科目：通訊系統(通訊原理)(500G)

校系所組：中大電機工程學系(電子組)
中大通訊工程學系(甲組)
交大電子研究所(乙組)
交大電信工程研究所(甲組)
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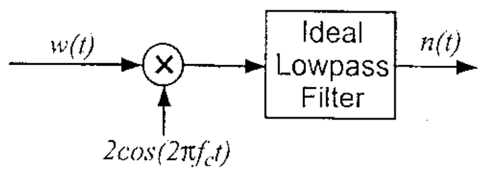
參考用

1. (6%) Consider narrowband bandpass noise $w(t)$ that is real, 0-mean, and wide-sense stationary with power spectral density

$$S_w(f) = \begin{cases} \frac{\pi N_o}{4B} \cos \frac{\pi(f-f_c)}{B}, & \text{for } |f-f_c| \le B/2, \\ \frac{\pi N_o}{4B} \cos \frac{\pi(-f-f_c)}{B}, & \text{for } |f+f_c| \le B/2, \\ 0, & \text{otherwise.} \end{cases}$$

By passing the noise through the receiver shown below, where the ideal lowpass filter is with bandwidth $B/2$, find the power spectral density of the output noise $n(t)$.



2. (26%) Please answer the following questions regarding continuous-wave modulation.

   (a) (4%) Please draw the block diagram of the quadrature-carrier multiplexing system including both transmitter and receiver.

   (b) (4%) Please implement the transmitter of upper sideband modulation by using the quadrature-carrier multiplexing system.

   (c) (3%) Please describe the virtues and limitations of amplitude modulation (AM).

   (d) (4%) Please describe the phenomena of cross talk in the quadrature-carrier multiplexing system.

   (e) (4%) Please draw the block diagram of the indirect method of generating a wide-band FM (frequency modulation) signal as detail as possible.

   (f) (4%) Please draw the block diagram of using pre-emphasis and de-emphasis filters in an FM system. In addition, please describe the function of the pre-emphasis and de-emphasis filters.

   (g) (3%) Please describe the advantages and disadvantages of FM systems as compared to AM systems.

注意：背面有試題

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3. (14%) Consider the transmission of an independent and identically distributed (i.i.d.) binary data sequence $\{a_k\}_{k=-\infty}^{\infty}$ with the baseband pulse $g(t)$, where a_k takes on the values $+1$ and -1 with equal probability. The signal arriving at the receiver is

$$r(t) = \sum_{\ell=-\infty}^{\infty} a_\ell \cdot g(t-\ell T) + n(t),$$

where $n(t)$ is additive white Gaussian noise with mean 0 and power spectral density $S_n(f) = \frac{N_o}{2}$. The signal $r(t)$ is first passed through the filter $h(t)$ and sampled periodically at multiples of T. The signal sampled at $t = kT$ is

$$y_k = y(kT) = \sum_{\ell=-\infty}^{\infty} a_\ell \cdot p(kT-\ell T) + w(kT) = \sum_{\ell=-\infty}^{\infty} a_\ell \cdot p_{k-\ell} + w_k,$$

where $y(t) = \int r(\tau)h(t-\tau)d\tau$, $p(t) = \int g(\tau)h(t-\tau)d\tau$ and $w(t) = \int n(\tau)h(t-\tau)d\tau$.

(a) (8%) Give conditions on $P(f)$ (i.e., the frequency response of $p(t)$), such that the sample at time kT is equal to

$$y_k = a_k + \frac{1}{2}a_{k-1} + w_k.$$

(Show the details of your derivation.)

(b) (6%) For $N_0 = \frac{1}{2}$, find the optimal coefficients (i.e., $\{c_0, c_1\}$) of the linear estimator (i.e., linear equalizer)

$$\hat{a}_k = c_0 y_k + c_1 y_{k-1}$$

that minimizes the mean square error $\mathrm{E}[(a_k - \hat{a}_k)^2]$. (Show the details of your derivation.)

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4. (12%) Two equiprobable messages m_1 and m_2 are to be transmitted through a channel with input X and output Y related by $Y = \rho X + N$, where N is a zero mean Gaussian noise with variance σ^2 and ρ is a random variable independent of the noise. Consider On-Off signaling with the inputs $X = 0$ and $X = A > 0$ associated with the messages m_1 and m_2, respectively. Assume that ρ takes on the values 0 and 1 with equal probability.

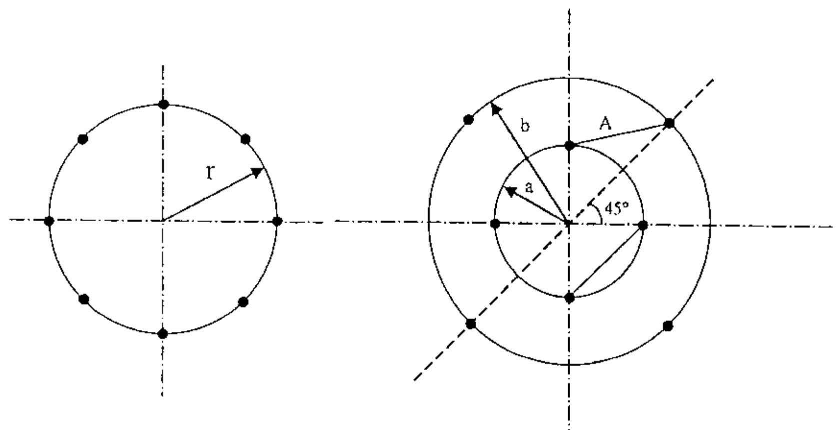
   (a) (6%) What is the optimal decision rule in terms of minimizing the probability of error? (Show the details of your derivation.)

   (b) (6%) Find the resulting error probability expressed in terms of the Q function defined as

$$Q(x) = \int_x^\infty \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du.$$

   (Show the details of your derivation.)

5. (16%) Consider the signal point constellations of 8-PSK and 8-QAM as shown below:



   (a) (6%) The nearest-neighbor signal points in the 8-QAM signal constellation are separated in distance by A units. Determine the radii a and b of the inner and outer circles respectively.

   (b) (5%) The adjacent signal points in the 8-PSK are separated by a distance of A units. Determine the radius r of the circle.

   (c) (5%) Determine the average transmitted powers for the two signal constellations. What is the relative power advantage of one constellation over the other? (Assume that all the signal points are equally probable.)

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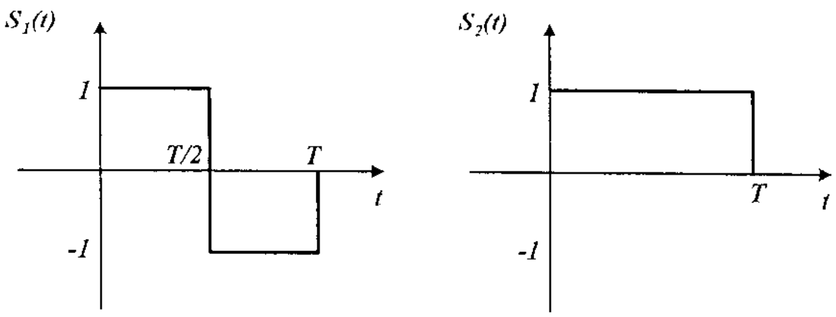
6. (26%) An equiprobable binary signaling scheme, using the signal set shown in the following figure, has rate R bits/s and symbol period T.



The received signal $r(t) = S_i(t) + N(t)$, $i = 1, 2$, where $N(t)$ is stationary white noise with probability density function of

$$f_N(n) = \frac{1}{\sqrt{2}a} e^{-\sqrt{2}|n|/a} \quad \text{for } n \in (-\infty, \infty).$$

The signal is passed through a set of matched filters and sampled at time $t = T$.

(a) (5%) Suppose the receiver is implemented by means of coherent detection using two matched filters that are matched to $S_1(t)$ and $S_2(t)$. Sketch the equivalent impulse response of the two matched filters.

(b) (5%) What is the average signal-to-noise ratio (SNR) of the system after taking the difference of the output of the two matched filters mentioned in (a)? (Show the details of your derivation.)

(c) (6%) What is the error probability of this system (in terms of a and T)? (Show the details of your derivation.)

(d) (4%) Now assume that the system is augmented with two more signals $S_3(t) = -S_1(t)$ and $S_4(t) = -S_2(t)$. What is the resulting transmission bit rate?

(e) (6%) Using the union bound, find a bound on the symbol error probability of the 4-ary system in (d). (Show the details of your derivation.)