

# 國立中央大學通訊工程學系 97 學年度碩士在職專班入學筆試

## 【基本通訊概論】試卷

考試地點：通訊館一樓 E1-105 室

考試時間：100 分鐘

試題總分：100 分

1. [15 %] Consider a sinusoidal signal with random phase, defined by

$$x(t) = A \cos(2\pi f_c t + \phi)$$

where  $A$  and  $f_c$  are constant and  $\phi$  is a random variable that is uniformly distributed over the interval  $[-\pi, \pi]$ , that is,  $f_\theta(\theta) = \begin{cases} 1/2\pi & -\pi \leq \theta \leq \pi \\ 0 & \text{elsewhere} \end{cases}$ . Please calculate the autocorrelation function of  $x(t)$ .

2. [10 %] Please determine the following statement whether it is true or false: For any real-valued random process  $x(t)$ , we can express the autocorrelation function as  $R_x(\tau) = R_x(t+\tau, t) = E\{x(t+\tau)x(t)\}$ .

3. [10 %] An amplitude-modulated (AM) wave is described as a function of time:

$$s(t) = A_c [1 + k_a m(t)] \cos(2\pi f_c t),$$

where  $A_c$  is the carrier amplitude,  $k_a$  is a constant, and  $f_c$  is the carrier frequency.  $m(t)$  is the baseband signal that carries the specification of the message whose Fourier transform is  $M(f)$ . Please find the mathematical expression of the Fourier transform of the AM wave  $s(t)$ .

4. [10 %] A narrowband signal has a bandwidth of 10 kHz centered on a carrier frequency of 100 kHz. It is proposed to represent this signal in discrete-time form by sampling its phase and quadrature component individually. What is the minimum sampling rate that can be used for this representation?
5. [10 %] An M-ary communication system transmits at a rate of 1000 symbols per second. What is the equivalent bit rate in bits per second for  $M=8$ ?
6. [10 %] We consider binary synchronous data transmission with arbitrary signal shapes. We let a logic 1 be represented by  $s_1(t)$  and a logic 0 by  $s_2(t)$ .  $s_1(t)$  and  $s_2(t)$  have finite energy in a T-second interval. Please draw a receiver structure for detecting  $s_1(t)$  and  $s_2(t)$  in additive white Gaussian noise.

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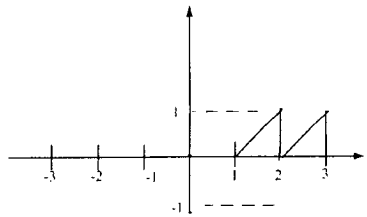
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7. [10 %] A signal with a waveform shown in the following figure is fed into the system with the impulse response:

$$h(t) = 2\delta(t) - 2\delta(t-1).$$

Please sketch the output waveform of the system output.



8. [10 %] A PCM system uses a uniform quantizer followed by a 5-bit binary encoder. The bit rate of the system is equal to  $50 \times 10^6$  b/s. What is the maximum message bandwidth for which the system operates satisfactory?

9. [15 %] The bit error rate for coherent binary PSK (BPSK) is  $P_e = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_b}{N_o}}\right) = Q\left(\sqrt{2E_b/I_o}\right)$ .  $E_b$  is the signal energy per bit;  $N_o$  is the noise

spectral density,  $\operatorname{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^\infty e^{-t^2} dt$  is the complementary error function,

and  $Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty \exp(-u^2/2) du$ . We consider coherent QPSK modulation.

Let E be the signal energy for the QPSK modulation.

- (a) What is the average probability of bit error in each channel (in-phase and quadrature)?
- (b) What is the average probability of symbol error for coherent QPSK?
- (c) With the Gray coding used for the incoming symbols, what is the bit error rate of QPSK?

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