University of Swaziland
Faculty of Science
Department of Electrical and Electronic Engineering

Main Examination 2012

Title of Paper: Digital Communications

Course Number: E530

Time Allowed: 3 hrs

Instructions:

1. Answer any four (4) questions.
2. Each question carries 25 marks.
3. Useful information is attached at the end of the question paper

This paper should not be opened until permission has been given by the invigilator.

This paper contains seven (7) pages including this page.

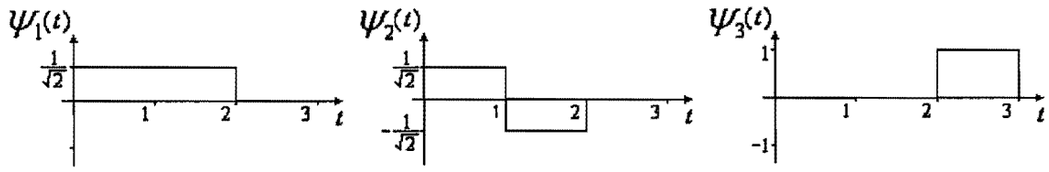
Question 1

(a) Draw a block diagram showing the basic elements of a digital communication system and also explain the function of each block element.

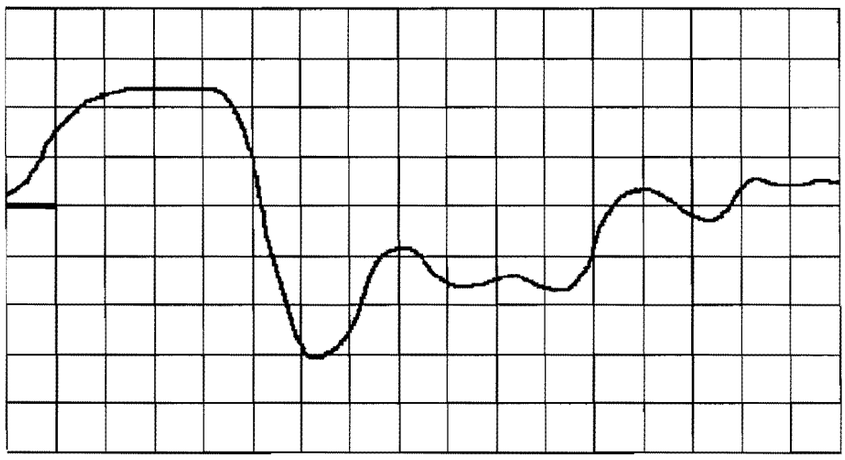
[6]

(b) Show that the following set is orthogonal and determine their individual energies.

[12]



(c) For the following signal, determine the binary stream coming out from adaptive-delta modulator that has two levels. Binary 1 indicates a rise and 0 indicates a fall. Grid steps correspond to small delta and $\Delta 2 = 2\Delta 1$. [5]



(d) A binary source continuously transmits the symbols 0111. Binary 0 and 1 are represented by -1 and +1 Volts on the transmission line. Show the DC buildup on a capacitive load.

[2]

Question 2

For a (6,3) systematic linear block code, the three parity check digits c_4, c_5 and c_6 are:

$$c_4 = b_1 + b_2 + b_3$$
$$c_5 = b_1 + b_2$$
$$c_6 = b_2 + b_3$$

(a) Construct the appropriate generator matrix for this code. [3]
(b) Construct the code generated by this matrix. [8]
(c) Determine the error-correcting capabilities of this code. [2]
(d) Prepare a suitable decoding table. [8]
(e) Decode the following received word: 101100 [4]

Question 3

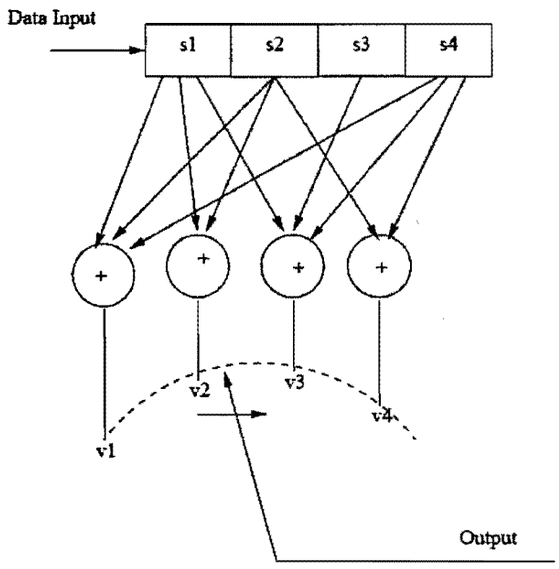
(a) Binary data is transmitted at a rate of 10^6 bits per second over a channel having a bandwidth of 3 MHz. Assume that the noise power spectral density at the receiver is $10^{-10} W/Hz$. Find the average carrier power required at the receiver input for coherent PSK signalling scheme to maintain $P_e = 10^{-4}$. [8]

(b) Consider the source $S = \{s_1, s_2, s_3\}$ with $P(s_1) = \frac{1}{2}$, $P(s_2) = P(s_3) = \frac{1}{4}$. Calculate the entropy of the second extension of S. [10]

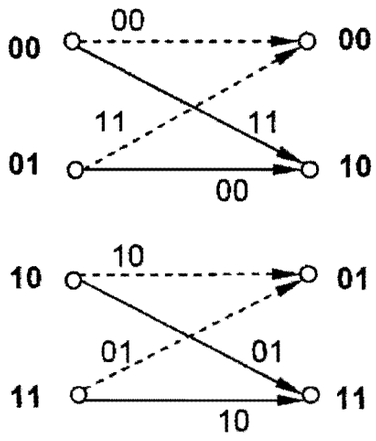
(c) A discrete source emits one of five symbols once every millisecond. The symbol probabilities are $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$ and $\frac{1}{16}$, respectively. Find the source entropy and information rate. [7]

Question 4

(a) Draw the code tree for the convolutional encoder shown in the figure below and determine the output digit sequence for the data digits: 1101011000. [20]



(b) Draw the state machine of the encoder with the following state transition graph. [5]



Question 5

(a) A frequency hopping digital communication system operates in 2.4-2.48 GHz ISM band with 8 hopping channels (10 MHz BW each, including the guard spacing). At each channel, 8-ary FSK is employed. System operates at 2 khops/s and transmits 8 symbols at each hopping channel. Calculate the bit rate. [3]

(b) If the bipolar input signal has maximum value of 1.0 V and the code words are eight bits long. Calculate the quantisation interval. [3]

(c) V.32bis modems can send data at 14400 bit/s. The modems operate on the assumption that the bandwidth of the telephone line is 2400 Hz. Using this bandwidth and a signal-to-noise ratio of 1500, calculate the theoretical channel capacity of the telephone line. What percentage of the theoretical channel capacity is achieved by a V.32bis modem? [5]

(d) Differentiate between Continuous ARQ with pullback and Continuous ARQ with selective repeat. [2]

(e) A receiver has a noise power bandwidth of 10 kHz. A resistor that matches the receiver input impedance is connected across its antenna terminals. What is the noise power contributed by that resistor in the receiver bandwidth, if the resistor has a temperature of 27°C? [4]

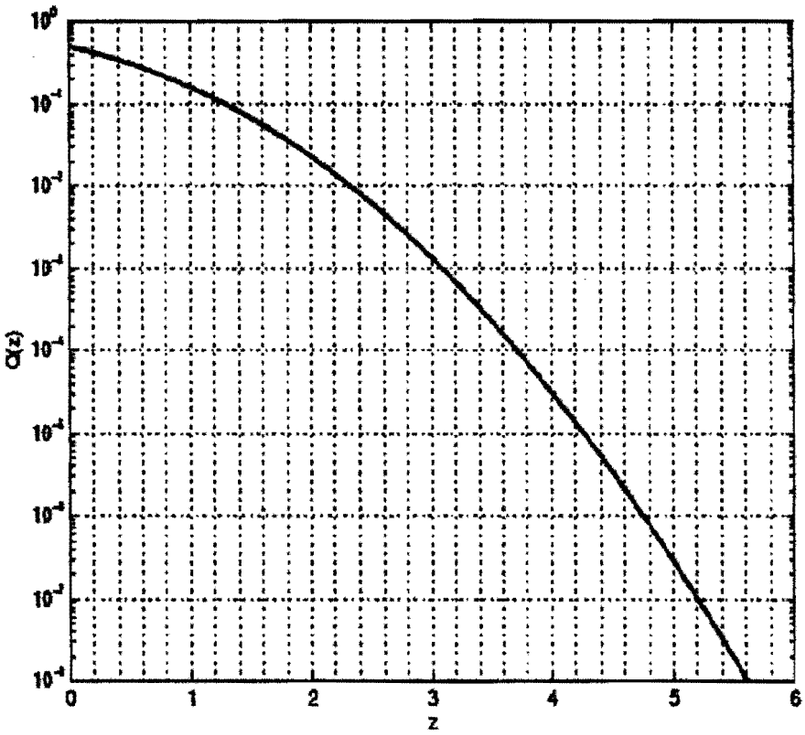
(f) Given a bandwidth of 5000Hz for an 8-PSK signal, what are the baud rate and bit rate? [4]

(g) Find the minimum bandwidth for an FSK signal transmitting at 2000 bps. Transmission is in half-duplex mode, and the carriers are separated by 3000Hz. [4]

Useful Information

- Boltzmann's constant = 1.38×10^{-23} *joules / kelvin*(J/K)

- Q-function



$$Q(x) = \int_{x}^{\infty} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du$$

Q(x)

x	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2168	0.2148
0.8	0.2169	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
	0.0446	0.0436	0.0427	0.0418.	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002