통신 시스템

중간고사

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- 책이나 노트는 볼 수 없음

1. (10 pts)
   a) Describe the advantages and disadvantages of differential BPSK.
   b) Give the definitions of bandwidth efficiency and energy efficiency. You need to give them both verbally and mathematically.

2. (10 pts)
   a) Describe the Nyquist criterion for no ISI.
   b) Describe the modified duobinary signal.

3. (10 pts) Find the minimum spacing Δf between the frequencies of signals of symbol duration T_s to maintain their orthogonality.

4. (15 pts) In an additive white Gaussian noise channel with noise power-spectral density of $\frac{N_0}{2}$, the transmitted signal set consists of two equi-probable messages given by

$$s_1(t) = \begin{cases} \dfrac{At}{T}, & 0 \le t \le T, \\ 0, & \text{otherwise}, \end{cases}$$

$$s_2(t) = \begin{cases} A\left(1 - \dfrac{t}{T}\right), & 0 \le t \le T, \\ 0, & \text{otherwise}. \end{cases}$$

a) Draw the block diagram of the optimal receiver. Give important parameters for each block.

b) Find the average probability of bit error.

c) Using the Q-function table, compute the average probability of bit error when $\frac{\varepsilon_b}{N_0} = 10$ dB.

5. (10 pts) Consider the symbol error probability of M-ary modulation P_M where $M = 2^k$ for an integer k. Assume an equiprobable data source.

a) For M-ary PSK with Gray coding, find the bit error probability P_b with respect to P_M. You can have approximation. Justify your answer.

b) For M-ary FSK, find the bit error probability P_b with respect to P_M.

6. (15 pts) Determine the bit rate that can be transmitted through a 4 KHz voice-band telephone (bandpass) channel if the following modulation methods are used:

a) binary PSK

b) 4-ary PSK

c) 16-ary rectangular QAM

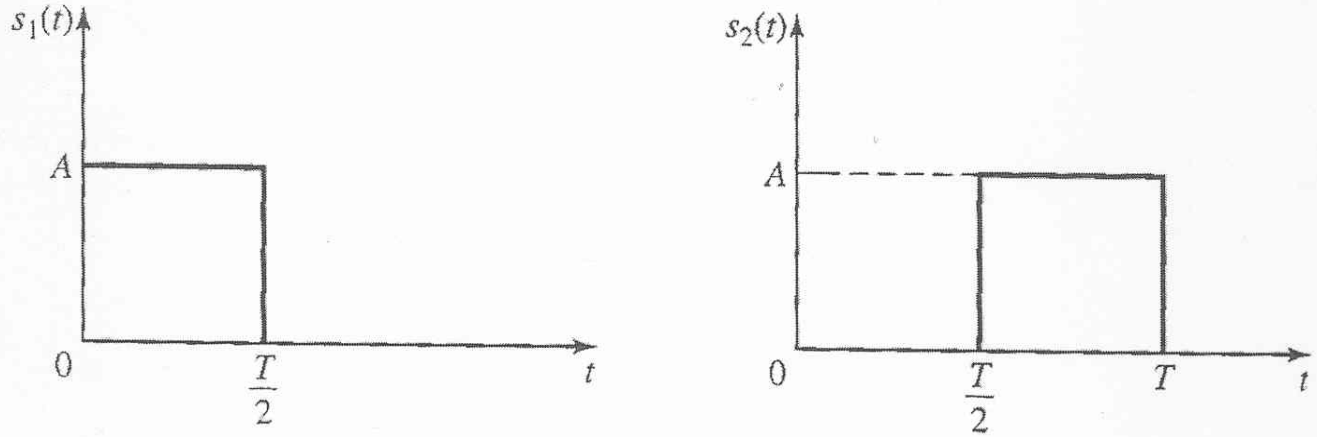
d) binary orthogonal FSK, with noncoherent detection

e) orthogonal 4-ary FSK with noncoherent detection.

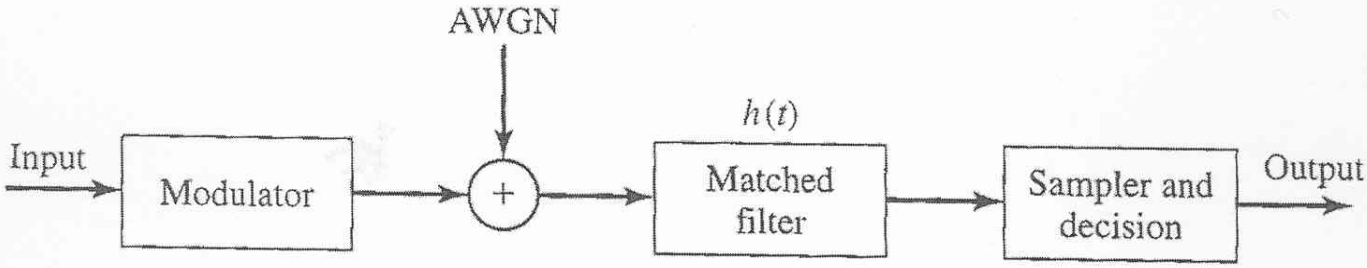
For parts a)-c), assume that the transmitter pulse shape has a raised cosine spectrum with a 50% roll-off and consider null-to-null bandwidth.

For parts c)-e), consider half-power bandwidth.

7. (15 pts) A baseband digital communication system employs the signals shown in Figure 1a) for transmission of two equiprobable messages. Assume that the messages are transmitted just once and no transmission takes place afterwards. The channel has no attenuation and the noise is AWG with power-spectral density $\frac{N_0}{2}$.



(a)



(b)

Figure 1

a) Find an appropriate orthonormal basis for the representation of the signals.

b) Find the error probability of the optimal receiver.

c) Show that the optimal receiver can be implemented by using just one filter [see block diagram shown in Figure 1b)]. Design the characteristics of the matched filter, the sampler, and decision device

d) Assume the channel is not ideal, but has an impulse response of $c(t)=\delta(t)+\frac{1}{2}\delta\left(t-\frac{T}{2}\right)$. Using the same matched filter you used in the previous part, design an optimal receiver.

e) Assuming that the channel impulse response is $c(t)=\delta(t)+\alpha\delta\left(t-\frac{T}{2}\right)$, where α is a random variable uniformly distributed on [0,1], and using the same matched filter, design the optimal receiver.

8. (15 pts) A binary antipodal signal with signal energy ε_b and interval T is transmitted over a nonideal bandlimited channel which introduces ISI over two adjacent symbols. For an isolated transmitted signal pulse $s(t)$, the (noise-free) output of the demodulator is $\sqrt{\varepsilon_b}$ at $t=T$, $\frac{\sqrt{\varepsilon_b}}{4}$ at $t=2T$, at zero for $t=kT$, $k>2$. Assume that the two signals are equally probable and the channel has additive noise white Gaussian noise. Find the average probability of bit error.

TABLE B.1 Complementary Error Function $Q(x)$

	$Q(x)$									
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
1.7	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	0.0094	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002