Exam in TSKS13 Wireless Communications

LINKÖPING UNIVERSITY

Date:	2017-03-16 **Time:** 08.00-12.00
Teacher:	Danyo Danev, tel: 013-281335
Place:	TER1
Allowed aids:	
Part A:	No aids allowed except pocket calculators.
Part B:	The course book "Principles of Wireless Communications", mathematical tables and handbooks, lecture notes, dictionaries, pocket calculators.
Instructions:	Start by answering the questions in part A. Usually 2-3 sentences are enough to correctly answer these questions. No helping aids (besides pocket calulator) will be allowed for part A. After handing in the part A answers you'll get the problems of part B and you'll be able to use the aids according to the list above.
Grading:	Each correctly answered question in part A yields 0.5 points. Each correctly solved problem in part B yields 5 points. For grade 3 you need 11 points with at least 2 points on part A, for grade 4 you need 16(3) points, for grade 5 you need 21(3.5) points. Sloppy solutions and solutions that are hard to read are subject to hard judgement, as are unreasonable answers.
Language:	Solutions in both english and swedish are accepted.
Project work:	Gives extra $0-4$ points to part B.
Solutions:	Will be published after the exam at http://www.commsys.isy.liu.se/en/student/kurser/tentor?TSKS13
Grading list:	A preliminary grading list will be send to all registered for the exam no later than 2017-03-30. Others can get information about the results from the course leader or at the exam return.
Exam return:	2017-04-04, kl. 12.15-12.45 in Hammingrummet, house B, entrance 27-29, 2nd floor, corr. A.
Complaints:	No later than 2017-04-04.
Exam code:	TEN1
Department:	ISY
Exam visits:	Around 09.30 and 11.00

Good luck!

PART A

A.1 Why do we have to use interleaving in connection to forward error-correction (FEC) for wireless transmissions?

A.2 When can we assume that we have transmission under "free-space conditions"?

A.3 What is the difference between the pure and slotted ALOHA random-access technique? Which of these two techniques is to be preferred in terms of throughput?

A.4 State the definitions for the notions *service area* of a mobile cellular system and *coverage area* of a Radio Access Port (RAP).

A.5 Give general definitions for coherence bandwidth, coherence time and WSSUS channel.

A.6 What is the efficiency of a selective-repeat ARQ scheme which exploits error-detecting code of rate 3/4 and the probability for acceptance of a received packet is 90%?

A.7 What is the difference between the maximal ratio and equal gain combining diversity methods? Provide some advantages for each of the methods.

A.8 In the WiFi standard the OFDM technique is used with IFFT/FFT of length 64. The bandwidth of the signal is 20 MHz and 12 of the sub-carriers are used to create a guard band between the different channels. Four sub-carriers are used for channel estimation. Every sub-carrier is modulated using 16-QAM. An error-correcting code of rate 3/4 is utilised for improving the quality of the link. The guard time interval is 25% of the length IFFT/FFT-period. The sampling rate is $2 \cdot 10^7$ samples/s. What is the information data rate?

A.9 A cellular network is regular symmetric hexagonal structure. The cells have radius $R = 1$ km. What is the reuse distance D if the network splits the available channels into $K = 12$ channel groups?

A.10 Define the parameter spectral efficiency for a communication link and provide a unit in which it can be measured!

PART B

B.1 A base station in a cellular network uses transmitter of power 20 W. The downlink carrier frequency is 950 MHz and the BS antenna is mounted at 60 m elevation. The antenna gain is 10 dBi. A mobile user is at 5 km distance from the BS antenna and walks on a bridge such that the mobile unit's half-wave dipole antenna is 5 m above the ground. The mobile unit's has a receiver which has system noise factor of 6 dB and the signal bandwidth is 200 kHz. Assume plane-earth propagation!

a) What is the SNR at the mobile? (2 p)

b) If the base station antenna is lowered to 40 m, how will this affect the SNR? (1 p)

c) Let the required SNR for successfull reception be 40 dB. What is the maximum distance at which the mobile user can communicate with the BS? Assume that all other parameters are the same as above (BS antenna height is 60 m)! (2 p)

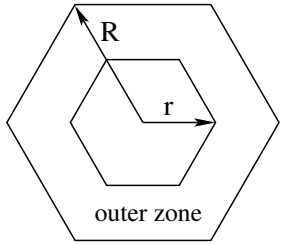
B.2 A transmission link utilises binary FSK modulation with non-coherent detection. The fading radio channel which is also disturbed by AWGN. The distribution of the received power is such that the density function of the received SNR is

$$p(\gamma) = \begin{cases} \frac{\gamma}{a^2} e^{-\gamma/a}, & \text{if} \quad \gamma \geq 0, \\ 0, & \text{if} \quad \gamma < 0. \end{cases}$$

If the required BER at the receiver is 10^{-3}, calculate the minimal possible mean-SNR γ_0 which fulfils this requirement. (5 p)

B.3 In order to improve the quality of a communication link diversity is used with two branches. The combination technique is switched combining. The two branches are modelled as frequency flat Rayleigh fading channels. They have the same mean-SNR γ_0 and there is no correlation between the received signals on the two branches. The modulation used is binary DPSK with non-coherent detection for both branches. Calculate the value of the switching threshold for which we can obtain the least possible BER! (5 p)

B.4 A cellular communication system utilises a reuse-partitioning scheme with two zones as shown in the figure.



A minimum SIR of 21 dB is required for a good signal quality of reception. The cell radius is $R = 2$ km. The (average) propagation path loss is assumed to be proportional to the fourth power of the distance.

a) Determine the cluster size (number of channel groups) that is required for the outer zone (zone 2)! (2 p)

b) Compute the maximum radius r of the inner zone if we choose to use the cluster size $K = 7$ in the corresponding cell plan! Consider all the interfering RAPs. (2 p)

c) What will be the maximum radius r of the inner zone if only the six nearest interfering RAPs are considered in the approximation of the SIR? The cluster size is again $K = 7$. (1 p)