國 立 臺 北 科 技 大 學

一百學年第二學期電機系博士班資格考試

數位通訊理論 試題

注意事項：

1. 本試題共【5】題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。
4. 考試時間:二小時。

1. (20%) Given that $g(t) = A\text{rect}(\frac{t}{T})\cos(2\pi f_c t)$, find

(a) G(*f*) (4%), (b) $g_+(t)$ (4%), (c) $\tilde{g}(t)$ (4%), (d) $g_I(t)$ and $g_Q(t)$ (8%).

2. (16%) Specify the Nyquist rate for each of the following signals: (Note that $\sin c(\lambda) = \frac{\sin \pi\lambda}{\pi\lambda}$)

(a) $s(t) = \sin c(200t)$. (6%)

(b) $s(t) = \sin c(200t) + \sin c^2(200t)$. (10%)

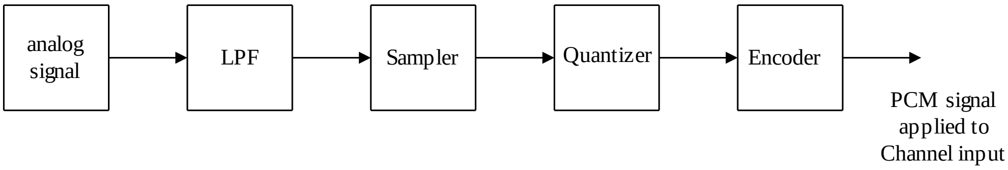
3. (20%) The transmitter of a PCM system is given below where a uniform quantizer followed by a 5-bit binary encoder is used. The bit rate of the PCM system is equal to 50×10^6 bits/s.

(a) What is the purpose of using the LPF (low pass filter)? (5%)

(b) Determine the maximum allowed bandwidth of the input analog signal, by which the system may operate satisfactorily. (5%)

(c) Determine the signal-to-(quantization) noise ratio of the (uniform) quantizer when the input analog signal is a full-load sinusoidal modulating wave of frequency 1 MHz. (5%)

(d) Explain why a PCM system can achieve better performance than an analog system. (5%)



4. (20%) Two sinusoidal waves of a coherent BPSK system are respectively represented by $s_1(t)=\sqrt{\dfrac{2E_b}{T_b}}\cos 2\pi f_c t$ and $s_2(t)=\sqrt{\dfrac{2E_b}{T_b}}\cos(2\pi f_c t+\pi)$, where $0\le t\le T_b$, and E_b is the transmitted signal energy per bit. The received signal is $x(t)=s_k(t)+w(t)$, $0\le t\le T_b$, $k=1,\ 2$, where $w(t)$ is AWGN of zero mean and PSD $N_0/2$. Note: $s_1(t)$ for symbol 1 and $s_2(t)$ for symbol 0.

(a) Assign orthonormal basis function(s) for this system. (4%)

(b) Plot signal-space diagram for this system with optimum decision boundary. (4%)

(c) Plot block diagrams of transmitter and receiver of this system. (8%)

(d) Simply describe your decision rule for this system. (4%)

5. (24%) Three signals are given below.

(a) Are they orthogonal to each other? Why? (6%)

(b) Using the Gram-Schmidt orthogonalization procedure, find a set of orthonormal basis functions to represent the three signals shown below. (12%)

(c) Express each of these signals in terms of the set of basis functions found in (b). (6%)

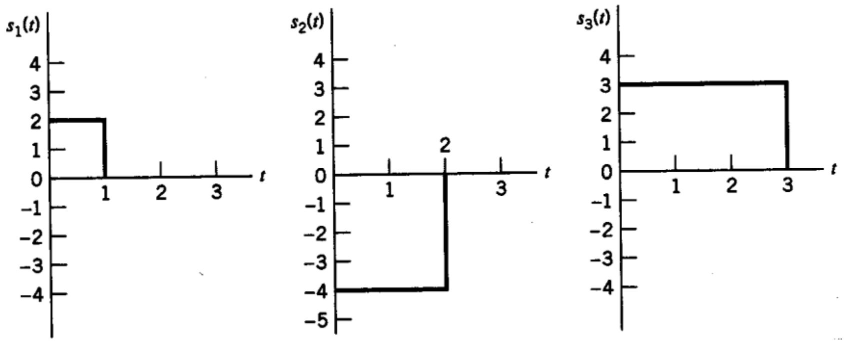


TABLE A6.3 *Fourier-transform pairs*

Time Function	*Fourier Transform*
$\text{rect}\left(\frac{t}{T}\right)$	$T\,\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}\,\text{rect}\left(\frac{f}{2W}\right)$
$\exp(-at)u(t), \quad a > 0$	$\frac{1}{a + j2\pi f}$
$\exp(-a\lvert t\rvert), \quad a > 0$	$\frac{2a}{a^2 + (2\pi f)^2}$
$\exp(-\pi t^2)$	$\exp(-\pi f^2)$
$\begin{cases} 1 - \frac{\lvert t\rvert}{T}, & \lvert t\rvert < T \\ 0, & \lvert t\rvert \geq T \end{cases}$	$T\,\text{sinc}^2(fT)$
$\delta(t)$	1
1	$\delta(f)$
$\delta(t - t_0)$	$\exp(-j2\pi f t_0)$
$\exp(j2\pi f_c t)$	$\delta(f - f_c)$
$\cos(2\pi f_c t)$	$\frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)]$
$\sin(2\pi f_c t)$	$\frac{1}{2j}[\delta(f - f_c) - \delta(f + f_c)]$
$\text{sgn}(t)$	$\frac{1}{j\pi f}$
$\frac{1}{\pi t}$	$-j\,\text{sgn}(f)$
$u(t)$	$\frac{1}{2}\delta(f) + \frac{1}{j2\pi f}$
$\sum_{i=-\infty}^{\infty} \delta(t - iT_0)$	$\frac{1}{T_0}\sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_0}\right)$

Notes: $u(t)$ = unit step function
$\delta(t)$ = delta function, or unit impulse
$\text{rect}(t)$ = rectangular function of unit amplitude and unit duration centered on the origin
$\text{sgn}(t)$ = signum function
$\text{sinc}(t)$ = sinc function