S-72.3210 CHANNEL MODELING FOR RADIO COMMUNICATION SYSTEMS

Home works 2007

Deadline for the answers: 14.12.2007 at 12:00:00 o'clock, After that the correct answers will be published on the course home page.

Answers should be delivered to a cabinet box marked with the course code in the open space in wing E3

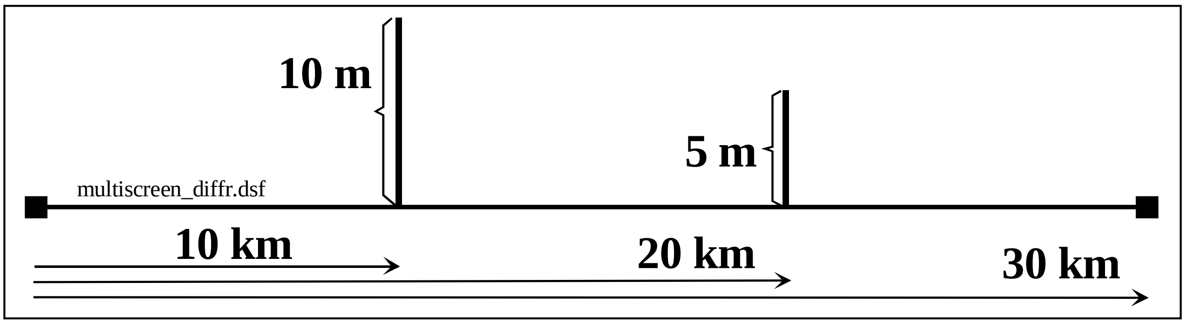
HOMEWORK 1,

A radio link is planned in the Bolivian highland 4 km above sea level. The refractivity behaviour vs. height above sea level is modeled with $N(h) = N_s \exp\left(-h/h_o\right)$, $N_s = 320$ NU/km, and $h_o = 8.0$ km. The equivalent Earth radius is $R_e = R_o / \left(1 + (\partial n/\partial h) R_o\right)$, where the true Earth radius R_o = 6370 km.

a. Determine the equivalent Earth radius on the actual region.

b. How far away is the radio horizon from a transmitter antenna 70 m above the spherical ground? Compare the value to that obtained at sea level where the equivalent Earth radius is 8548 km

HOMEWORK 2.



There are two significant knife edge obstacles on a radio path on 6 GHz. Their distances from the stations and height above the line of sight are shown in the above figure. Obviously the higher obstacle will cause the highest diffraction loss.

a) Determine the Fresnel diffraction parameter ν_1 of the first obstacle, and the modified parameter according to the Deygot method for the second obstacle.

b) Estimate with the Deygot method the excess loss caused by diffraction over the two obstacles.

HOMEWORK 3

The GSM Hilly Terrain multipath channel model comprises 6 independently Rayleigh-fading components having delays and average power levels relative to the strongest component according to the table below.

i	1	2	3	4	5	6
$\tau_i/\mu s$	0	0.1	0.3	0.5	15.0	17.2
P_{im}/dB	0	–1.5	–4.5	–7.5	–8.0	–17.7

a) Derive the autocorrelation function $R_h(\lambda, \Delta t)$ of the impulse response of this channel in terms of the mean power of each path gain.

b) Derive the expressions and the numerical values of the mean delay, r.m.s. delay, and delay standard deviation (a measure of half delay spread) of this channel.

HOMEWORK 4

Calculate using the method outlined in the lecture material how large is the maximum symbol rate for which the Rayleigh-fading channel in HOMEWORK 3 can be regarded as narrow-band when the bit error probability caused by multipath fading of the transmitted QPSK-signal with the roll-off parameter α = 0.5 is i) 10^{-3}, and ii) 10^{-6}. The r.m.s. bandwidth of a signal with raised cosine spectrum shape is

$$B_{rms} = \sqrt{\frac{R_s^2}{12} \cdot \frac{(1-\alpha)^3 + 3\alpha^3 - \frac{45\alpha^3}{2\pi^2} + \left(\frac{9}{2} - \frac{24}{\pi^2}\right)\alpha^2 (1-\alpha) + \frac{9}{4}\alpha (1-\alpha)^2}{\left(1 - \frac{\alpha}{4}\right)}}$$

where α is the spectrum roll-off parameter.

$Q(3.09) = 10^{-3}, \quad Q(4.75) = 10^{-6}$

HOMEWORK 5

Compare the average path losses predicted with the COST231 Hata model and the ITU-R P.1546 Recommendation in a suburban environment and with the tx antenna height 37.5 m on 2000 MHz. Give the loss values for the distances 1, 3, and 10 km. The rx antenna height is 1.5 m, and in the ITU model the field corrections for low rx-antenna height are made as for rural environment.

HOMEWORK 6

An ambulance is equipped with a 420 MHz TETRA radio, for which the signal fading can be approximated as flat Rayleigh fading, and the environment causes a Doppler spectrum according to Clarke's channel model. The ambulance is moving 108 km/h.

a) How many times per second does the signal cross the -15 dB level compared to average level in the upward direction?

b) How long is the average duration of a fade below the -15 dB level?