Indian Institute of Technology, Kharagpur

End-semester Examination, Spring : 2008-09

Dept. of E & ECE

Subject: Digital Communications (EC31002)

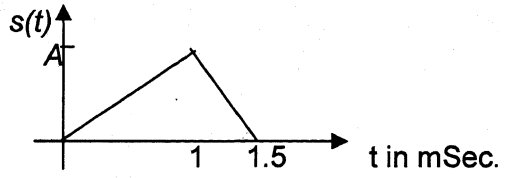
(For 3rd year B.Tech. students of the Depts of E&ECE and EE)

Date: Full Marks: 50

Time: 3 hours

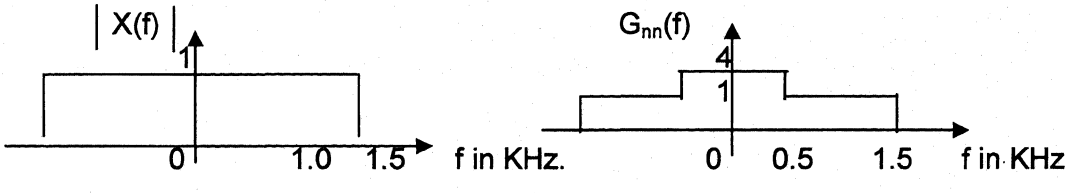
Answer question no. 1 and any four of the rest. Marks for each question are indicated on the right side.

1. Give short answers to the following questions.
   a) Explain how mutual information is useful in communications system. 1
   b) Give the constellation diagram of a 16 - QAM signal and give the no. of amplitudes the modulated carrier will possess. 2
   c) Compare the bandwidth requirements in ASK, FSK, BPSK and QPSK given the bit rate of the signal as 64 kbps 2
   d) Give the expressions for optimal terminal filters and explain how they help in obtaining optimum transmission performance 2
   e) Give and plot the psd of a BASK modulated pseudo random binary sequence. 1
   f) Draw the optimum detector for detecting s(t) in white noise 2



2. (a) Design a uniform quantizer for broadcasting quality video which is unipolar and uniformly distributed with rms value = 1 v, to satisfy the following specifications: minimum SNR required = 40 dB. Also find the bit rate if 4 Msps is used for sampling. 3
   (b) Give the ITU-T digital hierarchy for telephone voice transmission giving the standard bit rates and explaining the operation. 3
   (c) Derive an expression for obtaining the gain in a DPCM speech coder. 4

3. (a) Given the signal spectrum X(f) and noise psd, $G_{nn}(f)$ as shown below and that the channel is distortion-free find the matched filter response, the optimum detector for the signals and the optimum SNR that can be obtained. 4



   (b) Find the noise equivalent bandwidth of an RC LPF.of cutoff frequency. = 8 KHz. 2
   (c) Explain the operation of a carrier synchronizer with neat diagrams. 2
   (d) How is a channel equalizer made to track the variations of a communication channel? 2

4. (a) Give the optimum detector for QPSK signals. Given the bit error probability of BPSK as $Q([2E/\eta]^{0.5})$, extend the same to derive the expression for probability of error for QPSK. Explain briefly how PSK is different from QAM. 5
   (b) A 64 kbps communication system uses BPSK modulation with rectangular pulse

shapes for transmission over a channel of 10 Km distance. Design the link for a bit error probability of less than 1×10^{-5}, given that the noise temperature of the receiver as 1000^0K. ($k=1.38 \times 10^{-23}$ units and the channel attenuation as 10 dB/KM. You may use the Q-function table given at the end of the question paper). 5

5. a) A frame synchronizer uses a 24 bit synch word. Derive the probability of misdetection, given the probability of error as p_e and that the threshold as 22. 2
   b) Explain with neat diagrams about how a BPSK transceiver can be implemented using digital hardware. Given the bit rate as r bps and carrier frequency as f_c find the computational complexity of hardware when the, sampling frequency is f_s. 4
   c) The probability of error in a 64 Kbps binary communication system and a channel is 1×10^{-6}. Find the probability of error when a (12, 8) single error correcting code is applied to the signal. Find the permissible bit rate if the channel transmission rate is fixed at 64 Kbps. How much would have been the probability of error if the system uses the reduced bit rate with the transmitter power constrained (You may use the Q-function table given at the end of the question paper). 4

6. a) A communication source generates 8 different symbols at the rate of 8 ksps with the probability of occurrence of the symbols given by $p(0) = 1/2$, $p(1) = 1/4$, $p(2) = 1/8$, $p(3) = 1/16$, $p(4) = 1/32$, $p(5) = 1/64$, $p(6) = 1/128$ and $p(7) = 1/128$. Give an efficient entropy coding scheme for the symbols, find its efficiency and the channel bandwidth requirement for BPSK transmission. 5
   a) Find about at what maximum bit rate binary data can be transmitted over a 64 KHz channel with SNR = 30 dB. How to transmit data at such a rate 3
   b) Explain how Convolutional coding is done and give its advantages over the block codes. 2

Q-Function Table:

x	Q(x)	x	Q(x)	x	Q(x)	x	Q(x)
5.0	.0228	3.0	.0013	3.5	.00023	4.0	.00003
2.5	.0139	3.1	.001	3.6	.00016	4.27	.00001
3.6	.0082	3.2	.00069	3.7	.0001	4.78	.000001
2.6	.0047	3.3	.00048	3.8	.00007		
2.8	.0026	3.4	.00034	3.9	.00005		

Table - III : Cumulative Standard Normal Distribution

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-u^2/2}\, du$$

z	0.00	0.01	0.02	0.03	0.04
0.0	0.50000	0.50399	0.50798	0.51197	0.51595
0.1	0.53983	0.54379	0.54776	0.55172	0.55567
0.2	0.57926	0.58317	0.58706	0.59095	0.59483
0.3	0.61791	0.62172	0.62551	0.62930	0.63307
0.4	0.65542	0.65910	0.62276	0.66640	0.67003
0.5	0.69146	0.69497	0.69847	0.70194	0.70540
0.6	0.72575	0.72907	0.73237	0.73565	0.73891
0.7	0.75803	0.76115	0.76424	0.76730	0.77035
0.8	0.78814	0.79103	0.79389	0.79673	0.79954
0.9	0.81594	0.81859	0.82121	0.82381	0.82639
1.0	0.84134	0.84375	0.84613	0.84849	0.85083
1.1	0.86433	0.86650	0.86864	0.87076	0.87285
1.2	0.88493	0.88686	0.88877	0.89065	0.89251
1.3	0.90320	0.90490	0.90658	0.90824	0.90988
1.4	0.91924	0.92073	0.92219	0.92364	0.92506
1.5	0.93319	0.93448	0.93574	0.93699	0.93822
1.6	0.94520	0.94630	0.94738	0.94845	0.94950
1.7	0.95543	0.95637	0.95728	0.95818	0.95907
1.8	0.96407	0.96485	0.96562	0.96637	0.96711
1.9	0.97128	0.97193	0.97257	0.97320	0.97381
2.0	0.97725	0.97778	0.97831	0.97882	0.97932
2.1	0.98214	0.98257	0.98300	0.98341	0.98382
2.2	0.98610	0.98645	0.98679	0.98713	0.98745
2.3	0.98928	0.98956	0.98983	0.99010	0.99036
2.4	0.99180	0.99202	0.99224	0.99245	0.99266
2.5	0.99379	0.99396	0.99413	0.99430	0.99446
2.6	0.99534	0.99547	0.99560	0.99573	0.99585
2.7	0.99653	0.99664	0.99674	0.99683	0.99693
2.8	0.99744	0.99752	0.99760	0.99767	0.99774
2.9	0.99813	0.99819	0.99825	0.99831	0.99836
3.0	0.99865	0.99869	0.99874	0.99878	0.99882
3.1	0.99903	0.99906	0.99910	0.99913	0.99916
3.2	0.99931	0.99934	0.99936	0.99938	0.99940
3.3	0.99952	0.99953	0.99955	0.99957	0.99958
3.4	0.99966	0.99968	0.99969	0.99970	0.99971
3.5	0.99977	0.99978	0.99978	0.99979	0.99980
3.6	0.99984	0.99985	0.99985	0.99986	0.99986
3.7	0.99989	0.99990	0.99990	0.99990	0.99991
3.8	0.99993	0.99993	0.99993	0.99994	0.99994
3.9	0.99995	0.99995	0.99996	0.99996	0.99996

Table - III : *(continued)*

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-u^2/2}\, du$$

z	0.05	0.06	0.07	0.08	0.09
0.0	0.51994	0.52392	0.52790	0.53188	0.53586
0.1	0.55962	0.56356	0.56749	0.57142	0.57534
0.2	0.59871	0.60257	0.60642	0.61026	0.61409
0.3	0.63683	0.64058	0.64431	0.64803	0.65173
0.4	0.67364	0.67724	0.68082	0.68438	0.68793
0.5	0.70884	0.71226	0.71566	0.71904	0.72240
0.6	0.74215	0.74537	0.74857	0.75175	0.75490
0.7	0.77337	0.77637	0.77935	0.78230	0.78523
0.8	0.80234	0.80510	0.80785	0.81057	0.81327
0.9	0.82894	0.83147	0.83397	0.83646	0.83891
1.0	0.85314	0.85543	0.85769	0.85993	0.86214
1.1	0.87493	0.87697	0.87900	0.88100	0.88297
1.2	0.89435	0.89616	0.89796	0.89973	0.90147
1.3	0.91149	0.91308	0.91465	0.91621	0.91773
1.4	0.92647	0.92785	0.92922	0.93056	0.93189
1.5	0.93943	0.94062	0.94179	0.94295	0.94408
1.6	0.95053	0.95154	0.95254	0.95352	0.95448
1.7	0.95994	0.96080	0.96164	0.96246	0.96327
1.8	0.96784	0.96856	0.96926	0.96995	0.97062
1.9	0.97441	0.97500	0.97558	0.97615	0.97670
2.0	0.97982	0.98030	0.98077	0.98124	0.98169
2.1	0.98422	0.98461	0.98500	0.98537	0.98574
2.2	0.98778	0.98809	0.98840	0.98870	0.98899
2.3	0.99061	0.99086	0.99111	0.99134	0.99158
2.4	0.99286	0.99305	0.99324	0.99343	0.99361
2.5	0.99461	0.99477	0.99492	0.99506	0.99520
2.6	0.99598	0.99609	0.99621	0.99632	0.99643
2.7	0.99702	0.99711	0.99720	0.99728	0.99736
2.8	0.99781	0.99788	0.99795	0.99801	0.99807
2.9	0.99841	0.99846	0.99851	0.99856	0.99861
3.0	0.99886	0.99889	0.99893	0.99897	0.99900
3.1	0.99918	0.99921	0.99924	0.99926	0.99929
3.2	0.99942	0.99944	0.99946	0.99948	0.99950
3.3	0.99960	0.99961	0.99962	0.99964	0.99965
3.4	0.99972	0.99973	0.99974	0.99975	0.99976
3.5	0.99981	0.99981	0.99982	0.99983	0.99983
3.6	0.99987	0.99987	0.99988	0.99988	0.99989
3.7	0.99991	0.99992	0.99992	0.99992	0.99992
3.8	0.99994	0.99994	0.99995	0.99995	0.99995
3.9	0.99996	0.99996	0.99996	0.99997	0.99997