所別：通訊工程學系碩士班 甲組(一般生) 科目：通訊系統

1. [16 pts.] Referring to Figure 1, an input $n(t)$ to a filter with impulse response $h_1(t) = \text{sinc}\ 2Wt = \frac{\sin 2\pi Wt}{2\pi Wt}$ is a nonbandlimited white Gaussian process with $E\{n(t)\} = 0$ and $E\{|n(t)|^2\} = \sigma^2$, where $E\{\}$ is the expectation operation.
   (a) Find the mean of the output $x(t)$. [3 pts.]
   (b) Calculate the autocorrelation function of the output $x(t)$. [4 pts.]
   (c) Find the joint probability density function of the output $x(t)$ at the time instants t_1 and t_2. [4 pts.]
   (d) If the spectral density of y(t) is $S_y(f) = \begin{cases} \alpha^2, & |f|<B \\ 0, & \text{otherwise} \end{cases}$ and B < W, please find the transfer function of the filter $h_2(t)$. [5 pts.]

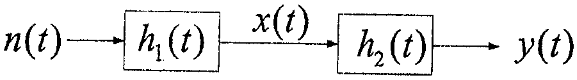

Figure 1.

2. [16 pts.] The following Figure 2 is a single sideband (SSB) system,

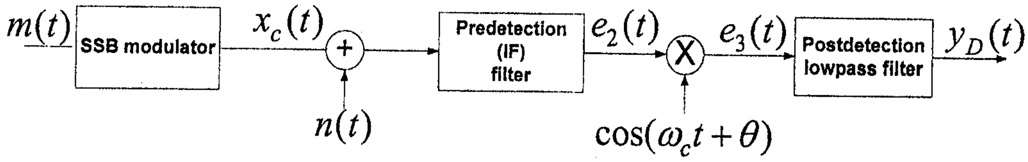

Figure 2.

where $m(t)$ is the baseband message signal with a bandwidth W and average power P, and $n(t)$ is an additive white Gaussian noise with double-sided power spectral density $N_0/2$.
   (a) If lower-sideband SSB is employed, please describe how you generate the lower-sideband SSB signal $x_c(t)$. [4 pt.]
   (b) What is the minimum required bandwidth of the predetection bandpass filter? [3 pts.]
   (c) Find the predetection SNR (measured at the output of the predetection IF filter). [4 pts.]
   (d) Find the postdetection SNR (measured at the output of the postdetection lowpass filter). [5 pts.]

3. [18 pts.] Please judge whether the statement is true or false and explain for your answer.
   (a) No matter how close together we sample a bandlimited white Gaussian noise process, samples are independent. [6 pts.]
   (b) If a random process with sample function $n(t) = A\cos(\omega_0 t + \varphi)$ where A and ω_0 is a constant and φ is a random variable with pdf $f(\varphi) = \begin{cases} 1/\pi, & |\varphi| \le \pi/2 \\ 0, & \text{otherwise} \end{cases}$, then the process $n(t)$ is not an ergodic process. [6 pts.]
   (c) Consider the analog signal $x_a(t) = 3\cos(2000\pi t) + 5\sin(6000\pi t) + 10\cos(12000\pi t)$. If we sample this signal using a sampling rate $f_s = 8kHz$ and $x(nT_s)$ is the sampled signal with $T_s = 1/f_s$, then we can reconstruct the signal $x_a(t)$ by using the ideal interpolation as $\frac{2B}{f_s}\sum_{n=-\infty}^{\infty} x(nT_s)\text{sinc}\{2B(t-nT_s)\}$ if B > f_s. [6 pts.]

注意：背面有試題

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4. [20 pts.] Consider BPSK in symbol interval [0,*T*]. The signals $A\cos w_c t$ and $-A\cos w_c t$ are transmitted for the information bit *b*=1 and *b*=0, respectively. Assume the channel is the AWGN channel with double-sided power spectral density $N_0/2$. At the receiver, the matched filter with impulse response $h(t)=k\prod((t-T/2)/T)\cos(2\pi f_c t)$ is used $\prod(t)=\begin{cases}1, & |t|<1/2\\ 0, & \text{otherwise}\end{cases}$. Let E_b denote the energy per bit and $v(t)$ denote the output signal of the matched filter. The value of *k* is chosen such that $v(t)$ is equal to 1+*N* or -1+*N*, where *N* is a zero-mean random variable. The detected value of *b* at the receiver is denoted by $\hat{b}$.

   (a) Find the variance of *N*. [6 pts.]

   (b) Determine the channel capacity (bits/symbol) if $\hat{b}=\begin{cases}1, & \text{v(T)>0}\\ 0, & \text{otherwise}\end{cases}$. [7 pts.]

   (c) Determine the channel capacity (bits/symbol) for the following decision rule. If $-0.5\le v(T)\le 0.5$, the received information is discarded; otherwise, $\hat{b}=\begin{cases}1, & \text{v(T)>0.5}\\ 0, & \text{v(T)<-0.5}\end{cases}$. Assume that E_b/N_0 is large enough such that the probability of $N\ge 1.5$ is almost equal to zero. [7 pts.]

5. [12 pts.] Consider 16-QAM with signal sets of the form $s_i(t)=a_i\cos w_c t+b_i\sin w_c t$, where $a_i,b_i\in\{\pm A,\pm 3A\}$.

   (a) For transmission rate 4 bits/*T*, 16 signals in one symbol interval [0,*T*] are used with equal probability. Find the average energy **per bit**. [4 pts.]

   (b) For transmission rate 3 bits/*T*, there are two choices: (1) choose 8 signals with the lowest average energy from 16-QAM in one symbol interval [0,*T*] (or [*T*,2*T*]). (2) choose 64 two-symbol signals with the lowest average energy (each two-symbol signal consists of one signal in [0,*T*] and one signal in [*T*,2*T*]) from all possible 256 two-symbol signals. To minimize average energy per bit, which one is preferred? Also find the minimum value of the average energy **per bit**. [8 pts.]

6. [18 pts.] Consider the modulation scheme with signals given as

$$s_i(t)=A_i\cos(w_c t+B_i),\qquad 0\le t\le T,\qquad i=1,2,\ldots,8$$

where $B_i=\frac{\pi}{4}(i-1)$ and $A_i=\begin{cases}r_1, & i\text{ is odd}\\ r_2, & i\text{ is even}\end{cases}$ $(r_1\le r_2)$. Note that when $r_1=r_2$, this modulation is 8PSK.

   (a) Devise an optimal coherent detector, which minimizes the symbol error probability, and show the optimal decision region. [10 pts.]

   (b) Determine the value of $\frac{r_2}{r_1}$ such that the symbol error probability can be minimized for a given average energy. [8 pts.]