MACQUARIE
UNIVERSITY ~ SYDNEY

END-OF-YEAR EXAMINATIONS 2005

Unit:	**ELEC321 Communication Systems (D2)**
Day and Time:	Tuesday, 22 November 2005, 9:20 a.m.
Time Allowed:	Three hours plus 10 minutes reading time.
Total Number of Questions:	SIX (6)
Instructions:	Answer any **FIVE** (5) questions only.
	Total marks for this paper: 100. The questions are of equal value. Use one or more examination booklets. Non-programmable electronic calculators may be used.

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1. Fourier Series; Sampling

(a) (5 marks)

Working from first principles, determine the Fourier series for a periodic waveform consisting of rectangular pulses of height A and width t, repeated at intervals of T. Choose the time origin so that the waveform is an even function of time.

(b) (6 marks)

A signal $p(t)$ is given by the product of two signals $s_1(t)$ and $s_2(t)$:

$$p(t) = s_1(t) \times s_2(t) \quad .$$

Show that the spectrum $P(w)$ of $p(t)$ may be obtained by convolving the spectra $S_1(w)$ of $s_1(t)$ and $S_2(w)$ of $s_2(t)$.

(c) (5 marks)

A band-limited signal $f(t)$ is sampled at regular intervals of time T for a time interval t, so that during time intervals t the sampled signal $s(t)$ is equal to $f(t)$ but is zero otherwise.

Use your answers to parts (a) and (b) to describe the spectrum of $s(t)$.

Show how this result leads to the ***sampling theorem***.

(d) (4 marks)

If the requirements of the sampling theorem are not satisfied, the phenomenon of ***aliasing*** may occur. Give two simple examples of aliasing.

2. Analogue Modulation

(a) (10 marks)

Using circuit blocks to perform the functions of addition and multiplication, and quadrature-phase networks capable of providing a phase shift of 90° at any frequency, show how signals modulated using the following techniques may be generated from a carrier signal at angular frequency w_c and modulation signal(s) at angular frequency w_{m1} and/or w_{m2}:

(i) single-sideband suppressed-carrier modulation (SSBSC);

(ii) narrow-band frequency modulation (NBFM); and

(iii) quadrature amplitude modulation (QAM).

(b) (10 marks)

For each case, explain whether the signal may be synchronously demodulated.

For each case, discuss whether synchronous demodulation is a practical method, or what better method of demodulation is available.

3. Miscellaneous

(a) (6 marks)

Explain what the process of ***companding*** is, and why it is used in transmission of analogue signals (e.g. voice) using pulse-code modulation.

(b) (7 marks)

Explain how eye patterns are used in testing transmission channels.

Illustrate your answer with sketches of typical eye patterns for channels which are

(i) band-limited;

(ii) noise-limited; and

(iii) comparably affected by band limiting and noise.

(c) (7 marks)

A differential-PCM transmission system uses a linear predictor; the predicted next value is obtained by extrapolating the straight line through the last two values. It uses a 4-bit sign-magnitude code, to cover values in the range $\pm 7 \times 0.1$ V, (i.e., integral multiples of 100 mV from -700 mV to +700 mV). The input $s(t)$ has been zero for a long time, but after $t = 0$ increases as shown below.

t (msec.)	0	10	20	30
$s(t)$ (V)	0.0	0.9	1.4	1.8

Explain how this system works, calculating the value of the 4-bit code sent by the transmitter at the three sampling instants ($t =$ 10, 20, 30 msec.) in the above table.

4. Line Coding, Matched-Filter Detection and Waveform Shaping

(a) (2 marks)

Line coding involves converting (say) standard TTL/CMOS logic levels to a suitable waveform for transmission. Describe the difference between a return-to-zero (RZ) and a non-return-to-zero (NRZ) waveform format.

(b) (2 marks)

In digital transmission systems, a sequence of decimal symbols is often gray-coded for transmission. Explain why Gray coding is preferable to binary coding.

(c) (12 marks)

A known signal $f(t)$ together with additive white Gaussian noise with two-sided noise power spectral density $\frac{n_0}{2}$ Watt/Hz is applied to the input of a matched filter. If the filter transfer function is $H(\omega)$ and its output is sampled at time t_0, use Parseval's Theorem and Schwarz's inequality to show that the maximum peak signal-to-noise power at the output of the matched filter is

$$\frac{A^2}{N} = \frac{2E}{n_0}$$

where E is the energy of the input signal $f(t)$, A is the amplitude of the output signal at time t_0, and N is the average output noise power.

(d) (4 marks)

A communication channel is used for transmitting audio signals in the range 600 Hz to 3000 Hz, using a 1800Hz carrier wave. If waveform shaping and phase-shift keying techniques are used, show that it is possible to use 4-PSK signals with a raised-cosine shaping filter to send data over the channel at a rate of 2400 bits per second.

5. M-ary AM-PM Link Error Probability

(a) (10 marks)

Consider an 8-point AM-PM signal and let $P(s_i)$ be the a priori probability of transmitting the signal symbol s_i for $1 \leq i \leq 8$. Figure 5 shows the signal constellation diagram of the 8-point AM-PM signal. In the presence of additive white Gaussian noise, the expression for the error probability can be derived from the signal constellation diagram. Without deriving the expression, use Figure 5 to explain a technique to compute the error probability of an 8-point AM-PM signal.

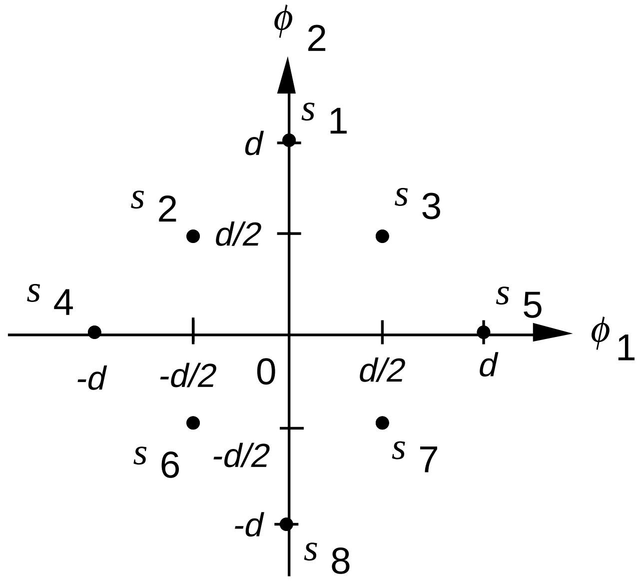

Figure 5 8-point AM-PM signal constellation diagram.

(b) (4 marks)

Discuss the advantages and disadvantages of M-point AM-PM signals as compared to binary amplitude-shift-keyed signals.

(c) (6 marks)

Suppose that the information transmission rate of the 8-point AM-PM signals employing a Nyquist shaping filter is 19.2 kbits/sec. Determine the transmission channel bandwidth if a sinusoidal roll-off factor of $r = 0.2$ is employed by the shaping filter.

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6. Information Capacity, Source Coding and Error-Control Coding

(a) (4 marks)

Consider a telegraph source having two symbols, dot and dash. The dot duration is 0.2 s. The dash duration is 3 times the dot duration, the probability of the dot's occurring is twice that of dash, and the time between symbols is 0.2 s. Calculate the information rate of the telegraph source.

(b) (2 marks)

Write down the Huffman encoding procedure for a discrete memoryless source with symbols x_i and corresponding probabilities p_i, $i = 1, 2, ..., m$.

(c) (4 marks)

Consider a discrete memoryless source with symbols x_1, x_2, x_3, x_4, and x_5, and corresponding symbol probabilities $p_1 = 0.4$, $p_2 = 0.2$, $p_3 = 0.2$, $p_4 = 0.1$, and $p_5 = 0.1$. Construct a Huffman code for the source.

(d) (10 marks)

Consider the (15, 11) cyclic code generated by the generator polynomial $g(x) = 1 + x + x^4$.

(i) Determine the parity-check polynomial $h(x)$ of this code.

(ii) Determine the generator polynomial and the dimension of its dual code.

(iii) Find the generator and parity matrices in systematic form for this code.
