6. The block length in a STM1 radio relay system is 19440 bits and the BBER requirement is $2 \cdot 10^{-4}$ on the 27500 km HRP.
a) To which BER-value does this correspond if the bit errors are independent?
b) Which BER-value must be achieved on a 50 km hop assuming a uniform allocation of the BBER requirement over the entire HRP?

7. Considering i) a high grade 140 Mbits PDH radio link and ii) a STM1 radio link hop, how many
a) errored seconds,
b) severely errored seconds
can be allowed during the worst month on a 40 km hop?

8. A radio sounder performs meteorological measurements up to 25 km height and transmits the data to a ground station with 1 W power at 4.5 GHz frequency using a dipole antenna with 2.1 dBi gain towards the ground station. The antenna feeder loss is 5.0 dB. The ground station receiver noise figure is 4.0 dB and its antenna feeder loss is 3.0 dB. The receiver antenna gain in the sounder direction is 12.0 dBi. The receiver IF bandwidth is 25 kHz. The minimum SNR for reliable transmission is 12.0 dB. A 10 dB fade margin is used.
a) Calculate the minimum receive level (dBm).
b) Calculate the needed average receive level (dBm) with the given fade margin.
c) Calculate the average radio path loss (dB) allowed by the radio link budget.
d) How far away from the meteorological station (along the Earth surface) the wind may move the sounder, when the propagation model is free space propagation?

9. The maximum distance between Pluto and Earth is 7.5 Tm. A space vehicle investigating Pluto has a 10 W transmitter and the transmission frequency is 2 GHz. The Earth station has a 64 m paraboloid antenna and the total receiver noise temperature is 16 K. The transmitted data rate is 300 bit/s and BPSK-modulation is used. What must the space vehicle antenna diameter be if a bit error probability of 10^{-6} is required and the efficiency of both antennas is $\eta=0.6$?

10. The short range radio communication system Bluetooth is working in the ISM-band and the maximum carrier frequency is 2.484 GHz. A class II transmitter has a maximum power level of 4 dBm, and the receiver sensitivity requirement is -70 dBm. How large is the flat fade margin on a 10 m connection, if during standard propagation conditions free space propagation occurs, and the net gain of both transmitter and receiver antenna systems is 0 dB.

11. In a radio communication system at 3,4 GHz the 2 Mbit/s datasignal is transmitted using coherent QPSK-modulation, and the receiver has exact carrier phase knowledge giving the bit error probability $P_b = Q\left(\sqrt{E_{rx}/N_o}\right)$. The total gain of the antenna systems including feeder losses is 8 dB.

a) Determine the theoretical receiver sensitivity (dBm) in the AWGN-channel, with the noise figure 5 dB, and the antenna noise temperature and the feeder temperature 290 K. The sensitivity is the received power level giving the bit error probability 10^{-6}. Q(4,75) = 10^{-6}. $\left(kT_o = 4 \cdot 10^{-21}\ \text{W/Hz}\right)$

b) Determine the longest possible connection, when the transmit power is 1 W, and the radio path loss corresponds to free space loss.

c) Determine the longest possible connection, when the radio path is a flat ground reflection path with the path loss on large distances being $L \approx \frac{d^4}{h_{tx}^2 h_{rx}^2}$. The antenna heights are 30 m and 3 m.

Home work 2 Submit your solution before March 2, 2006

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}.

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