Exam in TSKS13 Wireless Communications

Date:	2018-03-15	**Time:**	14.00-18.00

Teacher: Danyo Danev, tel: 013-281335

Place: G34

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 2018-03-27. Others can get information about the results from the course leader or at the exam return.

Exam return: 2018-03-28, kl. 12.15-12.45 in Hammingrummet, house B, entrance 27-29, 2nd floor, corr. A.

Complaints: No later than 2018-03-28.

Exam code: TEN1

Department: ISY

Exam visits: 15.15 and 16.45

Good luck!

PART A

A.1 What do we mean by "diffraction" when we talk about radiowave propagation?

A.2 A radio modem uses the OFDM technique with 512 sub-carriers. Every subcarrier is modulated using 16-PSK. An error-correcting code with the parameters $[31, 21, 5]$ is used for improving the quality of the link. The symbol duration is 0.4 ms. What is the information data rate for this modem?

A.3 What is the null-to-null bandwidth efficiency of the minimum shift keying (MSK) modulation?

A.4 How do we have to choose the length of the time-guard interval for an OFDM modulated signal if we want to avoid the inter-symbol interference (ISI) caused by the frequency selective WSSUS channel?

A.5 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.6 What is the efficiency of the "go-back-N" ARQ method?

A.7 In a two-branch diversity system using maximal-ration combining, the mean-SNRs for the two branches are 20 dB and 30 dB, respectively. What is the mean-SNR for the whole system?

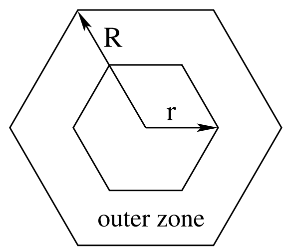
A.8 Name at least four different types of microscopic diversity methods?

A.9 Determine the scattering factor of a WSSUS channel with coherence time 50 ms and delay spread of 150 μs. Is the channel under or over spread?

A.10 A symmetric hexagonal cellular network has a reuse distance $D = 18$ km. Calculate the cell radius R if the network splits the available channels into $K = 27$ channel groups?

PART B

B.1 In a cellular communication system a reuse-partitioning scheme with two zones is used as it is shown in the figure.



A minimum SIR of 13 dB is required for a good signal quality of reception. The cell radius is $R = 8$ km. The (average) propagation path loss is assumed to be proportional to the third power of the distance.

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

b) Compute the maximum radius r of the inner zone if we choose to use the cluster size $K = 4$ in the corresponding cell plan! Consider all the interfering RAPs. (2 p)

c) What will the maximum radius r of the inner zone be if only the six nearest interfering RAPs are considered in the approximation of the SIR? The cluster size is still $K = 4$. (1 p)

B.2 A ground station communicates with a high flying drone. The bandwidth of the used signal is 180 kHz. The transmitted signal is modulated at a carrier frequency of 2.4 GHz and the ground station's antenna has gain 8 dB. This antenna is fed via coaxial cable with 6 dB attenuation. The drone is equipped with a halfwave dipole antenna of gain 2.1 dB which is directly connected to receiver without any attenuation. To get acceptable performance of the link an SNR of 15 dB is needed at the input of the receiver. The receiver has a noise factor of 13 dB and the transmitted power is 40 W. Determine the maximal distance between the drone and the ground station at which the communication can be performed if free space propagation is assumed and the external noise is neglected. (5 p)

B.3 A transmission link over a fading channel utilizes binary FSK modulation with non-coherent detection. The distribution of the received power is such that the probability density function of the received SNR is

$$p(\gamma) = \begin{cases} \dfrac{\gamma^2}{2a^3} e^{-\gamma/a}, & \text{if} \quad \gamma \geq 0, \\ 0, & \text{if} \quad \gamma < 0. \end{cases}$$

a) Calculate the mean-SNR γ_0 of this channel. (1 p)

b) If the required BER at the receiver is 0.5%, calculate the minimal possible γ_0 which fulfills this requirement. (2 p)

c) In order to improve the performance a two-branch diversity with selection combining is used. Calculate the probability density function of the received SNR after the signal combiner. Assume that the branches are independent. (2 p)

B.4 Consider a wideband channel characterized by the autocorrelation function

$$\phi_h(\tau, \Delta t) = \begin{cases} \text{sinc}(W\Delta t), & 0 \leq \tau \leq 10\,\mu\text{sec}, \\ 0, & \text{otherwise}, \end{cases}$$

where $W = 100$ Hz and $\text{sinc}(x) = \dfrac{\sin(\pi x)}{\pi x}$.

a) Find the delay spread for this channel. Also, comment on the type of channel (i.e., indoor or outdoor?) (1 p)

b) Compute the scattering function of this channel. (1 p)

Hint: Fourier transform of $\text{sinc}(at)$ is given by $\frac{1}{|a|}\text{rect}\left(\frac{f}{a}\right)$, where the rectangular function $\text{rect}(\cdot)$ is defined as $\text{rect}(x) = \begin{cases} 1, & |x| \leq \frac{1}{2}, \\ 0, & \text{otherwise.} \end{cases}$ Similarly,the Fourier transform of $\text{rect}(at)$ is given by $\frac{1}{|a|}\text{sinc}\left(\frac{f}{a}\right)$.

c) What is the Doppler spread for this channel? (1 p)

Hint: If Fourier transform of $x(t)$ is $X(f)$, then the Fourier transform of $x(at + b)$ is $\frac{1}{|a|}\,\mathrm{e}^{\frac{b}{a}f}\,X\left(\frac{f}{a}\right)$.

d) What is the estimated coherence bandwidth for this channel as obtained using the delay spread? Over approximately what range of data rates will a signal transmitted over this channel exhibit frequency selective fading? (1 p)

e) Determine the approximated coherence time for this channel. Will this channel exhibit slow fading or fast fading for a typical voice signal with a 3 kHz bandwidth? (1 p)