UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING
SUPPLEMENTARY EXAMINATION 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 RIHT HAND MARGIN.

THIS PAPER HAS 6 PAGES INCLUDING THIS PAGE.

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USEFUL INFORMATION

Cos (A ± B) = Cos A Cos B ∓ Sin A Sin B
Sin (A ± B) = Sin A Cos B ± Cos A Sin B
Sin A Sin B = ½ [Cos (A - B) - Cos (A + B)]
Cos A Cos B = ½ [Cos (A + B) + Cos (A - B)]
Sin A Cos B = ½ [Sin (A + B) + Sin (A - B)]
$\text{Cos}^2 A$ = ½ [1 + Cos 2 A]
$\text{Sin}^2 A$ = ½ [1 - Cos 2A]

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

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

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

QUESTION 1

(a) Linear block codes with a minimum distance d_{min} can correct up to $(d_{min}-1)/2$ errors and detect up to $d_{min}-1$ errors in each codeword.

Design a linear block code with $d_{min} = 3$ and a message block size of 11.

(10 marks)

(b) Use a worked example to show the number of errors which can be corrected by such a code.

(9 marks)

(c) Show that the corrected code vector of (b) is a valid codeword.

(4 marks)

QUESTION 2

(a) Binary data is transmitted at 20 kbps using amplitude shift keying (ASK). Given that the additive noise power is 10^{-12} W/Hz, the received carrier amplitude is 10^{-3}V and the carrier frequency is 20 MHz;

(i) design a coherent detector and calculate its bit error rate.

(11 marks)

(ii) design an incoherent detector and calculate its bit error rate.

(4 marks)

(b) The connection vectors representing a convolutional encoder are as follows:

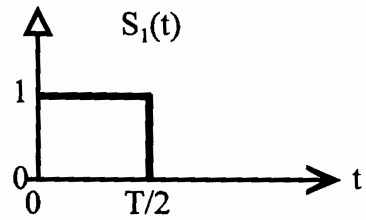
G1 = [1 1 0]
G2 = [0 1 1]
G3 = [1 1 1]

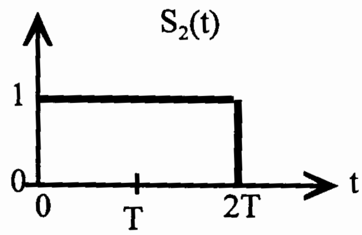
Determine the output sequence, given that the message vector $\overline{m} = [110]$

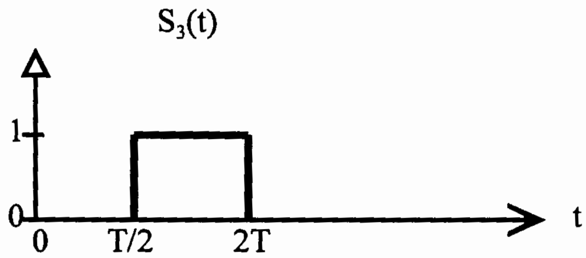
(11 marks)

QUESTION 3

(a) Compute a set of orthonormal basis functions, given the following set of signals:







(15 marks)

(b) Give the signal vector for each signal and (5 marks)

(c) evaluate by expanding it in terms of the basis functions. (5 marks)

QUESTION 4

(a) A source emitting 1000 symbols per second, produces one of three possible independent symbols a,b, or c with probabilities 0.7, 0.2 and 0.1 respectively during successive signaling intervals. Compute the redundancy of the source.

(10 marks)

(b) The general expressions for evaluating the probability of error for binary signaling can be given as $Pe = Q\left(\frac{V_T}{\sigma}\right)$ and $Pe = Q\left(\sqrt{E_d/_{2No}}\right)$ for either a low pass filter or a matched filter reception respectively. Derive the P_e expressions for NRZ unipolar signaling

(i) in terms of the average signal power to average noise power when a LPF is used at the reception and

(9 marks)

(ii) when a matched filter receiver is used (Pe in terms of E_b/N_o).

(6 marks)

QUESTION 5

(a) The 103/113 FDX modem has a 1170-Hz VCO deviated ± 100 Hz for the originate mode and a 2125 - Hz VCO deviated ± 100 Hz for the answer mode.

With the aid of a well labeled diagram, show how the modem frequencies can be accommodated in the telephone audio bandpass channel.

(5 marks)

(b) Explain, with the aid of a well labeled diagram, how an FSK signal can be generated. (5 marks)

(c) A coherent binary phase-shift keying (PSK) system has a transmit signal given as

$$S(t) = \pm\sqrt{\frac{2E_b}{T_b}}\,Cos(\omega_c t) \qquad \text{for}$$

$0 \le t < T$. The plus sign is for message m_1 and minus sign for message m_2. E_b is the transmitted signal energy per bit, f_c is the carrier frequency and T_b is the bit period.

(i) Determine the coordinates of the message points for the given PSK signal.

(10 marks)

(ii) Present the corresponding signal space diagram.

(3 marks)

(iii) Assuming an additive white Gaussian noise (AWGN) channel, how can you decide on which one of the two signals was sent?

(2 marks)