MANSOURA UNIVERSITY	Final 2013	3rd. YEAR COMM. ENGINEERING
FACULTY OF ENGINEERING	Prof. F.W.ZAKI	COMMUNICATIONS THEORY (2)
DEPT. OF ELECT. & COMM. ENG.		TIME ALLOWED = 3 HRS

Answer ALL questions (Note: total mark =100 distributed equally on the questions)

I- a)The channel capacity may be expressed as C = r where r is the symbol rate to be transmitted. However, as a result of noise, a 0 may be mistaken for a 1 and vice versa. For BSC the probabilities of making these two types of error are equal and designated as p. Prove mathematical expression for the net channel capacity in terms of r and p. Draw the relation between the channel capacity and p for values of $0 \le p \le 1$.

b) A roving vehicle equipped with a colour T.V. camera is used for the exploration of the surface of Mars. The T.V. pictures will be digitized for transmission back to earth. The Mars-to-earth link is a microwave radio system with carrier frequency $f_c = 4GHz$ and path length $= 3.5 \times 10^8\ Km$. The transmitter on the board of the vehicle delivers 30W of signal power to a dish antenna 0f 0.5 meter in diameter. The earth station receiver has a 25m dish antenna and low noise receiver with $T_{eq} = 60K^o$. The digitized picture consists of 512x512 pixels, each pixel having one of 128 possible brightness levels. If the channel bandwidth is assumed unrestricted, calculate:

i) Path loss $(L_p), A_t, A_r$, and received signal power (S_r), ii) Channel capacity, iii) Time required to transmit one picture, and iv) net BER if the modulation scheme used is either PRK or 8-PSK and same transmitted power.

II-a) Binary NRZ data signal of amplitudes $\pm A/2$ are transmitted over a transmission channel using M repeaters. Assuming additive Gaussian noise with zero mean and variance σ^2 is present at the input of each repeater, i- Prove Mathematical expressions for BER if either analog repeaters or regenerative repeaters are used, ii- For a matter of comparison, compute the net BER if M=20 in each type with $A/2\sigma$=4, and iii- Estimate the additional transmitted power (in dB) required in the case of analog repeaters to give the same net probability of error as a system in which regenerative repeaters are used.

b) A BPSK with pilot carrier system transmits the following signal:

$\phi(t) = mASin\omega_c t \pm A\sqrt{1-m^2}Cos\omega_c t \quad ; \quad 0 \le t \le T_b$, where m is a modulation index.

i- Prove mathematical expression for probability of error if additive Gaussian noise with zero mean and two-sided power spectral density of $\eta/2$ is present on the transmission channel (use matched filter receiver).

ii-Suppose that 25% of the transmitted signal power is allocated to the carrier component, estimate E_b/η required to realize a probability of error equal to 10^{-6}, and iii- Compare this value of E_b/η with that required for conventional PRK system for the same probability of error.

III-a) In the European E1-Telephone system, 32 voice channels are converted to binary PCM and then time-division-multiplexed (TDM). Each telephone signal with a bandwidth of 4 KHz is sampled at the Nyquist rate and PCM encoded. The maximum acceptable error in the sample amplitude (max. quantization error) is 0.5% of the peak amplitude $X_{Max.}$ and the quantized samples are binary coded. The data are transmitted in a form of frames, each frame consists of 32 multiplexed samples from the voice signals plus one bit at the end of each frame for synchronization. Determine: i- the frame rate, ii- the data rate, iii- the bandwidth (assuming NRZ code), iv- Compare the resulting bandwidth with that of the Bell Telephone T-1 system having similar specification except the number of channels are 24 voice channels.

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b) Suppose a digital binary source emits an on-off pulses at a rate of 4 Mbps for transmission over a channel corrupted with additive Gaussian noise with zero mean and $\eta = 2\times10^{-8} W/Hz$. The error rate is specified to be no greater than 24 bits per hour. Prove an expression for the probability of error if a decision threshold detector is used, then calculate numerical value for the amplitude of the received pulse.

IV-a) Matched filter is commonly used for detection in digital communication systems due to the fact that it maximizes the ratio $\dfrac{\left|f_o^2(t_m)\right|}{\overline{n_o^2(t)}}$. Starting from this statement, derive mathematical expressions for the filter impulse response, transfer function, outputs $f_o(t_m)$ and $\overline{n_o^2(t)}$.

b) Design a digital communication system to carry a data rate of 120 Mbps in the presence of additive Gaussian noise with one-sided power spectral density corresponding to equivalent noise temperature of 229 K°, total path and system losses of 140dB, a BER of 10^{-7} and modulation scheme of PRK. For your design estimate the expected transmitted and received power. Estimate the BER if FSK (orthogonal frequency separation), or QPSK or 8PSK were used instead of PRK. Estimate also the added transmitter power (in dB) required for 8PSK to provide the same performance as PRK.

V-a) The parity check bits for (7, 3) linear block code are given by :

$$C_1 = a_1 \oplus a_2,\ C_2 = a_2 \oplus a_3,\ C_3 = a_1 \oplus a_2 \oplus a_3 \quad and \quad C_4 = a_1 \oplus a_3$$

i- Determine the generation matrix G, the parity check matrix H. ii- Estimate the syndrome for the three received code words R1=1111001, R2=1011011, R3=0110001 and correct the incorrect words. iii- Draw block diagrams for electronic implementation of both encoder and decoder for the above code.

b) Design a communication link to carry the information rate of 90 Mbps to a satellite transponder operating at 14/12 GHz frequency band. The up-link parameters are: earth station TWT output power is 30dB, $L_{bo} = 2dB$, $L_{bf} = 2dB$, earth station parabolic dish transmit antenna with diameter = 12m, satellite T_e is 800K°, distance between earth station and transponder = 35×10^3 Km, free space path loss for 14GHz, additional path loss = 1dB, modulation scheme is 8-PSK, the transponder receive antenna is a parabolic dish with diameter =0.5m, with $L_{bf} = 0.5dB$. The down-link parameters are: satellite transmitter output power at saturation is 10dB, satellite transmit dish antenna of 0.5m, satellite $L_{bo} = 0.8dB$, $L_{bf} = 0.5dB$, free space path loss for 12GHz, additional path loss = 0.8dB, the earth station receiver antenna is a parabolic dish with diameter =10m, earth station T_e is 250K°, bit rate 90Mbps, 8PSK. Calculate the BER performance of your design if a matched filter receiver with $T_{eq} = 1000K^o$ is recommended.

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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

Table G.1 Values of Erfc (x) vs. x.

x	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
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

Table G.2 Values of Erfc (x) for large x.

x	Erfc (x)	x	Erfc (x)	x	Erfc (x)
3.00	1.35E-03	4.00	3.17E-05	5.00	2.87E-07
3.05	1.14E-03	4.05	2.56E-05	5.05	2.21E-07
3.10	9.68E-04	4.10	2.07E-05	5.10	1.70E-07
3.15	8.16E-04	4.15	1.66E-05	5.15	1.30E-07
3.20	6.87E-04	4.20	1.33E-05	5.20	9.96E-08
3.25	5.77E-04	4.25	1.07E-05	5.25	7.61E-08
3.30	4.83E-04	4.30	8.54E-06	5.30	5.79E-08
3.35	4.04E-04	4.35	6.81E-06	5.35	4.40E-08
3.40	3.37E-04	4.40	5.41E-06	5.40	3.33E-08
3.45	2.80E-04	4.45	4.29E-06	5.45	2.52E-08
3.50	2.33E-04	4.50	3.40E-06	5.50	1.90E-08
3.55	1.93E-04	4.55	2.68E-06	5.55	1.43E-08
3.60	1.59E-04	4.60	2.11E-06	5.60	1.07E-08
3.65	1.31E-04	4.65	1.66E-06	5.65	8.03E-09
3.70	1.08E-04	4.70	1.30E-06	5.70	6.00E-09
3.75	8.84E-05	4.75	1.02E-06	5.75	4.47E-09
3.80	7.23E-05	4.80	7.93E-07	5.80	3.32E-09
3.85	5.91E-05	4.85	6.17E-07	5.85	2.46E-09
3.90	4.81E-05	4.90	4.79E-07	5.90	1.82E-09
3.95	3.91E-05	4.95	3.71E-07	5.95	1.34E-09

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