＊作答前, 請先核對試題、答案卷（試卷）與准考證上之所組別與考試科目是否相符!!

1. A baseband message $m(t) = A\,sinc(2Bt)$ and a carrier signal $c(t) = \cos 2\pi f_c t$, where $f_c \gg B$, are used in the following applications.

   (a) i. (2%) Find and plot the Fourier transforms of $m(t)$ and $c(t)$.
       ii. (3%) Find the Hilbert transforms of $m(t)$ and $c(t)$.

   (b) i. (3%) Draw the block diagrams of the modulator and demodulator for a double-sideband(DSB) modulation.
       ii. (3%) Find out the complex envelope of this DSB signal.

   (c) i. (3%) Draw the block diagrams of the modulator and demodulator for a single-sideband(SSB) modulation.
       ii. (3%) Find the SSB signal.
       iii. (3%) Find out the complex envelope of this SSB signal.

   (d) i. (3%) Find the frequency modulated (FM) signal with peak frequency deviation constant $f_d$.
       ii. (2%) Find the bandwidth of this FM signal.

2. Consider a random process $x(t) = \sum_{k=-\infty}^{\infty} a_k \Pi\left[(t - kT - \Delta)/T\right]$, where $\Pi\left[\frac{t}{T}\right]$ is the rectangular window function with a height of 1 and a width of $T$, $a_k$'s are independent and identically distributed random variables with $\text{Prob}\{a_k = A\} = \text{Prob}\{a_k = -A\} = 0.5$ for all $k$, and $\Delta$ is a random variable uniformly distributed in $\left(-\frac{T}{2}, \frac{T}{2}\right)$ and is independent of all $a_k$'s.

   (a) (3%) Draw a typical sample function of this random process.
   (b) (3%) Derive the mean function of $x(t)$.
   (c) (4%) Derive the autocorrelation function of $x(t)$ and draw it to the scale.

3. Consider an AM receiver with envelope detection.

   (a) (5%) Write down a formula for a received AM signal including the narrowband Gaussian noise process. Explain each term in your formula.
   (b) (5%) Use both equation and phasor diagram to prove that when predetection SNR is large, envelope detection has the same postdetection SNR performance as coherent detection.
   (c) (5%) Use both equation and phasor diagram to prove that when predetection SNR is small, envelope detection has a threshold effect, *i.e.*, the message signal is totally lost.

4. Let $s_1(t)$ and $s_2(t)$ be two equally-likely binary signals.

(a) (8%) For unipolar signaling, binary 1's are represented by positive value and the binary 0's are represented by a zero level:

$$s_1(t) = +A, \quad 0 < t \leq T \quad \text{(binary 1)}$$
$$s_2(t) = 0, \quad 0 < t \leq T \quad \text{(binary 0)}$$

Draw the optimum receiver's block diagram for detecting the binary signals in additive white Gaussian noise with double-sided power spectral density $N_0/2$. What is the resulting error probability?

(b) (8%) For OOK signaling,

$$s_1(t) = A\cos\omega_c t, \quad 0 < t \leq T \quad \text{(binary 1)}$$
$$s_2(t) = 0, \quad 0 < t \leq T \quad \text{(binary 0)}$$

Draw the <u>noncoherent</u> receiver's block diagram for detecting the binary signals in additive white Gaussian noise with double-sided power spectral density $N_0/2$. Assume $A^2T \gg N_0$. What is the error probability if $s_2(t)$ is sent?

5. (a) (3%) Explain the purpose of an equalizer used in a communication system.

(b) (6%) Consider a channel for which the channel pulse response samples are:

$$p_c[-3T] = 0.001, p_c[-2T] = -0.01, p_c[-T] = 0.1, p_c[0] = 1.0,$$

$$p_c[T] = 0.2, p_c[2T] = -0.02, p_c[3T] = 0.05$$

Explain how to find the tap coefficients for a three-tap zero-forcing equalizer. (Exact numerical result is not necessary.)

# 國立交通大學八十九學年度碩士班入學考試試題

科目名稱：通訊原理(042)　　　　　　考試日期：89 年 4 月 22 日 第 3 節

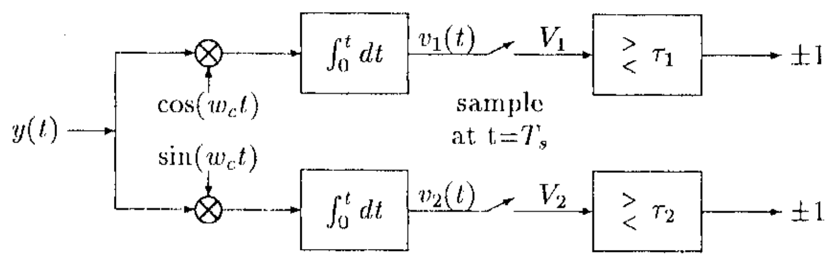
系所班別：電信工程學系　　組別：甲組　　　　　　

＊作答前,請先核對試題、答案卷（試卷）與准考證上之所組別與考試科目是否相符!!

6. (a) (5%) Assume that the input to a QPSK receiver is

$$y(t) = A \cdot d_1(t)\cos(w_c t) - A \cdot d_2(t)\sin(w_c t) + n(t) \text{ for } 0 < t \le T_s,$$

where $n(t)$ is an additive white Gaussian noise with double-sided power spectral density $N_0/2$. The signals $d_1(t)$ and $d_2(t)$ are either $-1$ or $+1$ for $0 < t \le T_s$, depending on the information bits to be transmitted. Let the system structure of the QPSK receiver be as shown below.




Also let $\int_0^{T_s} \sin(2w_c t)dt = \int_0^{T_s} \cos(2w_c t)dt = 0$. Derive $V_1$ and $V_2$, and show that they are uncorelated given $d_1(t)$ and $d_2(t)$.

(b) (4%) What is the optimal error probability for detecting signal $d_1(t)$? Does the optimal error probability for detecting $d_1(t)$ perform better than BPSK? Justify your answer.

(c) (4%) What kind of changes will be made on signals $d_1(t)$ and $d_2(t)$, if $y(t)$ now becomes an input to an *offset* QPSK receiver? Answer the same question for MSK (specifically, type-I MSK).

7. (a) (4%) A source consists of 6 outputs with respective probabilities

$$[1/2, 1/4, 1/16, 1/16, 1/16, 1/16].$$

Determine the entropy of the source.

(b) (4%) Construct a binary Huffman code for the source in (a).

(c) (4%) A channel with input $X \in \{1,2\}$ and output $Y \in \{0,1,2,3\}$ is described by the transition probability matrix

$$[P(Y|X)] = \begin{bmatrix} P(0|1) & P(1|1) & P(2|1) & P(3|1) \\ P(0|2) & P(1|2) & P(2|2) & P(3|2) \end{bmatrix} = \begin{bmatrix} 0.25 & 0.5 & 0.25 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Determine the channel capacity.