UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING
MAIN EXAMINATION, APRIL/MAY 2008

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 7 PAGES INCLUDING THIS PAGE.

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QUESTION 1

The encoder of Figure 1, generates a sequence whose received data stream is r_r = [1 1 0 0 1 1 0 1 0 0].

(i) Identify the errors using the Viterbi Algorithm (15 marks)

(ii) Compute the transmitted message bits. (2 marks)

(iii) Present the state diagram. (3 marks)

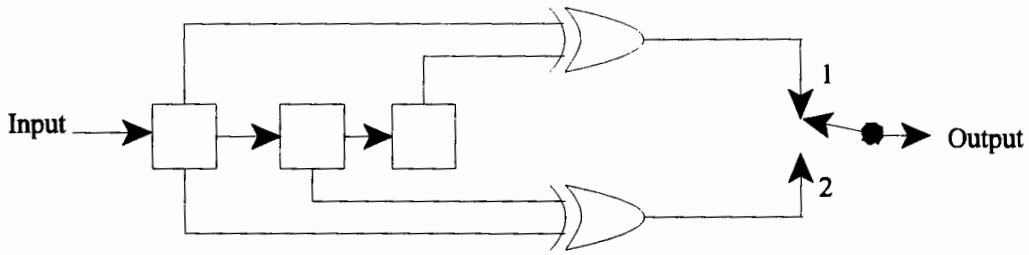

Figure 1

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

$$S\,i\,(t) = \sqrt{\frac{2Ei(t)}{T_b}}\,Cos\left(2\pi f_c t + \theta\right) \quad 0 \le t \le T_b$$

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

Compute the coordinates of the message points for ASK.

(5 marks)

QUESTION 2

(a) 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) Show that errors can not propagate in a precoded duobinary conversion filter system, given the binary input to the precoder, $x_k = [1\ 0\ 1\ 0\ 1\ 1\ 0]$. (10 marks)

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

(b) Consider an FSK system with a bit rate of 1 bps. The signals, having amplitudes of 0.4, are at frequencies of 1 kHz. and 2 kHz. Compare the error performances of the coherent and incoherent detectors for this system, given an additive noise power of 10^{-2} W/Hz.

(10 marks)

QUESTION 3

(a) A discrete source has two possible output symbols, A and B, having probabilities 0.3 and 0.7 respectively. The symbol rate is 3.5 symbols/second. The source output is connected to a binary channel of capacity 1 bit/symbol that can transmit a binary 0 or 1 at a rate of 2 symbols/sec with negligible error.

Explain how transmission can be facilitated. Show all computations.

(10 marks)

(b) Consider a (6, 3) block code whose generator matrix is

$$G = \begin{bmatrix} 110100 \\ 101010 \\ 011001 \end{bmatrix}$$

Design a simple circuit which can be used to generate the codeword set.

(9 marks)

(c) An NRZ polar format is used for baseband representation of digital data before transmission to its destination.

(i) How can this signalling format be modified to ensure that problems like data inversion, encountered during transmission through switched telephone networks, does not affect data interpretation? (4 marks)

(ii) Explain how the original information may be recovered from the received signal. (2 marks)

QUESTION 4

(a) A scanner produces source data by converting a black and white document, line by line into binary data, at a scan rate of 1000 pixels/s. The data comprises symbols representing runs of up to 5 similar image pixel elements. The probabilities of occurrence of consecutive pixels are as given in Table 2.

Table 2

No. of consecutive pixels	1	2	3	4	5
Probability of occurrence	0.5	0.3	0.1	0.06	0.04

Compute the

(i) average length of a run in pixels. (6 marks)

(ii) information rate for the source. (4 marks)

(b) An ASK system has a probability of error $P_e = 3.14 \times 10^{-2}$, $\rho_o = \rho_1 = 0.5$, message points m_1 at $\left(\sqrt{E_b},0\right)$ and m_o at $(0,0)$.

(i) Compute the probability of error geometrically for BPSK and Frequency Shift Keying(FSK) using the same average transmitted power.

The BPSK system has m_1 and m_o at $\left(\sqrt{E_b},0\right)$ and $\left(-\sqrt{E_b},0\right)$ respectively while an FSK one has m_1 and m_o at $\left(\sqrt{E_b},0\right)$ and $\left(O,\sqrt{E_b}\right)$ respectively.

(12 marks)

(ii) Which system has the best error performance and why?

(3 marks)

QUESTION 5

Given the following parity check equations, design an (n, k) systematic linear block code.

$$p_1 = m_1 + m_2$$

$$p_2 = m_1 + m_3$$

where p_i are check bits and m_i are message bits.

Make both the standard array and syndrome table for the correctable error patterns for the code.

(25 marks)

USEFUL INFORMATION

$\text{Cos}(A \pm B) = \text{Cos } A \text{ Cos } B \mp \text{Sin } A \text{ Sin } B$

$\text{Sin}(A \pm B) = \text{Sin } A \text{ Cos } B \pm \text{Cos } A \text{ Sin } B.$

$$erfc(u) = \frac{2}{\sqrt{\pi}} \int_u^\infty e^{-z^2} dz$$

$\text{Sin } A \text{ Sin } B = \frac{1}{2} [\text{Cos}(A - B) - \text{Cos}(A + B)]$

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

$\text{Sin } A \text{ Cos } B = \frac{1}{2} [\text{Sin}(A + B) + \text{Sin}(A - B)]$

$$Q(V) = \frac{1}{\sqrt{2\pi}} \int_V^\infty e^{\frac{-x^2}{2}} dx$$

$\text{Cos}^2 A = \frac{1}{2} [1 + \text{Cos } 2A]$

$\text{Sin}^2 A = \frac{1}{2} [1 - \text{Cos } 2A]$

The Gaussian probability func.

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

Table 1 Values for Q(x)

	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
2.3	.0107	.0104	.0102	.00990	.00964	.00939	.00914	.00889	.00866	.00842
2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139