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UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE
DEPARTMENT OF ELECTRONIC ENGINEERING
MAIN EXAMINATION 2004 / 2005

TITLE OF PAPER : DIGITAL COMMUNICATIONS

COURSE NUMBER : E530

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : READ EACH QUESTION CAREFULLY
ANSWER ANY **FOUR** OUT OF **FIVE** 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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USEFUL INFORMATION

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

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

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

Values of $Q(x)$ for Large x.

x	10 log x	$Q(x)$	x	10 log x	$Q(x)$	x	10 log x	$Q(x)$
3.00	4.77	1.35E-03	4.00	6.02	3.17E-05	5.00	6.99	2.87E-07
3.05	4.84	1.14E-03	4.05	6.07	2.56E-05	5.05	7.03	2.21E-07
3.10	4.91	9.68E-04	4.10	6.13	2.07E-05	5.10	7.08	1.70E-07
3.15	4.98	8.16E-04	4.15	6.18	1.66E-05	5.15	7.12	1.30E-07
3.20	5.05	6.87E-04	4.20	6.23	1.33E-05	5.20	7.16	9.96E-08
3.25	5.12	5.77E-04	4.25	6.28	1.07E-05	5.25	7.20	7.61E-08
3.30	5.19	4.83E-04	4.30	6.33	8.54E-06	5.30	7.24	5.79E-08
3.35	5.25	4.04E-04	4.35	6.38	6.81E-06	5.35	7.28	4.40E-08
3.40	5.31	3.37E-04	4.40	6.43	5.41E-06	5.40	7.32	3.33E-08
3.45	5.38	2.80E-04	4.45	6.48	4.29E-06	5.45	7.36	2.52E-08
3.50	5.44	2.33E-04	4.50	6.53	3.40E-06	5.50	7.40	1.90E-08
3.55	5.50	1.93E-04	4.55	6.58	2.68E-06	5.55	7.44	1.43E-08
3.60	5.56	1.59E-04	4.60	6.63	2.11E-06	5.60	7.48	1.07E-08
3.65	5.62	1.31E-04	4.65	6.67	1.66E-06	5.65	7.52	8.03E-09
3.70	5.68	1.08E-04	4.70	6.72	1.30E-06	5.70	7.56	6.00E-09
3.75	5.74	8.84E-05	4.75	6.77	1.02E-06	5.75	7.60	4.47E-09
3.80	5.80	7.23E-05	4.80	6.81	7.93E-07	5.80	7.63	3.32E-09
3.85	5.85	5.91E-05	4.85	6.86	6.17E-07	5.85	7.67	2.46E-09
3.90	5.91	4.81E-05	4.90	6.90	4.79E-07	5.90	7.71	1.82E-09
3.95	5.97	3.91E-05	4.95	6.95	3.71E-07	5.95	7.75	1.34E-09

QUESTION 1

Consider a communication system which can transmit and receive error - free binary symbols at a rate of 1250 bits/s. Three symbols x, y, z, occurring with probabilities 0.7, 0.2 and 0.1 respectively, are to be sent over this channel. The symbols are produced at a rate of 1000 per second.

(i) Is it possible to use a binary code with equal codeword lengths? (4 marks)

(ii) Can a variable - length code be used for the source output? (5 marks)

(iii) Can a Huffman code be used for the source output? (7 marks)

(iv) Can a second order extension be used? (9 marks)

QUESTION 2

(a) You are given the following information for a phase - shift - keying system.

Binary data transmission is at 10 Mbps
Carrier amplitude at receiver = 10^{-1} V
Additive noise power = 1 x 10^{-10} W/Hz
Carrier frequency = 10 MHz

(i) Find the bit error rate for the system. (9 marks)

(ii) If 100 W of power is required to transmit the data, what antenna gain (in dB) should be used? (4 marks)

(b) A K = 3 , rate $1/3$ convolutional code can be generated by

$$g_1(X) = X + X^2$$
$$g_2(X) = 1 + X$$
$$g_3(X) = 1 + X + X^2$$

(i) Determine the output of the convolutional encoder whose connections are characterized by the generator polynomials above, given a message vector **m = 0 1 1**. (10 marks)

(ii) Compute the effective code rate of the encoder. (2 marks)

QUESTION 3

(a)Given the following MSK signal,

$$S_{(t)} = \sqrt{\tfrac{2Eb}{T_b}}Cos\left(\tfrac{\pi t}{2T_b}\right)Cos\left(2\pi f_c t\right) - \sqrt{\tfrac{2E_b}{T_b}}Sin\left(\tfrac{\pi t}{2T_b}\right)Sin\left(2\pi f_c t\right):$$

Find the coordinates of the message points and construct a signal space diagram.

(15 marks)

(b)Polar signaling format is not very suitable for use in transmission where switching circuits are to be used.

(i) Explain how a polar format can be improved at the transmitter so that the effects of polarity inversion can be eliminated and how the original binary sequence can be recovered at the receiver. (6 marks)

(ii) Why will the interpretation of the data at the reception not be affected by polarity inversion along the channel? (2 marks)

(iii) Give two advantages offered by the bipolar format over the Manchester one (2 marks)

QUESTION 4

Design a systematic linear block code with codeword - lengths of 6 bits.

(i) Find the generator and parity check matrices for the codeword set. (7 marks)

(ii) Enter all the 6 - tuples into a standard array. (4 marks)

(iii) Determine the minimum distance of the code and its error - correcting capability (4 marks)

(iv) Determine the syndrome table for the correctable error patterns. (5 marks)

(v) Design a simple circuit implementation for the encoder for this code. (5 marks)

QUESTION 5

(a) (i) Compute the minimum average length of a code with five messages , m_1,m_2, m_3, m_4 and m_5, with probabilities $\frac{1}{16}, \frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{1}{2}$ respectively. (4 marks)

(ii) Assuming a prefix- free code was used to encode the messages, give the possible codewords for m_1,m_2, m_3, m_4 and m_5, (5 marks)

(iii) Find the redundancy of the code. (4 marks)

(b) Figure 5.0 shows two signals $S_1(t)$ and $S_0(t)$ which are used to transmit a symbol 1 and symbol 0 respectively.

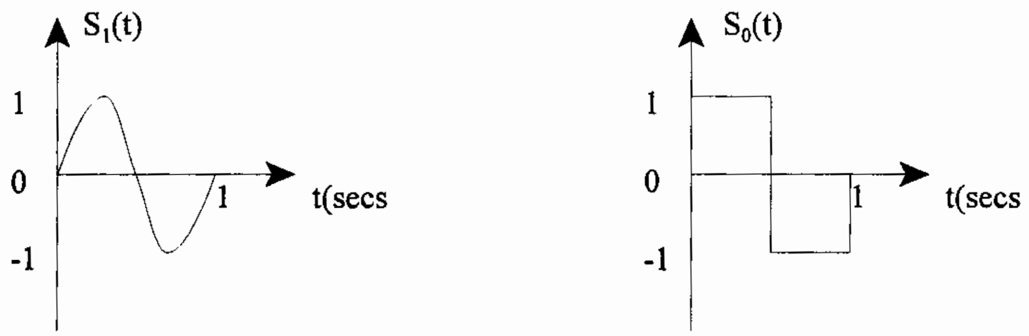

Figure 5.0

Design a correlator detector which can be used for detection of the two symbols. (7 marks)

(c) Explain, with the aid of a well labelled diagram, the generation of a FSK signal. (5 marks)