S-72.3220 RADIO COMMUNICATION SYSTEMS

HOMEWORK 1.

The noise figure of a radio receiver is 1.5 dB (T_s = 290 K).

a) What is the SNR degradation (dB) in the receiver when the source noise temperature is i) 290 K, ii) 50 K, iii) 8 K and the source is directly connected to the receiver?

b) Repeat the above degradation calculation when the source is connected to the receiver with a lossy cable, the loss being $L =$ 1.2 dB.

Answer

a) i) $T_S = 290\ \text{K} \rightarrow \Delta SNR = 1.50\ \text{dB}$

ii) $T_S = 50\ \text{K} \rightarrow \Delta SNR = 5.30\ \text{dB}$

iii) $T_S = 8\ \text{K} \rightarrow \Delta SNR = 12.03\ \text{dB}$

b) i) $T_S = 290\ \text{K} \rightarrow \Delta SNR = 1.00\ \text{dB}$

ii) $T_S = 50\ \text{K} \rightarrow \Delta SNR = 2.29\ \text{dB}$

iii) $T_S = 8\ \text{K} \rightarrow \Delta SNR = 2.98\ \text{dB}$

HOME WORK 2

In a radio communication system the data rate in the radio channel is 812.5 kbit/s and the modulation method is 8PSK giving a theoretical bit error probability in the AWGN-channel $P_b \approx \frac{2}{3} Q\left(\sqrt{\frac{0.293 E_{rx}}{N_o}}\right)$.

The noise figure of a receiver is 7.0 dB and the antenna and feeder system noise temperature is 290 K. Determine the theoretical sensitivity (dBm) in the AWGN-channel. The sensitivity is defined as the received power level, which gives the bit error probability 10^{-4}.

$\left(Q(3.62) = 1.5 \cdot 10^{-4}, \quad kT_o = 4 \cdot 10^{-21}\ \text{W/Hz}\right)$

Answer: $P_{rx} = 2.429 \cdot 10^{-10}\ \text{mW} \leftrightarrow -96.15\ \text{dBm}$

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 and α = 0.943**.**

Answer: $A_{0.001\%} = 132.14$ dB

HOMEWORK 4

During the worst month the measured channel model of a terrestrial radio relay hop gives the following prediction formulas for the outage probability caused by frequency selective fading and flat fading respectively: $P_{o,sf} = P_{sf} W \tau \, \mathrm{e}^{-B/4.0}$, $P_{o,ff} = r \cdot 10^{-FFM/10}$.

the parameter values of the channel models are:	the fade tolerance parameters of the receiver are:
• P_{sf} = 0.01 • r = 0.1 • q = 5 • τ = 6.3 ns	• FFM = 45 dB • B is the M-signature height (dB) • W is the signature width (GHz) The signature is the same in both minimum phase and non-minimum phase channel

The total outage target due to flat and selective fading is 0.001%. Calculate the necessary signature height when the signature width is a) 10 MHz, b) 20 MHz, c) 30 MHz outage improvement.

SOLUTION

$W = 0.01$ GHz $\rightarrow B = 18.84$ dB

$W = 0.02$ GHz $\rightarrow B = 21.61$ dB

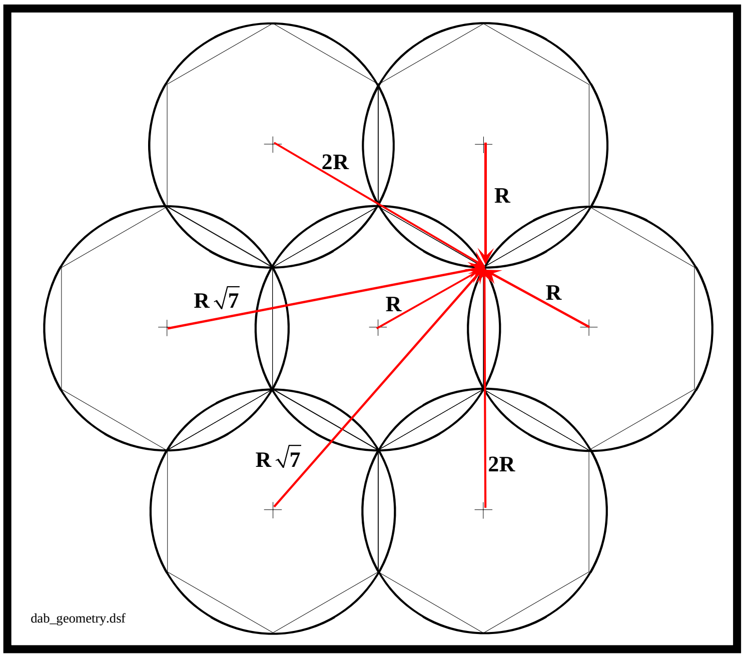
$W = 0.03$ GHz $\rightarrow B = 23.23$ dB

HOME WORK 5

An audio broadcasting network is initially built for FM-transmission. The planning parameters are:

transmitter power: P_{tx} = 60 kWEIRP,
transmitter antenna height: h_{tx} = 300 m,
required field strength at coverage area border: E_{rx} = 54.0 dBµV/m.

a) Estimate the radius of the coverage area.



This broadcasting network should be utilised for DAB-transmission at 200 MHz requiring a field strength of 44.0 dBµV/m at the coverage area border.

b) Determine the required transmitter power (kWEIRP) in the case of a single DAB-transmitter.

c) Estimate the field strength at the receiver place, marked with arrows in the figure, from the other transmitters compared to the field from the transmitter in the centre (all transmitter parameters are identical).

d) In the DAB-network only one transmitter frequency is used, and it is assumed that the received powers (W) sum up in the receiver. Determine the required transmitter power (kWEIRP) in this case.

Answers

a) $R \approx 81$ km   b) $P_{tx,DAB} = 10^{1.04} = 10.96$ kW (200 MHz)

(At 100 MHz $\rightarrow P_{tx,DAB} = 6.0$ kW)

c) with 1 kW transmitters:

$$R = 81\ \text{km} \rightarrow E = 33.6\ \text{dB}\mu\text{V/m} \leftrightarrow 2291\ \mu\text{V/m}$$

$$R = 2R = 162\ \text{km} \rightarrow E = 10.9\ \text{dB}\mu\text{V/m} \leftrightarrow 12.3\ \mu\text{V/m}$$

$$R = \sqrt{7}R = 214\ \text{km} \rightarrow E = 2.7\ \text{dB}\mu\text{V/m} \leftrightarrow 1.86\ \mu\text{V/m}$$

d) $P_{tx,DAB} = 10^{0.8} = 6.31$ kW