S-72.3230 Radio transmission and network access
Exercise 7 - 8

P22 What is the total traffic in bit/s in a multi-rate CDMA cell, where the rate parameters are given in the table, and a fractional load of 70% of the pole capacity is allowed

net rate	$SNR_o \rightarrow \gamma_o$	G	ρ	f	fraction of the users a)	b)
9.6 kbit/s	7 dB $\rightarrow$ 5.01	256	0.40	0.6	100%	60%
48 kbit/s	5 dB $\rightarrow$ 3.16	64	1.00	0.6	0%	30%
384 kbit/s	3 dB $\rightarrow$ 2.00	8	1.00	0.6	0%	10%

P23.A practical definition of the up-link capacity of a DS-CDMA system could be the number of users, when a new user would increase the interference margin by 0.2 dB. We shall investigate a single-cell system and a multiple-cell system with the following parameters :

- processing gain G = 128,
- target signal to interference ratio γ_o = 5,
- activity factor ρ = 0.5,
- other to home cell interference ratio f = 0.6.

a) Determine the up-link capacity of this system.
b) Determine the corresponding fractional load in %, and interference margin in dB.

P24In a DS-CDMA-system the interference margin is $IM = 10\lg\left(\frac{1}{1-\eta}\right)$, and the up-link fractional load is $\eta = (1+f)\sum_{i=1}^{N}\frac{\rho_i\gamma_i}{G_i}$.

a) How many speech user $(\rho_i = 0.4, 10\log\gamma_i = 8 \text{ dB}, G_i = 256)$ can be served when the other cell to own cell interference ratio is f = 0.75, and the fractional load target is 0.7?
b) A new data user $(\rho_{N+1} = 1, 10\log\gamma_{N+1} = 4 \text{ dB}, G_i = 32)$ is admitted in the own cell. How many dB must the interference margin be increased from the value in subtask a) to maintain all the connections?

P25 A rapidly fading narrow-band Rayleigh-channel is defined as a channel where all fading states are realized in the time interval used for a BER-measurement. The measured BER-value gives then an estimate of the average bit error probability P_b of a narrow-band digital system which is

$P_b = \int_{\gamma} p(\gamma) P_b(\gamma) d\gamma$, where γ is the instantaneous signal to noise ratio and $p(\gamma)$ is its p.d.f. (However, the channel should be quasi-invariant over the symbol duration).

The diversity gain is determined as the difference in average SNR:s required for a given P_b-value without diversity and with diversity.

In a slowly fading narrow-band Rayleigh-channel the channel remains fairly constant during a BER-measurement. Instead of the average P_b a better performance measure is the time percentage during which a given P_b-value is exceeded. In a narrow-band channel this equals the time (probability) the instantaneous γ-value goes below the value giving this P_b-value.

Diversity improvement is defined as the ratio between the times that the instantaneous BER is exceeding a given value without and with diversity.

a) Derive the expression for average bit error probability of DPSK in the rapidly fading Rayleigh-channel without diversity and when two-fold diversity with selection combining is applied. The bit error probability of DPSK in the AWGN-channel is $P_b(\gamma) = \frac{1}{2} e^{-\gamma}$.

b) Calculate the diversity gain in dB for the average bit error probability values 10^{-2} and 10^{-4}.

c) Calculate the diversity improvement on the bit error probabilities 10^{-2} and 10^{-4} when the average SNR in each branch is 20 dB

d) If the bit error probability 10^{-2} and 10^{-4} may be exceeded during 1% and 0,01 % of the time so what is then the diversity gain based on the required average SNR:s to obtain these outage performances?

P26 In a radio communication system space diversity is used where the second branch average power level is lower than in the first branch. The branches are independently Rayleigh-fading.

a) Derive the SNR p.d.f. when selection combining is used.

b) Derive the SNR p.d.f. when maximum ratio combining is used

Narrow-band DPSK is used and the average power level difference of the branches is 6 dB. Based on average bit error probability 10^{-3}, what is the diversity gain penalty in dB compared to a system with equally strong branches,

c) when selection combining is used,

d) when maximum ratio combining is used?

P27 With the actual system parameters the flat fade margin (FFM) of a radio link is 20 dB.

a) The channel is flat Rayleigh-fading. During how large fraction of time the received power level without diversity is below the power level P_{min} determined by FFM?

b) The requirement is that the time fraction the received power level could be below P_{min} is no more than 10^{-5}. How many independent and on average equally strong, flat Rayleigh-fading diversity branches with selection combining must be used to fulfil the requirement?

P28 The bit error probability of DPSK in the AWGN-channel is $P_b = 0.5\exp(-\gamma)$, where γ is the signal to noise ratio.

a) Derive the average bit error probability expression in the slowly Rayleigh-fading channel: i) without diversity, and ii) with diversity using two independent branches with selection combining.

b) Determine the diversity gain (dB) at a bit error probability of 10^{-2}.

Homework 7

In the up-link of a DS-CDMA system with perfect power control and providing a single rate service, the pole capacity is estimated from the expression $\dfrac{P_k}{\dfrac{(1+f)}{G_c}\sum\limits_{\substack{i=1\\ i\neq k}}^{M} P_i + \dfrac{N_o R_s}{2}} = \gamma_k \geq \gamma_o$, and the interference margin is $10\log\left(\dfrac{1}{1-\eta}\right)$.

a) Estimate the pole capacity of a single cell system under low noise conditions when the bit rate is 30 kbit/s, the chip rate is 3.84 Mchip/s, the user activity factor is 0.5, and the target SIR is 4 dB.

b) The interference margin in this system is designed for a 30% fractional load. The system is turned into a multicell system where the other to own cell interference ratio is 0.75. From which dB-value to which dB-value does the interference margin change?

Homework 8

In a radio communication system the received signal is slowly Rayleigh-fading and the disturbances are of AWGN-type. The performance target is that the signal to noise ratio should fall more than 10 dB below the average value less than 5 % of the time.

a) How large should the signal to noise ratio (dB) be if no diversity is used?

b) In the receiver two-branch diversity with selection combining is used. The two branches fade independently and have the same average signal to noise ratio. How many dB can the average signal to noise requirement be lowered compared to the single branch receiver?