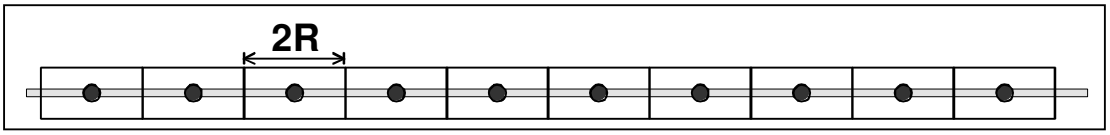
S-72.2210 Home exercises 2005

Home work 1. Deadline for submission of solutions 15.12.2005



On a straight highway the co-channel reuse distance is chosen so, that the CIR-target in GPRS CS1 9.5 dB is reached at the cell border, when a single interferer is considered. The path loss exponent of the average radio path loss is 3.2. All base stations are identical.

a) Determine the minimum normalised reuse distance D/R based on the strongest interferer in the cell configuration given in the above figure. Calculate the achieved CIR-value (dB), when also the interferer in the opposite direction is considered.

b) Check whether GPRS CS4 can be used at the distance R/2 from the base station, when the two strongest interferers are considered, and the CIR-target is now 22 dB.

Home work 2. Deadline for submission of solutions 15.12.2005

How many percent will the coverage area increase if a gain term in the radio link budget is improved with 3 dB, and the path loss exponent of the single slope average loss model is i) 3.0, ii) 4.0, and iii) 5.0?

Home work 3. Deadline for submission of solutions 15.12.2005

After selection combining the probability that the signal to noise ratio (SNR) drops below a given value with M independent diversity branches is $P\{\gamma < \gamma\} = \prod_{k=1}^{M} \left(1 - \exp\left(-\gamma/\gamma_{m_k}\right)\right)$, where γ_{m_k} is the average SNR of the k^{th} diversity branch. Here two-branch diversity is investigated.

a) How large is the diversity improvement at 20 dB fade (i.e. the instantaneous SNR is 20 dB less than the average SNR, when the branches are equally strong in average?

b) The second diversity branch is in average 10 dB weaker than the first branch. How large is now the diversity improvement at 20 dB fade?

Home work 4.

The p.d.f of the signal to noise ratio after M-fold diversity with maximum ratio combining is

$$p_c(\gamma) = \frac{1}{(M-1)!} \cdot \frac{\gamma^{M-1}}{\gamma_m^M} \cdot e^{-\gamma/\gamma_m}\, \mathrm{u}(\gamma)$$

a) Derive an expression for the average bit error probability of DPSK in the rapidly fading Rayleigh-channel when two-fold diversity is applied. Explain the formula, do not just copy from demo exercise 13.

b) Calculate the diversity gain at the bit error probability level 0.001.

Home work 5. Deadline for submission of solutions 15.12.2005

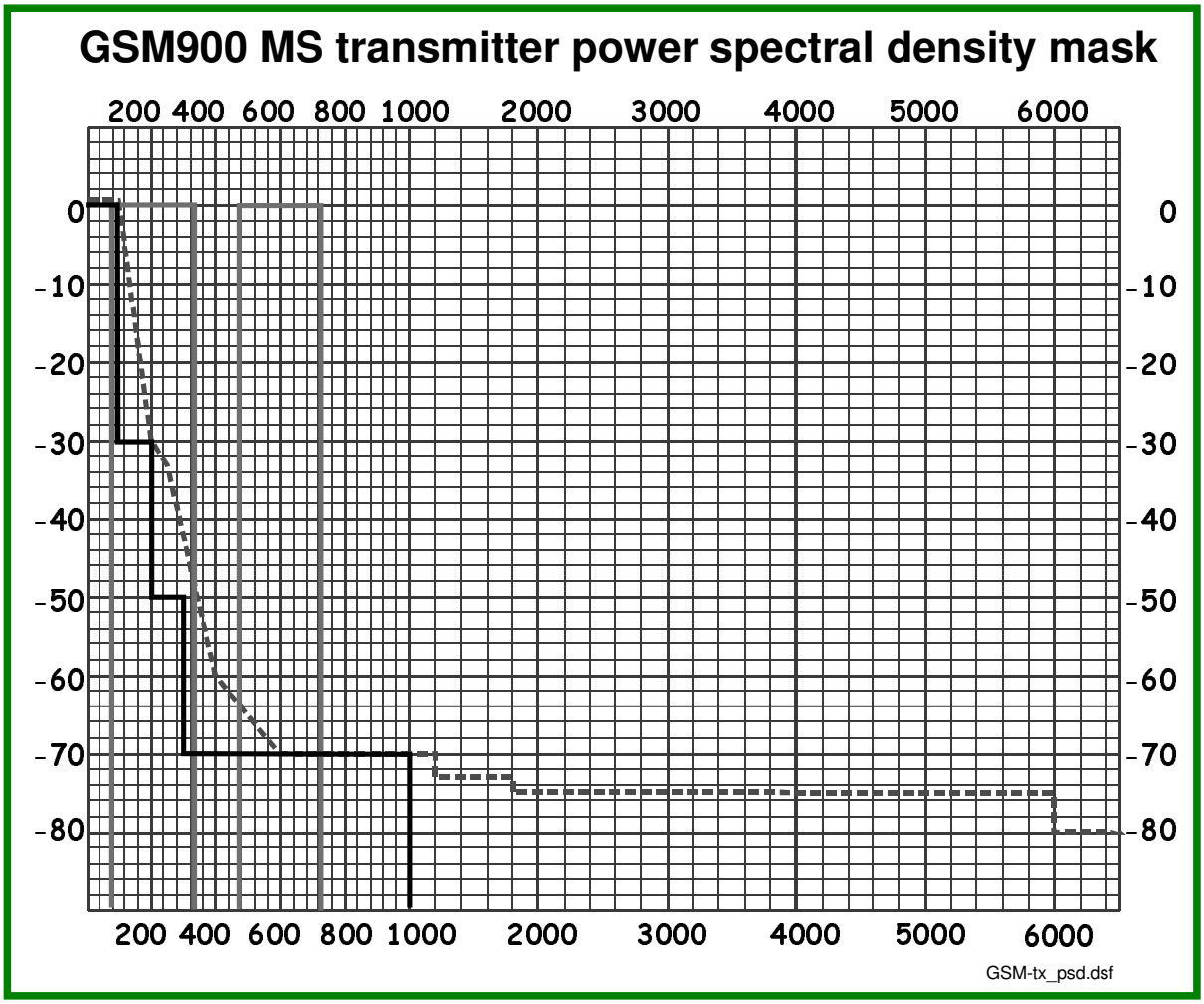
In the highest power classes the GSM900 BTS power spectrum must be below a spectrum mask shown with a dashed line in the figure. The implemented power spectrum (right part only) is shown with a solid line and is defined as:

$$S_{tx}(f) = \begin{cases} +0.0 \text{ dBc}, & 0 \le f \le 100 \text{ kHz} \\ -30.0 \text{ dBc}, & 100 \le f \le 200 \text{ kHz} \\ -50.0 \text{ dBc}, & 200 \le f \le 300 \text{ kHz}, \\ -70.0 \text{ dBc}, & 300 \le f \le 100 \text{ kHz} \\ -\infty \text{ dBc}, & 1000 \le f \le \infty \text{ kHz} \end{cases}$$

a) Give the piecewise expression of the absolute valued spectral power density defined above and in the figure in logarithmic units.

b) In the mobile phone an ideal band-pass filter with 250 kHz bandwidth is assumed to be used. In the figure this filter is shown shifted to the 1st and 3rd adjacent channels. Under the assumption that BTS transmits the same power on all carriers calculate the signal to interference ratio (dB) on the three first adjacent carriers in the filter output. The absolute-valued signal and interference powers are defined as the

integral $P_O = \int_{-\infty}^{\infty} \left|H_{rx}(f)\right|^2 S_{tx,i}(f - n\Delta f_c)df$, where i stands for either signal or interference, n is the order of the adjacent channels (n = 0 for the signal channel), and Δf_c is the carrier spacing.



Home work 6. Deadline for submission of solutions 15.12.2005

Estimate the reduction of base station transmit power in dB, when the user density becomes higher near to the base station, having the p.d.f. $p(r,\phi) = \frac{2}{R}\left(1-\frac{r}{R}\right)\frac{1}{2\pi}$. Utilize results from Problem 18.

- ideal power control compensating exactly distance depending path loss is used,
- the cell is dimensioned for 50 % coverage probability at cell border,
- the power control range is i) 10 dB, ii) 20 dB, iii) 30 dB, iv) 40 dB
- the average path loss model is single-slope with the path loss exponent 3.5.

Home work 7. Deadline for submission of solutions 15.12.2005

The user rate and EGPRS900-BTS receiver sensitivity requirements for different modulation and coding classes in different propagation environments are given in the table below.

Coding class	User net rate kbit/s	BTS-receiver sensitivity/dBm				
		static	TU50	TU50FH	RA250	HT100
MCS1	8.8	–104	–102.5	–103	–103	–102
MCS2	11.2	–104	–100.5	–101	–100.5	–100
MCS3	14.8	–104	–96.5	–96.5	–92.5	–95.5
MCS4	17.6	–101.5	–91	–91	–	–
MCS5	22.4	–101	–96.5	–97	–96	–95
MCS6	29.6	–99.5	–94	–94.5	–91	–91
MCS7	44.8	–96	–89	–88.5	–87	–86
MCS8	54.2	–93	–84	–84	–	–81.5
MCS9	59.2	–91.5	–80	–80	–	–

a) Calculate for the up-link the distances from the BTS where switching from one MCS state to another takes place. Calculate then the average bearer rate when the user is moving along a cell diameter in TU50

propagation environments, when cell size is dimensioned based on –104 dBm sensitivity, and the path loss exponent is 3.5.

b) Calculate under the same conditions the average bit rate, if the cell is dimensioned based on the sensitivity value – 90 dBm

Hints: The change in sensitivity will change the effective coverage area of each MCS-state. Use the radio link budget to calculate the coverage area radius of each MCS-state, and then the distance along the diameter where each MCS-state will be used to give the highest rate. In the calculation of the average it can be assumed that the time to change MCS can be neglected.

Home work 8. Deadline for submission of solutions 15.12.2005

a) How long time will the transmitted and received symbols overlap in the 3+1 multi-slot EDGE mobile station, when it transmits and receives normal bursts with maximum timing advance?

b) Determine the theoretical degradation of receiver sensitivity at symbol error probability 0.01 of the uncoded symbols in i) the static AWGN-channel, and ii) the single-tap Rayleigh-fading channel, when link adaptation switches from MCS1 to MCS5?

Home work 9. Deadline for submission of solutions 15.12.2005

The maximum processing gain in the WCDMA-system is 512.

a) How many simultaneous users with the activity factor 0.4 can coexist in theory (pole capacity) in a single-cell network, if a sufficient performance requires a signal to interference ratio of 3 dB. The up-link is investigated and all users are received with the same power at the base station (ideal power control).

b) The power control is malfunctioning for one user, which is transmitting with constant power corresponding to that required at the cell border. How near to the base station (measured in cell radius) this user can come without reducing the total number more than half of the number in sub-task b? The path loss exponent is 3.5, and slow and fast fading are not considered.

Home work 10. Deadline for submission of solutions 15.12.2005

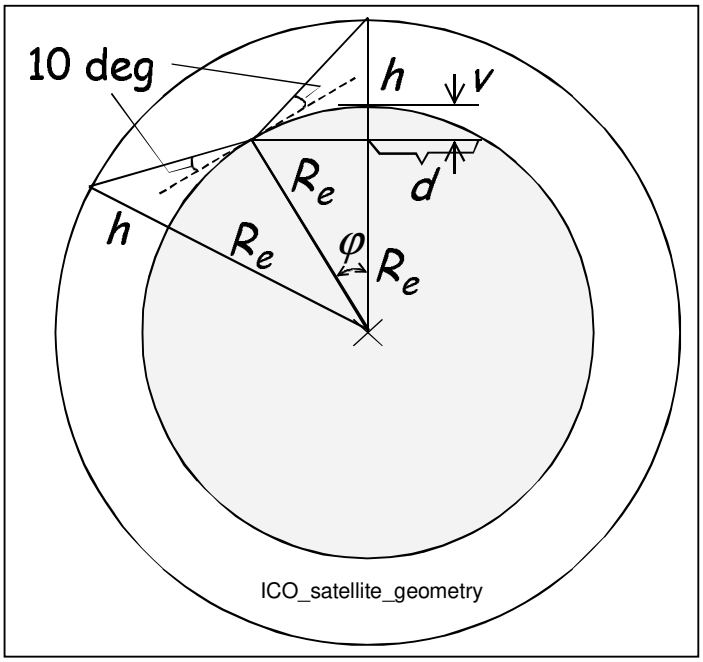
A mobile satellite system uses satellites in circular orbits at 1500 km altitude.

a) How large is the coverage area of a satellite, if this is defined as the area from which the satellite elevation (angle above the tangential plane in the observation point) is more than 10 degrees at a given time instant?

b) During how long time will the satellite be observed with more than 10 degree elevation, if it passes through zenith in the observation point?

Area of a spherical segment:

$$A = 2\pi R_e v$$



Full orbit time:

$$T = \frac{2\pi}{\sqrt{\mu}} r^{1.5},$$

$$\mu = 3.986 \cdot 10^{14} \ \mathrm{m}^3/\mathrm{s}^2$$