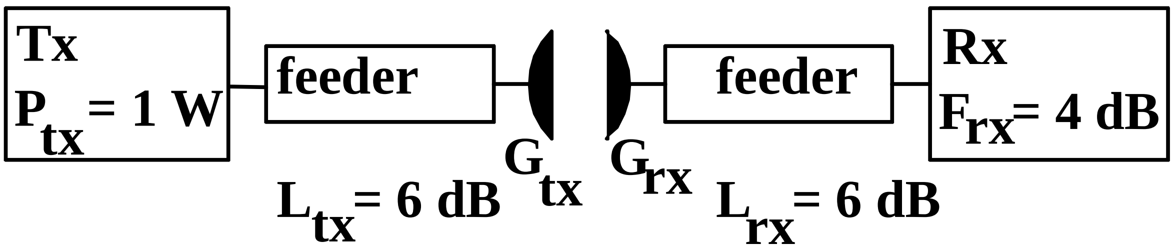
S-72.3220 RADIO COMMUNICATION SYSTEMS
EXERCISE 3, 9.2.2006

P12



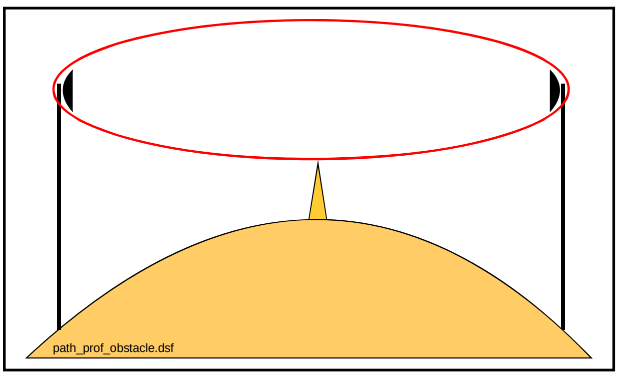
In the above 155.2 Mbit/s MQAM-SDH radio link (M = 4, 16, 64 or 256) is used in the 6.8 GHz frequency band, with the original allocation of 8 channels with 40 MHz spacing.

a) How many radio channels is it possible to use on the different M-values in this frequency band, and how large is the total capacity (Mbit/s) of the N+1-protected radio relay system, when the roll-off parameter of the raised cosine spectrum is $\alpha = 0.3$. You don't need to care about the original channel allocation, but the signal spectra should not overlap.

b) Determine the system gain ($G = P_{tx} - P_{rx,min}$, dB) and the flat fade margin ($FFM = P_{rxo} - P_{rx,min}$, dB) on the BER-level 10^{-6}, when $\varnothing$ 3m paraboloidal antennas with the efficiency η=0,65 are used, and the obstacle-free path length is 50 km. Implementation degradation is 1.0 dB in the 4QAM-system, 1.5 dB in the 16QAM-system, 2.5 dB in the 64QAM-system, and 4.0 dB in the 256QAM-system. The receiver noise figure is 5 dB.

P13 A 7 GHz radio relay system is used on a 40 km hop, which has a knife edge obstacle in the mid-point with a height of 25 m above the otherwise spherical ground level.

a. Determine the necessary equally large antenna heights, which leave the 1st Fresnel zone free of obstacles during

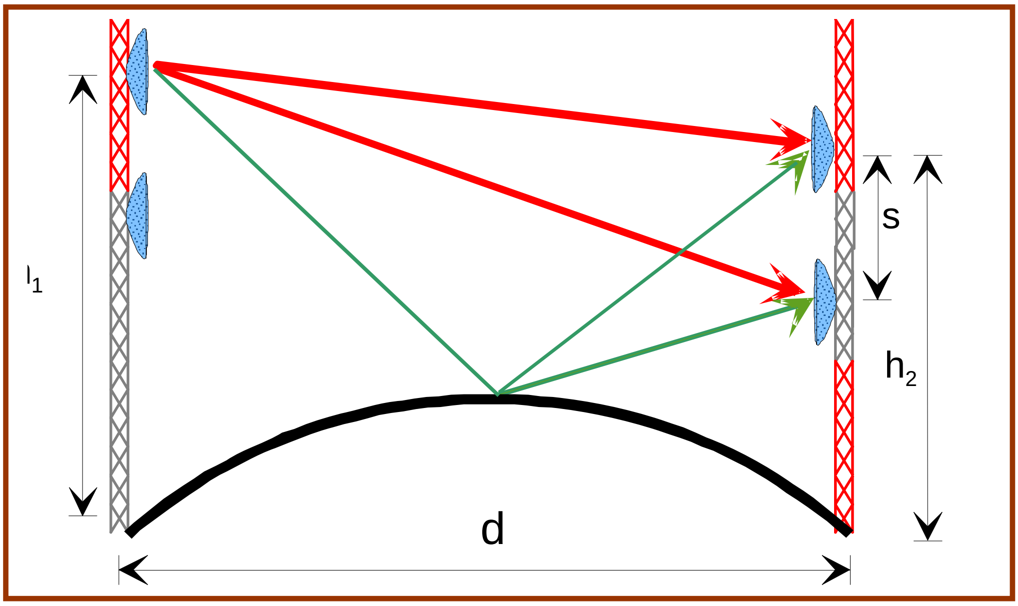


standard propagation conditions (k = 4/3, R_o= 6370 km).

b. The link parameters are dimensioned for a 30 dB flat fade margin. Determine the k-value leading to outage due to diffraction losses during sub-**refractive propagation conditions**.

P14

On a normal 40 km over water radio path in Southern Finland a 7.3 GHz radio relay system (2x8 Mb/s, DMR7000) is used. The clearence dimensioning is as usual, and the receiver antenna is at 15 m lower height above the reference level than the transmitter antenna. The transmitter power level is 26 dBm, the threshold receive power level is -87 dBm, antenna diameters 3.0 m, antenna efficiency 0.6, feeder and connector losses in each station is 4.2 dB, and the total branching loss is 8 dB.



a) Determine the heights of the main antennas. (Water reflections are not considered.)

b) Calculate the outage time fraction without diversity.

c) Calculate the outage time fraction with diversity, when the diversity antenna spacing is 10 m.

P15

On a normal 45 km terrestrial radio relay path is used a 2 GHz radio link 2×8 Mbit/s, DMR2000). The receiver flat fade margin (*FFM*) is 29 dB. The antenna diameter is 2.4 m and the outage time percentage (SES) is 0.00433 % when the planning target was 0.005 %. The path clearence is the usual and the crucial obstacle is at the path center.

a) In the situation above one of the antennas must be replaced by an 1.8 m antenna. What is the new outage time percentage? Will the radio link still fulfil the error performance requirement?

b) The original propagation situation is changed by new buildings at the path center decreasing the clearence, so that during standard propagation the flat fade margin decreases with 1 dB.
i) Will the transmission quality requirement still be fulfilled?
ii) Will the system still pass the “small-k” -check?

c) In the original situation a new co-channel interference signal appears (from a different direction), so that the signal to disturbance ratio at the receiver input is 46.3 dB during standard propagation. What is now the system outage time percentage? Sketch the attenuation curves.
Hint: In the determination of threshold level degradation a 0.5 dB accuracy is satisfying.

P16

In a 58 GHz terrestrial radio relay system the transmission rate is 16 Mbit/s and the modulation method is QPSK. The transmitter power level is 17 dBm, the receiver noise figure is 8 dB, and the implementation margin is 3 dB.

a) Determine the flat fade margin during clear air conditions on a 2 km path when 30 cm parabolic antennas with efficiency 0.5 are used, and the feeder system loss in each station is 3 dB. The receiver sensitivity level should correspond to the bit error probability 10^{-3}.
b) Determine the outage time fraction due to rain on this path when the rain rate corresponding to 10^{-4} occurrence probability is 22 mm/h.
c) If the ITU Medium grade (class 3) HRDS(50 km) unavailability requirement 0.05 % is divided linearly on the individual link paths, what would be the maximum path length with this radio?

P17

The parameters for calculation of specific rain attenuation at different frequencies are given in the following table.

f/GHz	20	30	40	50	60
k	0.09611	0.2291	0.4274	0.6472	0.8515
α	0.9847	0.9129	0.8421	0.7871	0.7486

What is the maximum hop length at these frequencies if the clear air flat fade margin is 25 dB, and rain attenuation should not exceed this value for more than 0.01% of time. The rain rate exceeds 25 mm/h 0.01% of time.

P18

The parameters for calculation of the specific rain attenuation at 38 GHz for vertical polarization are k_V = 0.356 and α_V = 0.943, and the absorption loss in clear air is 0.12 dB/km. Estimate the outage time fraction on a 10 km hop when the rain rate exceeds 25 mm/h 0.01% of time. The receiver flat fade margin FFM = 25 dB – clear air absorption loss.

P19

A radio link at 60 GHz has the following technical parameters:

- transmitter power level 30 dBm,
- receiver sensitivity –80 dBm,
- transmitter and receiver antenna gain 42.5 dB/antenna,
- transmitter and receiver antenna feeder system losses 3dB/antenna.

a) Determine the flat fade margin on a 2 km path taking into account free space loss and oxygen attenuation. Assume r_p and r_t to be one in the oxygen loss formula and ρ = 7.5 g/m3 in the water vapour loss formula.

b) With constant rain rate on the entire path, what is the maximum allowable rain rate? At 60 GHz k=0.8515 and α=0.7486 in the specific rain attenuation formula.

Homework 3

Determine the flat fade margin of a 38 GHz radio system, which is used on a 6 km hop, when the outage caused by rain should be 0.001%. The system is used in a region where the 0.01% rain intensity is 70 mm/h. The parameters of the specific rain attenuation (dB/km) on this frequency are $k = 0.279\ \alpha v\delta\ \alpha$ = 0.943.