國立交通大學94學年度碩士班入學考試試題

科目名稱：通訊原理（6005）　　考試日期：94 年 4 月 10 日 第 3 節

系所班別：電機聯招　學系　組別：　組　第 1 頁，共 3 頁

＊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!!

注意事項:

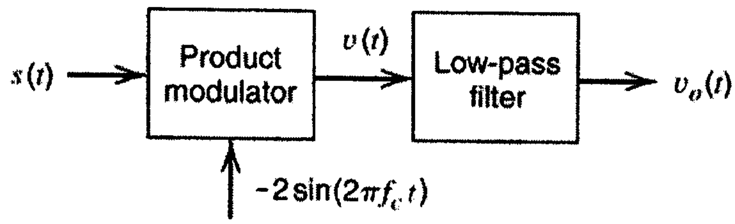
1. 答案請依題號順序排列
2. 可用中文或英文答題
3. 若你認為某題目所給的條件不完整，則請自行作適當的假設，並請敘明你的假設與理由

1. (20%)

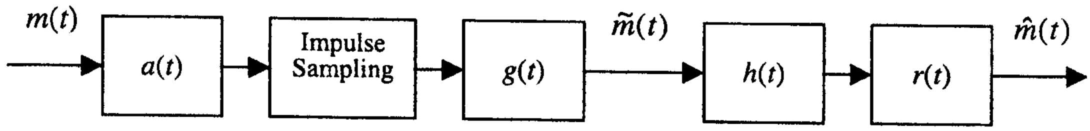
(a) (4%) The passband signal expression for DSB-C modulation with amplitude sensitivity k_a and informational signal $m(t)$ is $s(t) = A_c[1+k_a m(t)]\cos(2\pi f_c t)$. Write down the passband signal expression for frequency modulation with frequency sensitivity k_f and the same informational signal.

(b) (8%) Prove that the FM passband signal in (a) can be approximated by $A_c\cos(2\pi f_c t) - A_c 2\pi k_f \sin(2\pi f_c t)\int_0^t m(\tau)d\tau$, if $\left|2\pi k_f \int_0^t m(\tau)d\tau\right| \ll 1$.

(c) (8%) What will the output be, if $A_c\cos(2\pi f_c t) - A_c a(t)\sin(2\pi f_c t)$ is passed through a product modulator with multiplicand $-2\sin(2\pi f_c t)$, followed by an ideal lowpass filter as shown below?



2. (15%) A PAM transmission system is shown below:



$a(t)$: anti-aliasing filter
$g(t)$: pulse shaping filter
$h(t)$: channel [$H(f)$: frequency response]
$r(t)$: reconstruction filter

$$m(t)=\begin{cases}1, & 0\le t\le T\\ 0, & otherwise\end{cases},\quad g(t)=\begin{cases}1, & 0\le t\le T/2\\ 0, & ,otherwise\end{cases},\quad H(f)=\begin{cases}1, & |f|\le 0.8/T\\ 0, & ,otherwise\end{cases}$$

(a) (5%) Determine the lowest sampling frequency f_s and the frequency response of $a(t)$ such that we can have minimum distortion in the reconstructed signal $\hat{m}(t)$.

(b) (5%) With the result in (a), plot the magnitude spectrum of the PAM signal [i.e., $\tilde{m}(t)$].

(c) (5%) With the result in (a), determine the magnitude spectrum of the $r(t)$ such that the filter can reconstruct $m(t)$ with minimum distortion.

3. (15%) Consider baseband binary digital transmission over an AWGN (additive white Gaussian noise) channel with symbol period equal to T. The symbol values are ± 1. One symbol is transmitted starting at each time kT where k is an integer. Let the impulse response of the transmitter filter corresponding to the symbol value +1 be given by

$$p(t) = \begin{cases} 1, & 0 < t < T/3, \\ -0.5, & T/3 < t < T, \\ 0, & otherwise. \end{cases}$$

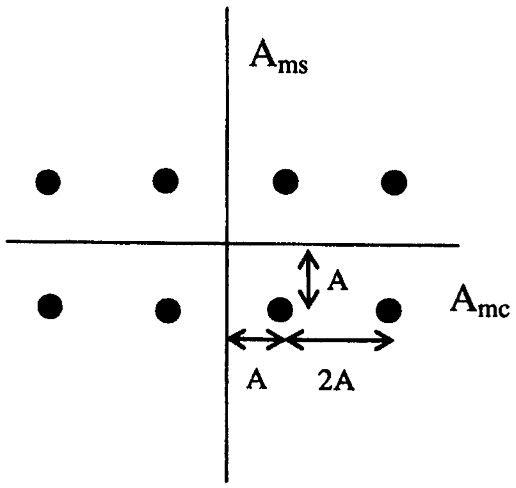
(a) (9%) Assume that the transmitter employs antipodal signaling. *Sketch* the block diagram of a matched-filter receiver. *AND specify* the following things for the receiver:
   i. The impulse response of the matched filter. The filter should be causal.
   ii. The sampling time of the sampling circuit for the symbol transmitted in the time interval $[kT,(k+1)T]$.
   iii. How the decision circuit should make its decisions.

(b) (6%) Assume that the transmitter employs orthogonal signaling with equal symbol energy for both symbol values. Obtain a suitable impulse response waveform for the transmitter filter corresponding to the symbol value -1.

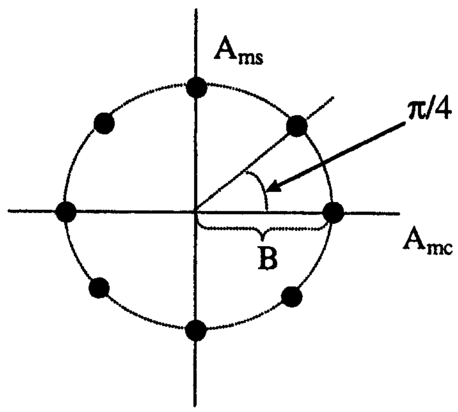
4. (15%) Assume a sequence of M-ary signals (M = 8) and are to be transmitted over an AWGN channel in the form of

$$r(t) = A_{mc}\cos(2\pi f_c t) + A_{ms}\sin(2\pi f_c t) + n(t) \qquad 0 \le t \le T,$$

with the baud rate being R = 1/T symbols per second. The power-spectral density of n(t) is assumed to be $N_0/2$ W/Hz. Here, we consider two different signal-point constellations as shown below. The signal points are assumed to be equally probable.



Constellation A



Constellation B

(a) (5%) Find the ratio $\frac{A}{B}$ such that the average transmitter powers for these two constellations become equal.

(b) (8%) For each constellation, estimate the average probability of symbol error at the receiver.

(c) (2%) For each constellation, estimate the null-to-null bandwidth requirement.

5. (20%) A bit error probability of $P_E=10^{-3}$ is required for a system with a data rate of 100kbps to be transmitted over an AWGN channel using coherently detected MPSK modulation. The system bandwidth is 50kHz. Assume that the system frequency transfer function is a raised cosine with a roll-off characteristic of r=1 and that a Gray code is used for the symbol to bit assignment.
   (a) (5%) What is M ?
   (b) (5%) What is the bandwidth efficiency in bits per second per hertz for this modulation ?
   (c) (5%) What E_s/N_0 is required for the specified $P_E=10^{-3}$?
   (d) (5%) What E_b/N_0 is required?

6. (15%) A random binary digital source generates symbol "1" with probability 3/4 and symbol "0" with probability 1/4. The generated binary digital signal is transmitted through a band-limited additive white Gaussian channel with equal error probability 1/16.
   (a) (5%) What is the average source information generated and the average transmitted information?
   (b) (5%) In order to increase the efficiency of the source every 2 symbols from the binary source is encoded using Huffman encoding. Find out the resulting code words.
   (c) (5%) Find the minimum E_b/N_0 (the ratio of energy per bit to noise spectral density) for an transmission information rate of 400 Mbs/s in the ideal Gaussian channel with bandwidth of 100 MHz.