LINKÖPINGS UNIVERSITET

Exam in TSDT74 Radio Communication

Date:	2014-05-28 **Time:** 14.00-18.00
Teacher:	Danyo Danev, tel: 013-281335
Place:	KÅRA
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.
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?TSDT74
Grading list:	A preliminary grading list will be send to all registered for the exam no later than 2014-06-16. Others can get information about the results from the course leader or at the exam return.
Exam return:	2014-06-18, kl. 12.00-12.30 in Hammingrummet, house B, entrance 29, 2nd floor.
Complaints:	No later than 2014-06-18.

Good luck!

PART A

A.1 How is the constant known as *the impedance of vacuum* defined and what is approximately its value and physical unit.

A.2 What is the value of the power of the distance with which the signal power decays asymptotically (for large distances) according to the Plane Earth model? What is this value for the Free Space propagation model?

A.3 Give general definitions for coherence bandwidth, coherence time and WSSUS channel.

A.4 How is the "effective Earth radius" defined? Which is the main phenomena that is included in its calculation?

A.5 Describe shortly at least two combining techniques for space diversity on receive. Give some advantages and disadvantages for the techniques you have chosen to describe.

A.6 A radio modem uses the OFDM technique with 100 sub-carriers. Every subcarrier is modulated using 64-QAM. An error-correcting code with the parameters $[24, 12, 8]$ is used for improving the quality of the link. The symbol duration is 100μs. What is the information data rate for this modem?

A.7 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%? What is the expected message delay if the round-trip delay is 10 ms and the transmission of one packet takes 45 ms?

A.8 What is the length of the cyclic prefix for an OFDM symbol if the guard time is $T_G = 0.4\ ms$ and the sampling frequency is $f_s = 75\ kHz$?

A.9 Why do we have to introduce time-guard interval in wireless communications? How should the length of this interval be chosen if we assume that we have an WSSUS channel and we want to achieve the purpose of its introduction?

A.10 Describe briefly the differences between convolutional interleaving and block interleaving.

PART B

B.1 A GSM cell is to be set up in the middle of a dense urban area with a path-loss exponent of 4. The carrier frequency used is 980 MHz. The transmit power of the base station antenna is limited to 20 dBW. Assume that we use the statistical model with median path loss to calculate the propagation losses and also assume a free space model for the first 1 meter of propagation. The transmit and receive antennas have gain of 2 dB each. The mobile receiver's noise figure is 6 dB and the required carrier-to-noise-density ratio is 60 $dB-Hz$. What is the coverage radius of the cell if a margin of at least 6 dB is needed at its edge?

B.2 A communication link over a fading channel utilizes BPSK modulation with coherent detection. The instantaneous SNR at the receiver can be modeled as a stochastic variable with the probability distribution function

$$P_\Gamma(\gamma) = 1 - e^{-\gamma/\gamma_0} - \frac{\gamma}{\gamma_0} e^{-\gamma/\gamma_0}$$

for all $\gamma \geq 0$ and 0, otherwise. Successful transmission requires BER of at most 10^{-6}.

a) Prove that the mean-SNR for this channel is $2\gamma_0$. (1 p)

b) Calculate the BER for this link as a function of the half-mean-SNR γ_0. (3 p)

c) Check if a half-mean-SNR of 26 dB satisfies the requirement. Is $\gamma_0 = 27$ dB satisfying it? (1 p)

B.3 A communication link between a base station and a mobile receiver utilizes non-coherent binary FSK modulation and selective-repeat ARQ to transmit messages. The messages have a constant length of 80 bits of which 20 bits are used for error detection. The error detection is assumed to be perfect. The flat Rayleigh fading channel with a mean SNR of 16 dB can be approximated with a Gilbert-Elliott model where the bit error probability is 10% in the bad state and 1% in the good state. The noise can be regarded as independent between successive bits.

a) Assume that the mobile reciever moves very slowly or even stops in the terrain. In the GE-model this results in a probability for switching from bad state to good state of 5%. What is the efficiency of the system? (3 p)

b) Assume instead that the mobile receiver moves very fast in the terrain. What is the efficiency of the system in this case? Assume that the time in the bad state is exactly 1 bit. (2 p)

B.4 Consider a two branches diversity system with the switched combining scheme. More precisely, a branch with good quality (SNR) is chosen and used until the SNR drops below 10 dB. The modulation method is binary DPSK. Assume that the two branches are subject to independent Rayleigh fading channels with the same mean-SNR $\gamma_0 = 10$ dB.

a) Determine the average bit error rate (BER). (2 p)

b) Compute the average BER if the maximum ratio combing scheme is used. Compare this BER with the BER obtained in a). Justify the results! (3 p)