UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION 2010

TITLE OF PAPER : DIGITAL COMMUNICATIONS

COURSE NUMBER : E530

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : READ EACH QUESTION CAREFULLY
ANSWER ANY **FOUR** QUESTIONS.
EACH QUESTION CARRIES **25 MARKS**.
MARKS FOR EACH SECTION ARE SHOWN ON THE RIGHT-HAND MARGIN.

THIS PAPER HAS 5 PAGES INCLUDING THIS PAGE.

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QUESTION 1

(a) (i) An information source contains 100 different, statistically independent, equiprobable symbols. Find the maximum code efficiency. [6 marks]

The first 20 symbols occur with probability 0.004, the next 40 with probability 0.003, the next 20 with probability 0.03 and the last 20 with probability 0.01.

(ii) Determine

1) the information conveyed by the specific message containing the first twenty and the last twenty symbols. [2 marks]

2) the redundancy of the source. [4 marks]

(b) You are given a discrete memoryless source with symbols $S_0, S_1,$ occurring with probabilities 0.7, 0.3 respectively at its output.

How does the efficiency of the second order source compare with that of the original source? [13 marks]

QUESTION 2

Consider the encoder connections characterized by the following generator polynomials:

$$g_1(D) = 1 + D$$
$$g_2(D) = 1$$
$$g_3(D) = D$$

(i) If the input sequence fed into the encoder is B = [1 0 1 1], compute the output sequence using the impulse response method.

[8 marks]

(ii) What is the effective code rate ? [2 marks]

(iii)Present a well labeled state diagram of the encoder. [12 marks]

(iv) The output sequence of the encoder is observed to be [110011101000], find the input sequence using the state diagram.

[3 marks]

QUESTION 3

Design a (5,2) systematic linear block code.

(i)Find the generator matrix for the codeword set.

[3 marks]

(ii)Enter all of the n-tuples into a standard array.

[12 marks]

(iii)Make a syndrome table for the correctable error patterns.

[5 marks]

(iv)Design a hardware implementation which can be used to generate the syndrome of any received vector **R** for the code.

[5 marks]

QUESTION 4

The general analytic expression for Amplitude Shift Keying(ASK) is

$$S_i(t) = \sqrt{\frac{2E(t)}{T_b}}\,Cos(2\pi f_c t + \theta) \quad 0 \le t \le T_b$$

for i = 1, ... , M . The phase term θ is an arbitrary constant.

(i) For M = 2, construct the signal space diagram for ASK.

[13 marks]

(ii) Given an AWGN channel, derive the expression for the corresponding average probability of error, assuming that symbols 1 and 0 occur with equal probability.

[6 marks]

(iii) Digital data is transmitted at 10 kbps through a channel which adds noise with single - sided power spectral density, No = 10^{-11} W/Hz. Compute the amplitude Ac, of the received carrier signal required to give a Pe of 10^{-6} when binary Phase Shift Keying is used.

[6 marks]

QUESTION 5

(a)A source emits symbol A and B with a probability of 0.9 and 0.1 respectively, at a rate of 3.5 symbols/second. The source output is connected to a binary channel of capacity 1 bit/symbol, and can transmit a binary 0 or 1 at a rate of 2 symbols/sec with negligible error.

Is transmission possible with or without source coding?
Explain each answer showing all your working. [10 marks]

(b) Partial Response Signaling systems suffer from the problem that once errors are made, they tend to propagate in the detected data stream. A practical solution is to use precoding.

(i) Given the binary input x_k = [0 0 1 1 0 1 1], to a precoded duobinary filter, show how the decoding process eliminates error propagation. [10 marks]

(ii) Design a circuit which can be used for decoding Y_k in (i) above and give its output sequence. [5 marks]

USEFUL INFORMATION

$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$
$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B.$

$\sin A \sin B = \frac{1}{2}[\cos(A - B) - \cos(A + B)]$
$\cos A \cos B = \frac{1}{2}[\cos(A + B) + \cos(A - B)]$
$\sin A \cos B = \frac{1}{2}[\sin(A + B) + \sin(A - B)]$

$\cos^2 A = \frac{1}{2}[1 + \cos 2A]$
$\sin^2 A = \frac{1}{2}[1 - \cos 2A]$

The Gaussian probability func.

$$p(y) = \frac{1}{\sigma}\frac{1}{\sqrt{2\pi}} e^{-(y-m)^2/2\sigma^2}$$

$$erfc(u) = \frac{2}{\sqrt{\pi}} \int_u^{\infty} e^{-z^2}\, dz \qquad Q(V) = \frac{1}{\sqrt{2\pi}} \int_V^{\infty} e^{\frac{-x^2}{2}}\, dx$$

Table 1 Values for Q(x)

x	10log x	Q(x)	x	10log x	Q(x)	x	10log x	Q(x)
3.00	4.77	1.35 E-03	4.00	6.02	3.17 E-05	5.00	6.99	2.87 E-07
3.05	4.84	1.14 E-03	4.05	6.07	2.56 E-05	5.05	7.03	2.21 E-07
3.10	4.91	9.68 E-04	4.10	6.13	2.07 E-05	5.10	7.08	1.70 E-07
3.15	4.98	8.16 E-04	4.15	6.18	1.66 E-05	5.15	7.12	1.30 E-07
3.20	5.50	6.87 E-04	4.20	6.23	1.30 E-05	5.20	7.16	9.96 E-08
3.25	5.12	5.77 E-04	4.25	6.28	1.07 E-05	5.25	7.20	7.61 E-08
3.30	5.19	4.83 E-04	4.30	6.33	8.54 E-06	5.30	7.24	5.79 E-08
3.35	5.25	4.04 E-04	4.35	6.38	6.81 E-06	5.35	7.28	4.40 E-08
3.40	5.31	3.37 E-04	4.40	6.43	5.41 E-06	5.40	7.32	3.33 E-08
3.45	5.38	2.80 E-04	4.45	6.48	4.29 E-06	5.45	7.36	2.52 E-08
3.50	5.44	2.33 E-04	4.50	6.53	3.40 E-06	5.50	7.40	1.90 E-08
3.55	5.50	1.93 E-04	4.55	6.58	2.68 E-06	5.55	7.44	1.43 E-08
3.60	5.56	1.59 E-04	4.60	6.63	2.11 E-06	5.60	7.48	1.07 E-08
3.65	5.62	1.31 E-04	4.65	6.67	1.66 E-06	5.65	7.52	8.03 E-09
3.70	5.68	1.08 E-04	4.70	6.72	1.30 E-06	5.70	7.56	6.00 E-09
3.75	5.74	8.84 E-05	4.75	6.77	1.02 E-06	5.75	7.60	4.47 E-09
3.80	5.80	7.23 E-05	4.80	6.81	7.93 E-07	5.80	7.63	3.32 E-09
3.85	5.85	5.91 E-05	4.85	6.86	6.17 E-07	5.85	7.67	2.46 E-09
3.90	5.91	4.81 E-05	4.90	6.90	4.79 E-07	5.90	7.71	1.82 E-09
3.95	5.97	3.91 E-05	4.95	6.95	3.71 E-07	5.95	7.75	1.34 E-09