Högskolan i Halmstad
Sektionen för Informationsvetenskap, Data- Och Elektroteknik (IDÉ)

Written Exam in Wireless Communication Systems for DE4, ICT3, and E3

11 January 2005.

Allowed aid in addition to the attached formulae:
Calculator and writing material.

Welcome to the exam!

READ THIS FIRST:

Motivate all answers. Insufficient motivations can give reduced points even if the answer is correct. Describe all calculations in detail. You will then have chance on points even if the calculations contain careless mistakes. If required, you are allowed to make own (reasonable) assumptions. You are allowed to answer in either ENGLISH or SWEDISH but do not mix languages in the same answer.

GOOD LUCK!

Number of exercises: 13
Maximal number of points: 60

The grade limits are 24p to pass the exam (Grade 3), 36p for Grade 4, and 48p for Grade 5.

Formulae

Line of sight distance $d(km) \approx 3.57\sqrt{K}(\sqrt{h_1(m)} + \sqrt{h_2(m)})$

K ≈ 4/3

Beam width $\theta = 1{,}2\frac{\lambda}{D}$

Gain $G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2}$

$G_{dB} = 10\log G$

c = 3.00×10^8 m/s in vacuum (and in air, with very small error)

Shannon capacity limit $C = B\log_2\left(1+\frac{S}{N}\right)$

Effective area A_e

Small dipole, loop	$1.5\lambda^2/4\pi$
Half-wave dipole	$1.64\lambda^2/4\pi$
Horn, mouth area A	0.81A
Parabolic, face A	0.56A
Turnstile	$1.15\lambda^2/4\pi$

Free space loss: $L_{fs} = \frac{(4\pi d)^2}{\lambda^2}$

Received power: $P_r = \frac{P_t G_t G_r}{L_{fs}}$

$P_{dBW} = 10\log\frac{P(W)}{1W}$

$P_{dBm} = 10\log\frac{P(W)}{1mW}$

$P_{dBm} = 30 + P_{dBW}$

Noise power density: $N_0 = kT$ k = 1.38×10^{-23} J/K

$$\frac{E_b}{N_0} = \frac{S/R}{N_0} = \frac{S}{N}\frac{B_T}{R}$$

$P_{ERP} = P_t\, G_t$

Signal to noise ratio: $\frac{S}{N} = \frac{P_t G_t G_r}{L_{fs} F k T_0 B}$

Amplitude modulation $s(t) = A_c[1 + n_a x(t)]\cos\omega_c t$

B_T = 2B

Angle modulation $s(t) = A_c \cos[\omega_c t + \Phi(t)]$

$n = |\Phi_{\max}|$

$f_i = f_c + \frac{1}{2\pi}\Phi'(t)$

Carson´s rule $B_T = 2B(n+1)$

L = ^{2}log M

$^2\log x = \frac{^{10}\log x}{^{10}\log 2}$

Modulation rate D = 1 / T_s = R / L

Modulation Transmission bandwidth B_T $0 \le r \le 1$

ASK	$(1+r)R$
FSK	$2\Delta F + (1+r)R$
MFSK	$\frac{(1+r)M}{L}R$ ($f_d \ll \Delta F$)
MPSK	$\frac{(1+r)}{L}R$

Kepler´s law: $P = \left(\frac{4\pi^2 r^3}{GM}\right)^{1/2}$

(r is radius to center of Earth.)

G = 6.67×10^{-11} $kg^{-1}m^3s^{-2}$; M = mass of Earth = 5.98×10^{24} kg

Radius of Earth R = 6370 km

$$\frac{R}{R+h} = \frac{\cos(\beta+\theta)}{\cos\theta}$$

θ is the minimum elevation angle, β the angle at the center of Earth

Distance to satellite $d = \frac{R\sin\beta}{\sin\alpha}$

Orbit height of GEO satellite h = 35863 km (above surface of Earth)

Section I: short questions (20 p)

Exercise 1: (4 p)

A. Describe the theoretical radiation pattern for an isotropic antenna. (1p)

B. Describe antenna gain. (1p)

C. Describe the 3 dB beam width. (1p)

D. Describe what the resonance frequency means, e.g., for a dipole antenna. (1p)

Exercise 2: (4 p)

A. Describe co-channel interference. (1p)

B. Describe adjacent channel interference. (1p)

C. Describe thermal noise. (1p)

D. Describe multi-path fading. (1p)

Exercise 3: (4 p)

A. How can continuous wave (CW) be used for communication? (1p)

B. Give examples of an antipodal modulation scheme and an orthogonal modulation scheme. (1p)

C. Draw the base-band signal constellation for an antipodal binary modulation scheme, binary orthogonal modulation scheme and for on-off keying. Further, mark where to place the decision boarder if the symbols are equally probable. (2p)

Exercise 4: (4 p)

A. Why is multiplexing so cost effective? (2 p)

B. Describe the three physical dimensions (one of these dimensions is actually three dimensional) that can be utilized for multiplexing. (2 p)

Exercise 5: (4 p)

A. Explain what interleaving is and why it can improve the possibility to correct the received data in a wireless system. (2 p)

B. Define channel capacity. (1 p)

C. Describe what coding gain is. (1 p)

Section II: Essay questions (25 p)

Exercise 6: (5 p)

Describe the structure of WAP, with its different parts and their tasks.

Exercise 7: (5 p)

Give a description of pulse coded modulation (PCM).

Exercise 8: (5 p)

Explain what GEO, LEO and MEO satellites are (including what the acronyms stand for). Compare the three types with respect to factors as size and shape of orbits, signal power, propagation delay, and number of necessary satellites for global coverage.

Exercise 9: (5 p)

Explain the need for tunneling and encapsulation in Mobile IPv4. Which options are there and how do they work?

Exercise 10: (5 p)

A. Describe the functionality of the authentication center database (AuC). (2.5 p)
B. Describe the functionality of the visitors location register (VLR). (2.5 p)

Section III: Problems (15 p)

Exercise 11: (5 p)

Consider a cyclic (7,4) code with the generator polynomial; P(X)= X^3+X^2+1. The received data block is 1101101 it contains one bit error, correct it.

Error pattern E	Syndrome S
0000001	001
0000010	010
0000100	100
0001000	101
0010000	111
0100000	011
1000000	110

Table of syndromes for single bit errors.

Exercise 12: (5 p)

According to the legislation, in Europe, the maximum emitted radiated power (P_{ERP}) for a wireless LAN operating at the 2.45 GHz ISM band is 100mW. Assume that you have a wireless LAN card with an output power of 20 mW, how large antenna gain (expressed in dBi) is allowed for the antenna?

Exercise 13: (5 p)

In an ordinary system, a reasonable goal for the bandwidth efficiency might be 1bps/Hz. That is, to transmit a data stream of 1 Mbps, a bandwidth of 1 MHz is used. In this case, what is (theoretically) the necessary SNR?