國立臺灣科技大學
九十三學年度碩士班考試試題

系所組別：電機工程系丙二組
科　　目：通訊系統

總共 100 分

1. Assume the modulated signal is generated as

$$x(t)=\left(\cos(2\omega_0 t)+\sin^2(\omega_0 t)\right)\cos(\omega_c t)$$

with $\omega_c \gg 2\omega_0$.

(a) (5 %) Find and sketch the spectrum of signal.

(b) (5 %) Find out the lowpass equivalent signal of the modulated signal.

(c) (5 %) What is the average power of the modulated signal?

(d) (5 %) Which part (time domain) of the modulated signal is transmitted if the single-sideband modulation (SSB) is used instead?

2. (10 %) Consider a system shown in Fig. P2.

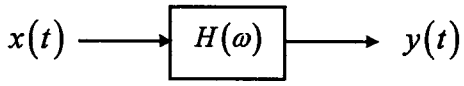

Fig. P2

where $H(\omega)=\dfrac{1}{1+j\omega}$ and input $x(t)=e^{-2t}u(t)$ with $u(t)=\begin{cases}1 & \text{for } t\geq 0\\ 0 & \text{otherwise}\end{cases}$

What is the energy output/input ratio $\left(\dfrac{E_{out}}{E_{in}}\right)$ of the system?

3. An angle-modulated signal with carrier frequency $w_c=2\pi\times10^5$ is described by the equation $\varphi_{EM}(t)=20\cos(w_c t+5\sin 3000t+10\sin 2000\pi t)$.

(a) (5 %) Find the frequency deviation Δf.

(b) (5 %) Find the deviation ratio β.

(c) (5 %) Find the phase deviation $\Delta\phi$.

(d) (5 %) Estimate the bandwidth of $\varphi_{EM}(t)$.

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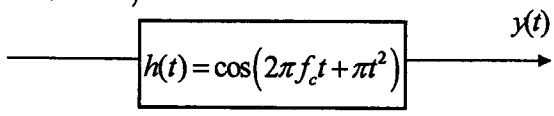
4. (10 %) Consider a communication system depicted below, where the symbol rate, $1/T$, is much less than the carrier frequency f_c in this problem.

$s(t) = a(t)\cos\left(2\pi f_c t - \pi t^2\right)$



and $a(t) = 1$ for $0 \le t \le T$

Fig. P4

Find out the expression of system output $y(t)$.

5. In an additive white Gaussian noise (AWGN) channel with a two-sided power spectral density $N_0/2$, assume two possible messages {0, 1} are transmitted with equal probability by employing corresponding waveforms as follows:

$$\begin{cases} s_1(t) = A \\ s_2(t) = At - A\dfrac{T}{2} \end{cases}$$

for $0 \le t \le T \quad \forall s_i(t)$
where A and T are real-valued parameters and $A < T$

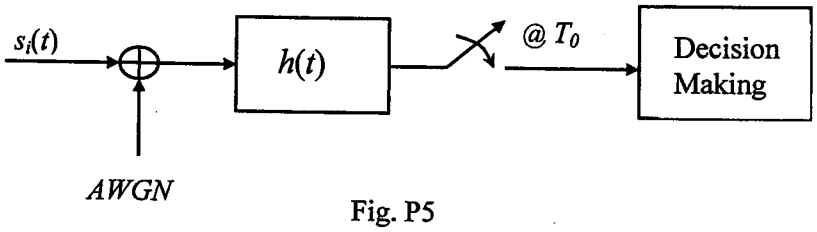


Fig. P5

(a) (5 %) Find orthonormal basis functions for signaling set $\{s_1(t), s_2(t)\}$.

(b) (5 %) What is the matched filter, $h(t)$?

(c) (5 %) Find out the optimal threshold when $A = 1$ and $T = 2$.

(d) (10 %) Derive an expression for the message error probability as a function of N_0 in terms of Q-functions when $A = 1$ and $T = 2$, where Q-functions is defined as

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty \exp\left(-\frac{\tau^2}{2}\right) d\tau$$

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6. Consider an analog signal occupying the frequency spectrum from 300*Hz* to 3300*Hz* with input voltage range from -5*V* to 5*V*. It is known that the quantization distortion (error) is required to be less than ± 1% of the peak-to-peak analog signal after sampling the original waveform at the Nyquist rate.

(a) (5 %) What is the sampling rate and the minimum number of uniform quantization levels needed?

(b) (10 %) A *natural sampling* operation, described in the following sentence, is applied at the Nyquist rate before quantization. Here the analog signal, denoted as $x(t)$, is multiplied by, $s_p(t)$, a train of pulses having duration τ and separated by the sampling interval T_s, as shown in Fig. P6. Find out the spectrum of the sampled version of $x(t)$ in terms of $X(f)$, the Fourier transform of $x(t)$. Also, determine if the original analog signal could be reconstructed perfectly.

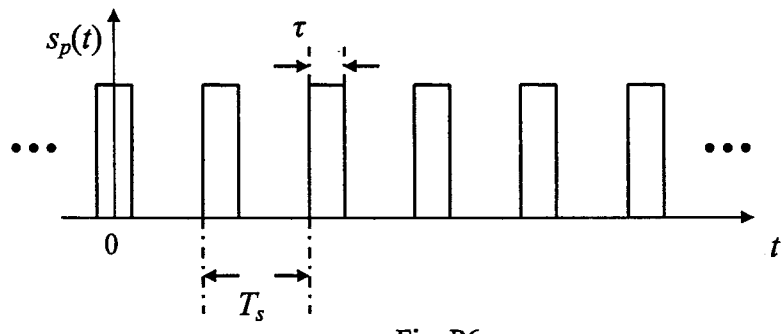

Fig. P6