Tutorial No.9

Period 3 - 2006

Topic: Link budget, Communication systems design

Exercise 1

You are required to make modulation and error-correction code choices for a real-time communication system operating over an AWGN channel. The required data rate and bit-error probability are 9600 bits/s and 10^{-5}, respectively. You are allowed to choose one of two modulation types – either non-coherent orthogonal 8-FSK or 16-QAM with matched filter detection. If you wish you are also allowed to use one of two codes – either the (127,92) BCH code or a rate 1/2 convolutional code that provides 5 dB of coding gain at a bit-error probability of 10^{-5}. Consider the following cases :

1. The available bandwidth is 2400 Hz and the available E_b/N_0 is 14 dB.
2. The available bandwidth is 40 kHz and the available E_b/N_0 is 7.3 dB.
3. The available bandwidth is 3400 Hz and the available E_b/N_0 is 10 dB. The channel now manifests deep fades lasting up to 100 ms in duration. Apart from meeting the bandwidth- and error-performance requirements, you must also combat these fades. You may use either of two interleavers – a 16x32 interleaver or a 150x300 interleaver.

Assuming ideal filtering, verify that your choices achieve the desired bandwidth- and error-performance requirements.

Exercise 2

In a communication system binary FSK is used as modulation. The detection is made non-coherently. You want to transmit 1.2 kbits/s. A rate 1/2 convolutional code with the constraint length 5 is used. What is the bit error rate if the received signal power is $2 * 10^{-6}$ W and $\frac{1}{2}N_0 = 10^{-10}$ W? The optimal rate 1/2 Convolutional code with $K = 5$ has the free distance of 6 and the shortest error path gives rise to one decoded error. Assume a matched filter receiver.

Exercise 3

The distance between transmitter and receiver in a radio connection is 50 km. Free space between transmitter and receiver can be supposed. The transmitter

antenna gain is 3 dB and the receiver antenna gain is 3 also dB. The receiver noise factor is 3.5 dB. The carrier frequency is 500 MHz and the bandwidth is 250 kHz. The transmitter power is 4 W. What is the bit error rate in the transmitted message if BPSK is used? Maximum signalling rate is assumed.

Exercise 4

We like to establish a radio link between a base station and a mobile phone inside a building. Measurements have shown that due to absorbtion in walls etc. the propagation attenuation to a receiver on the bottom floor is 50 dB larger than the propagation in free space. The base station has an antenna gain of 5 dB and the distance to the receiver is 8 km. The carrier frequency is 900 MHz and the bandwidth of the sent signal is 200 kHz. The receiver has a noise factor of 5 dB and an antenna gain of 2 dB. BPSK is used. We tolerate a bit error probability of at most 0.02. What is the minimum output power from the base station?