

WIRELESS COMMUNICATIONS I (521320S)

1. Intermediate exam 25.10.2013 (Based on parts 1-6 of the course, answer in English or in Finnish, no material is allowed)

1. a) You are using 4-level PSK in your system. How many bits you send in symbol? How many base functions are needed in this case to present the signal in signal space, and what are the properties of base functions? How do you find out the position of sent signal in signal space? (4 p)
b) You have to calculate the spectrum of digitally modulated signal. How do you obtain the results and which factors have effect on the spectrum? (2 p)
2. a) Compare roughly the bit error rate performances of coherent binary PSK and FSK modulations in AWGN channel (no need for equations).
b) Present the principle of differential PSK. Compare the performance with coherent one.
3. a) Assume that error rate equation $P_b(\gamma)$ for used modulation method in AWGN channel is known. How it is obtained error rate in fading channel?
b) What means diversity and what methods exist?
c) What kind of combining methods exists and which one has the best performance?
4. For a multipath fading channel let a scattering function $S_c(\tau, \rho)$ is nonzero over $0 \leq \tau \leq 10 \mu\text{s}$ and $-3000 \leq \rho \leq 3000 \text{ Hz}$. Assume that the power of the scattering function is approximately uniform over the range where it is nonzero.
a) What are the multipath spread and the Doppler spread of the channel? Explain what the meaning of these spreads is.
b) Suppose you input to this channel two identical sinusoids. What is the minimum value of Δf for which the channel response to the first sinusoid is approximately independent of the channel response to the second sinusoid? Explain you answer.
c) For two sinusoidal inputs to the channel $u_1(t) = \sin 2\pi f t$ and $u_2(t) = \sin 2\pi f (t + \Delta t)$, what is the minimum value of Δt for which the channel response to $u_1(t)$ is approximately independent of the channel response to $u_2(t)$? Explain you answer.
d) Will this channel exhibit flat fading or frequency-selective fading for channel with a 2 kHz bandwidth? How about for a channel with a 400 kHz bandwidth? Explain you answer.
e) Assume that $BT_s \approx 1$. Is there fast fading, if we use these bandwidths? Explain you answer.
5. You are travelling from Rovaniemi to Helsinki without any hurry in four days. In the map in Fig. 1, you can find the possible routes. You will stay overnight as follows:
 1. night: Oulu or Kuusamo
 2. night: Vaasa or Joensuu
 3. night: Turku or Tampere.Select the **shortest** route using **Viterbi algorithm** (4 p). Draw enough intermediate steps so that the Viterbi algorithm idea can be easily seen. What is the length of the route (1 p) and which places you will visit (1 p)?

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Final exam 25.10.2013 (Based on all parts of course, answer in English or in Finnish, no material is allowed)

1.
 - a) You are using 4-level PSK in your system. How many bits you send in symbol? How many base functions are needed in this case to present the signal in signal space, and what are the properties of base functions? How do you find out the position of sent signal in signal space? (4 p)
 - b) You have to calculate the spectrum of digitally modulated signal. How do you obtain the results and which factors have effect on the spectrum? (2 p)
2.
 - a) What are the performance measures for synchronization algorithms and what is meant with efficient estimate? (2 p)
 - b) Explain decision feedback equalizer (principle, functioning and block diagram). (4 p)
3.
 - a) Assume that error rate equation $P_b(\gamma)$ for used modulation method in AWGN channel is known. How it is obtained error rate in fading channel?
 - b) What means diversity and what methods exist?
 - c) What kind of combining methods exists and which one has the best performance?
4. A CDMA system consists of 10 equal-power users that transmit information at a rate 20 kbits/s, each using a DS spread spectrum signal operating at a chip rate of 1 MHz. The modulation is binary PSK.
 - a) Determine the ϵ_b/J_0 , where J_0 is the spectral density of the combined interference.
 - b) What is the processing gain?
 - c) How much should the processing gain be increased to allow for doubling the number of users without affecting the output SNR?
5. You are travelling from Rovaniemi to Helsinki without any hurry in four days. In the map in Fig. 1, you can find the possible routes. You will stay overnight as follows:
 1. night: Oulu or Kuusamo
 2. night: Vaasa or Joensuu
 3. night: Turku or Tampere.Select the **shortest** route using **Viterbi algorithm** (4 p). Draw enough intermediate steps so that the Viterbi algorithm idea can be easily seen. What is the length of the route (1 p) and which places you will visit (1 p)?

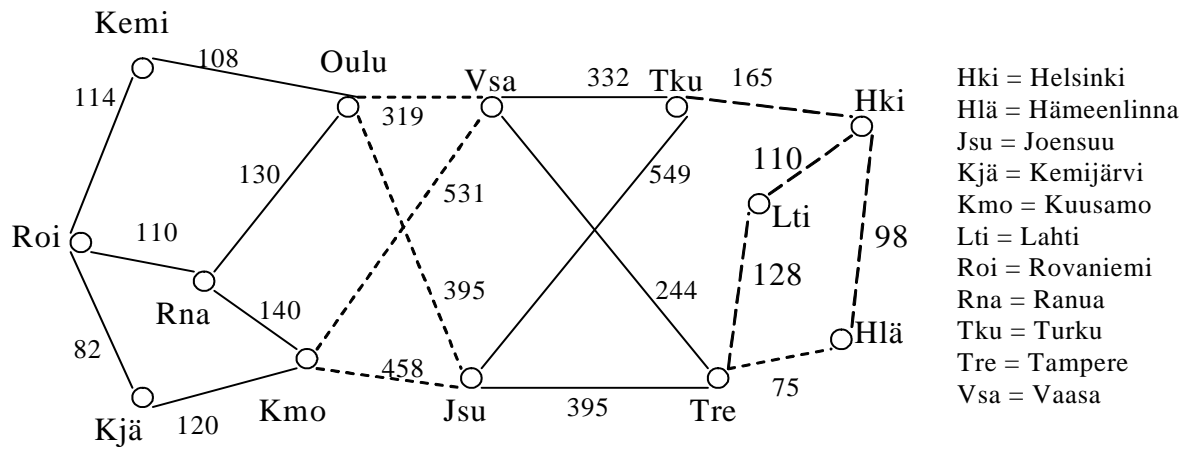


Fig. 1.

TABLE B.1 Complementary Error Function $Q(x) = \int_x^\infty (1/\sqrt{2\pi}) \exp(-u^2/2) du$

x	Q(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	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002