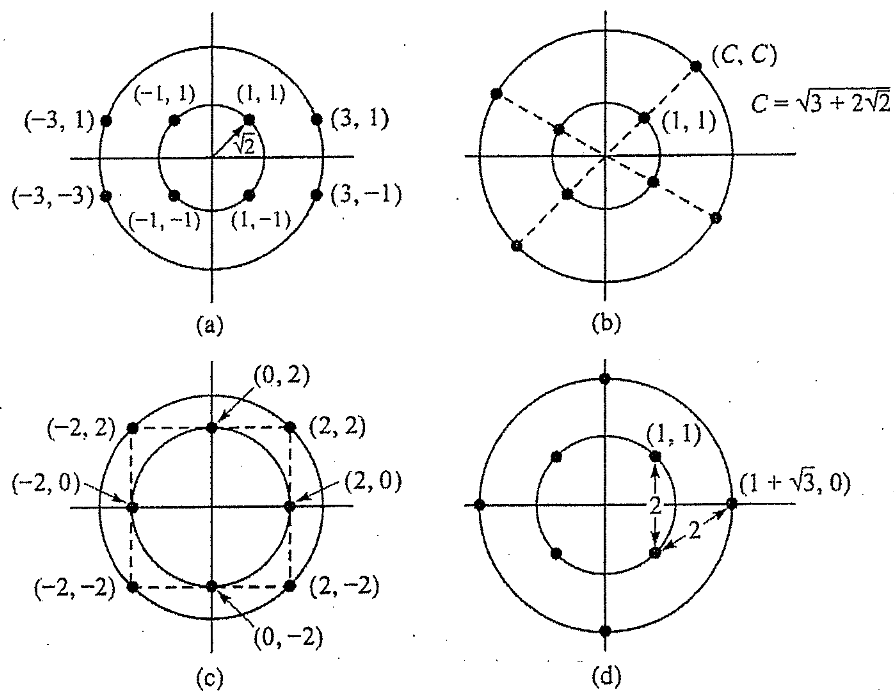
科目：通訊理論【通訊所碩士班甲組】

通訊理論 （Communications Theory）

1. [20] **Nyquist Pulse-Shaping Criterion:** Let the symbol duration $T = 1$. Which of the following signals are Nyquist pulses for zero-ISI? Please explain your answers.

   (a)[4] $\dfrac{\sin \pi t}{\pi t}$ (b)[4] $\dfrac{\sin \pi t}{\pi t}\exp\left\{-2t^2\right\}$ (c)[4] $\sin \pi t + \cos \pi t$ (d)[4] $\exp\left\{-\dfrac{t^2}{2}\right\}$ (e)[4] $\left(\dfrac{\sin \pi t}{\pi t}\right)^4$

2. [20] **Signal Constellation:**
   (a) [10] Please design the Gray coding for an 8-PSK modulation scheme.
   (b) [10] Which of the following 8-QAM modulation schemes has the best performance? Please explain your answer. (Assume that all signal points are equally probable.)



3. [20] **Optimum Receivers for AWGN Channels:** Please derive the error probability for M-ary biorthogonal signaling that adopts optimal detection. All signals are equiprobable and have equal energy. The noises are i.i.d. Gaussian random variables with zero-mean and variance $\dfrac{N_0}{2}$. (You do not have to show a closed form expression.)

4. [20] **Explanations:**
   (a) [2] What is an energy signal?
   (b) [2] What is a power signal?
   (c) [2] What kind of system is said to be causal?
   (d) [2] What kind of system is said to be stable?
   (e) [2] What is an Ergodic process?
   (f) [2] What is a cyclostationary process?
   (g) [2] Please describe the condition that two events are statistically independent.
   (h) [2] Please describe the condition for two random variables X and Y to be orthogonal.
   (i) [2] Please describe the conditions for a random process to be wide-sense stationary (WSS).
   (j) [2] Please describe the Offset QPSK modulation scheme.

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5. [20] **Fourier Transform**: (Hint: You may use the attached properties of the Fourier transform.)
   (a) [10] Please show that the Fourier transform of a decaying exponential pulse is given by:
   $$\exp(-at)u(t) \rightleftharpoons \frac{1}{a+j2\pi f},\ a>0, \text{ where } u(t)=\begin{cases}1, & t>0\\ \frac{1}{2}, & t=0.\\ 0, & t<0\end{cases}$$
   (b) [10] Please show that the Fourier transform of a double exponential pulse is given by:
   $$\exp(-a|t|) \rightleftharpoons \frac{2a}{a^2+(2\pi f)^2},\ a>0.$$

Properties of the Fourier Transform

Property	Mathematical Description
Linearity	$ag_1(t)+bg_2(t) \rightleftharpoons aG_1(f)+bG_2(f)$, where a and b are constants.
Time scaling	$g(at) \rightleftharpoons \frac{1}{\lvert a\rvert}G\left(\frac{f}{a}\right)$, where a is a constant.
Duality	If $g(t) \rightleftharpoons G(f)$, then $G(t) \rightleftharpoons g(-f)$.
Time shifting	$g(t-t_0) \rightleftharpoons G(f)\exp(-j2\pi f t_0)$.
Frequency shifting	$\exp(j2\pi f_c t)g(t) \rightleftharpoons G(f-f_c)$.
Area under $g(t)$	$\int_{-\infty}^{\infty} g(t)\,dt = G(0)$.
Differentiation in the time domain	$\frac{d}{dt}g(t) \rightleftharpoons j2\pi f G(f)$.
Integration in the time domain	$\int_{-\infty}^{t} g(\tau)\,d\tau \rightleftharpoons \frac{1}{j2\pi f}G(f)+\frac{G(0)}{2}\delta(f)$.
Conjugate functions	If $g(t) \rightleftharpoons G(f)$, then $g^*(t) \rightleftharpoons G^*(-f)$.
Multiplication in the time domain	$g_1(t)g_2(t) \rightleftharpoons \int_{-\infty}^{\infty} G_1(\lambda)G(f-\lambda)\,d\lambda$.
Convolution in the time domain	$\int_{-\infty}^{\infty} g_1(\tau)g_2(t-\tau)\,d\tau \rightleftharpoons G_1(f)G_2(f)$.
Rayleigh's energy theorem	$\int_{-\infty}^{\infty} \lvert g(t)\rvert^2 dt = \int_{-\infty}^{\infty} \lvert G(f)\rvert^2 df$.