國立臺灣科技大學
九十學年度碩士班招生考試試題

系所組別： 電子工程系乙一組
科　目： 通信系統

This examination includes seven problems, which in turn consist of twenty subproblems. Every subproblem is worth five points.

1. Sampling and quantization of a continuous-time signal is addressed in this problem. Let us consider the signal $z(t) = x(2t)y(t)$, where $x(t)$ and $y(t)$ are bandlimited to 12.7 KHz and 31.2 KHz, respectively.

(a). Find the Nyquist sampling rate for $z(t)$.

(b). Explain how the original continous-time signal $z(t)$ can be reconstructed from its samples. Please do your explanation in the frequency-domain.

(c). Is quantization a linear operation ?

2. Let us consider a continuous-time signal

$$h(t) = \begin{cases} A\exp(-at) , & t \geq 0 , \\ 0 , & \text{otherwise} . \end{cases}$$

(a). Find the Fourier transform of $h(t)$.

(b). Find $y(t) = \exp(j2\pi f_0 t) * h(t)$, where $*$ denotes doing the convolution integral.

3. Two versions of amplitude modulation are given below :

$$x_{AM1}(t) = A_c(1 + \mu x(t)) \cos 2\pi f_c t .$$
$$x_{AM2}(t) = A_c x(t) \cos 2\pi f_c t .$$

where μ is the modulation index chosen to make $|\mu x(t)| < 1$ and $x(t)$ is the baseband message signal. Assume that the spectrum of $x(t)$ is given by

$$X(f) = \begin{cases} B(W - |f|) , & |f| \leq W , \\ 0 , & \text{otherwise} . \end{cases}$$

(a). Plot the spectrum of $x_{AM1}(t)$.

(b). What is the bandwidth needed for the transmission of $x_{AM2}(t)$.

(c). Please answer which one of the two amplitude-modulation signals can be easily demodulated with an envelope detector. Then, construct the detector circuit with a resistor, a capacitor and a diode.

(d). One of the two amplitude-modulation signals can not be demodulated by the envelope detector discussed in the preceding problem. Please design a demodulator for this signal.

4. A frequency-modulation signal can be described as

$$x_c(t) = A_c \cos(2\pi f_c t + 2\pi k_f \int_0^t x(\tau)\, d\tau) ,$$

where $x(t)$ is the baseband message signal. Let us consider the case that $x(t)$ is given by

$$x(t) = A_m \cos(2\pi f_m t) .$$

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(a). What is the maximum frequency deviation of $x_c(t)$?

(b). Let us rewrite $x_c(t)$ as

$$x_c(t) = x_I(t)\cos(2\pi f_c t) - x_Q(t)\sin(2\pi f_c t) .$$

Please find $x_I(t)$ and $x_Q(t)$. Express your answer in terms of A_c, A_m, k_f and f_m, etc.

(c). Find the complex envelope (i.e. baseband equivalent representation) of $x_c(t)$.

5. In a baseband transmission, logical 0 and logical 1 are equally likely to occur and are, respectively, mapped into waveforms

$$s_0(t) = At\ , \quad 0 < t < T\ ,$$

and

$$s_1(t) = -At\ , \quad 0 < t < T\ ,$$

where A is a positive constant. Assume that the communication is through an AWGN (additive white Gaussian noise) channel, where the two-sided power spectral density of the noise is $N_0/2$.

(a). Is it possible to find a matched filter that is matched to $s_0(t)$ and $s_1(t)$ at the same time ? If yes, find it.

(b). Design a demodulator structure for the transmission.

(c). Find the bit error rate for $A = \sqrt{3}$, $T = 2$ and $N_0 = 1$.

<P.S.> You may need the approximation formula

$$\int_z^{\infty} \frac{1}{\sqrt{2\pi}} \exp(-x^2/2)dx \ \approx\ \frac{1}{z\sqrt{2\pi}} \exp(-z^2/2) \quad \text{for } z > 3.$$

6. Let us consider the signal

$$x(t) = \sum_{n=-\infty}^{\infty} d_n q(t - nT)$$

where d_n represents the n^{th} information bit of a binary data sequence and is a discrete random variable with probability function

$$\text{Prob}(d_n = 1) = \text{Prob}(d_n = -1) = 1/2$$

and

$$q(t) = \begin{cases} B\ , & 0 \le t \le T\ , \\ 0\ , & \text{otherwise}\ . \end{cases}$$

The signal $x(t)$ is passed through a filter, whose impulse response is

$$h(t) = \begin{cases} A\exp(-at)\ , & t \ge 0\ , \\ 0\ , & \text{otherwise}\ , \end{cases}$$

which happens to be the signal that was considered in Problem **1**. The output from the filtering is denoted by $y(t)$.

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(a). Let $R_x(\tau)$ denote the autocorrelation function of $x(t)$. Find $R_x(0)$.

(b). Find the power spectral density of $x(t)$.

(c). Find the power spectral density of $y(t)$.

7. A (6,3) linear block code for error correction is listed below, in the form of a table,

message word	codeword
0 0 0	0 0 0 0 0 0
1 0 0	1 1 0 1 0 0
0 1 0	0 1 1 0 1 0
1 1 0	1 0 1 1 1 0
0 0 1	1 0 1 0 0 1
1 0 1	0 1 1 1 0 1
0 1 1	1 1 0 0 1 1
1 1 1	0 0 0 1 1 1

(a). If the word 011111 is received, which message word should it be decoded into ?

(b). Obviously we see that a codeword consists of 6 code-bits. If the probability of code-bit at the receiver is .001, find the probability that a received codeword can not be decoded correctly.

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