國立台灣科技大學九十六學年度碩士班招生試題

系所組別： 電機工程系碩士班丙二組

科　　目： 通訊系統

總分 100 分

Problem 1 (25%):

White Gaussian noise $w(t)$ of zero mean and power spectral density $N_0/2$ is applied to the filtering scheme shown in Fig. P1a. The frequency responses of these two filters are shown in Fig. P1b. The noise at the low-pass filter output is denoted by $n(t)$.

(a) (6 %) Write down the *probability density function* of white Gaussian noise $w(t)$.

(b) (9 %) Find the autocorrelation function of $n(t)$.

(c) (10 %) What is the *minimum* rate at which $n(t)$ can be sampled so that the resulting samples are essentially uncorrelated?

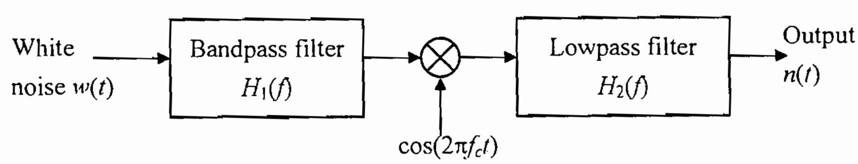

Fig. P1a

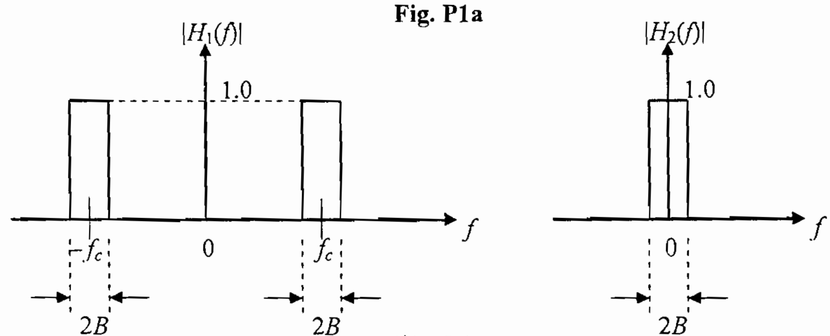

Fig. P1b

Problem 2 (25 %):

Figure P2 shows the block diagram of an example of frequency modulation. The given real signal $g(t)$ and a frequency-modulated signal $s(t)$ are applied to a multiplier and the output $g(t)s(t)$ is fed into a filter of impulse response $h(t)$. The $s(t)$ and $h(t)$ are linear FM signals whose instantaneous frequencies vary linearly with time at opposite rates, as shown by

$$s(t) = \cos(2\pi f_c t - \pi k t^2)$$
$$h(t) = \cos(2\pi f_c t + \pi k t^2)$$

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where k is a constant.

(a) (5 %) Write down the complex envelope of $s(t)$.

(b) (10 %) Define the complex envelopes of the input signal $g(t)s(t)$ and impulse response $h(t)$ to be $\tilde{v}(t)$ and $\tilde{h}(t)$, respectively. What is the complex envelope of the signal at the filter output in terms of $\tilde{v}(t)$ and $\tilde{h}(t)$?

(c) (10 %) Show that the envelope of the filter output is proportional to the magnitude spectrum of the input signal $g(t)$ with kt playing the role of frequency f.

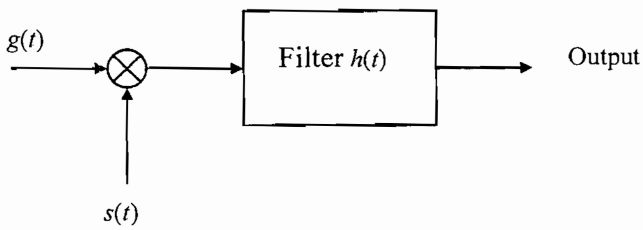

Fig. P2

Problem 3: (25 %)

A digital sequence consisting of symbols 1 and 0 is transmitted as depicted in Fig. P3; symbol 1 is represented by a rectangular pulse of amplitude A and duration T_b; symbol 0 is represented by a rectangular pulse of amplitude 0 and duration T_b. The channel noise is modeled as additive, white and Gaussian, with zero mean and power spectrum density $\frac{N_0}{2}$. It is assumed that symbols 1 and 0 occur with equal probability.

(a) (5%) Determine the matched filter at the receiver.

(b) (10%) Find the optimum threshold γ that minimizes the average probability of symbol error P_e.

(c) (10%) Derive the average probability of symbol error P_e at the receiver output.

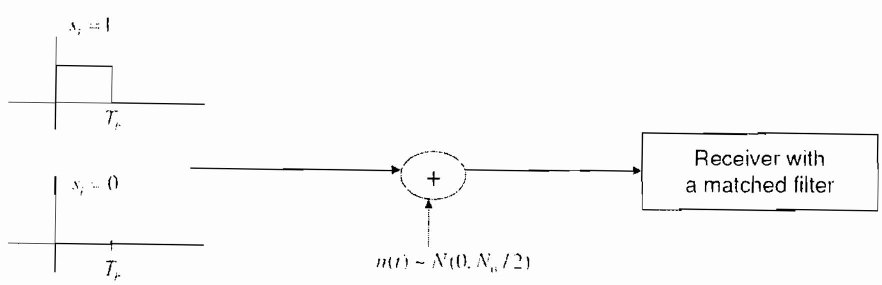

Fig. P3

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Problem 4: (25 %)

(a) (5%) Show that the following two basis functions are orthonormal.

$$\phi_1(t)=\begin{cases}\sqrt{2}\cos(2\pi t), & 0\le t\le 1\\ 0, & otherwise\end{cases}$$

$$\phi_2(t)=\begin{cases}\sqrt{2}\sin(2\pi t), & 0\le t\le 1\\ 0, & otherwise\end{cases}$$

(b) (10%) Draw the constellation points for the following waveforms using the basis functions $\phi_1(t)$ and $\phi_2(t)$.

$$x_0(t)=\begin{cases}\sqrt{2}\left(\cos(2\pi t)+\sin(2\pi t)\right), 0\le t\le 1\\ 0, otherwise\end{cases}$$

$$x_1(t)=\begin{cases}\sqrt{2}\left(\cos(2\pi t)+3\sin(2\pi t)\right), 0\le t\le 1\\ 0, otherwise\end{cases}$$

$$x_2(t)=\begin{cases}\sqrt{2}\left(3\cos(2\pi t)+\sin(2\pi t)\right), 0\le t\le 1\\ 0, otherwise\end{cases}$$

$$x_3(t)=\begin{cases}\sqrt{2}\left(3\cos(2\pi t)+3\sin(2\pi t)\right), 0\le t\le 1\\ 0, otherwise\end{cases}$$

$$x_{i+4}(t)=-x_i(t), i=0,1,2,3$$

(c) (10%) Determine the average energy of the signal constellation if all signals are equally likely transmitted in a communication system.