Wireless Communications I 521395S

GENERAL INFORMATION: Read the questions (6) carefully. Answer to the questions (nothing else). **Justify all your answers** and write clearly handwriting using pencil. *Voit vastata myös suomeksi.*

1. a) Explain bit duration, symbol duration, and their correspondences. (2 p)
    b) Describe frequency shift keying: principle, signal space diagram and demodulator structure. ～ (3 p)
    c) Explain early-late gate synchronizer. For which purpose it is used? (2 p) —

2. For a multipath fading channel let a scattering function $S_c(\tau,\rho)$ is nonzero over $0 \leq \tau \leq 5$ μs and $-2000 \leq \rho \leq 2000$ Hz. Assume that the power of the scattering function is approximately uniform over the range where it is nonzero.
    a) What are the multipath spread and the Doppler spread of the channel (numerical values)? Explain what the meaning of these spreads are. (2 p)
    b) Suppose you input to this channel two identical sinusoids. What is the minimum value of Δf for which the channel response to the first sinusoid is approximately independent of the channel response to the second sinusoid? Explain your answer. (1 p)
    c) For two sinusoidal inputs to the channel $u_1(t) = \sin 2\pi f t$ and $u_2(t) = \sin 2\pi f(t + \Delta t)$, what is the minimum value of Δt for which the channel response to $u_1(t)$ is approximately independent of the channel response to $u_2(t)$? Explain your answer. (1 p)
    d) Will this channel exhibit flat fading or frequency-selective fading for channel with a 1 kHz bandwidth? How about for a channel with a 500 kHz bandwidth? Explain your answer. (1.5 p)
    e) Assume that $BT_s \approx 1$. Is there fast or slow fading, if we use these bandwidths (1 kHz and 500 kHz)? Explain your answer. (1.5 p)

3. Explain briefly, but accurately.
    a) Minimum distance. (1 p)
    b) How can you measure error detection and correction capability of a code? (1 p)
    c) Coding gain. (1 p)
    d) The basic ideas of the turbo encoding and decoding. (4 p)
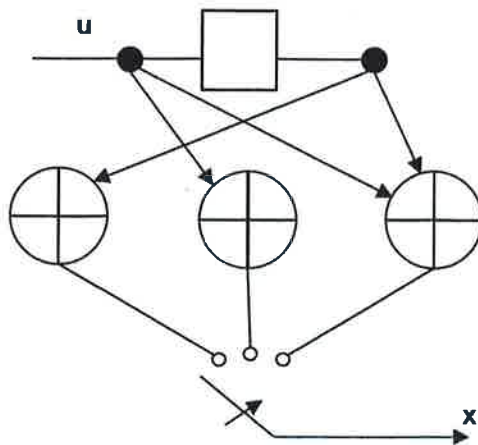
4. A convolutional encoder ($k_0 = 1$) is in Figure 1.

Figure 1.

a) What is the value for n_0 and constraint length N of the code? (1 p)
b) What are the generator vectors in binary and octal notation defined by the structure in Figure 1? (1 p)
c) Draw a state diagram corresponding to the encoder in Figure 1. (1 p)
d) Encode the data sequence 0110. (1 p)
e) How much is the free distance (value) of the code? What does a free distance of the code mean? (1.5 p)
f) Solve the transfer function of the code. What does a transfer function of the code mean? (1.5 p)

5. a) Compare roughly bit error probability of binary PSK in AWGN and in Rayleigh fading channel (no need for equations, just behavior). Explain what causes the difference and how it changes as signal-to-noise ratio increases. (3 p)
   b) Explain outage probability in fading channel. (1 p)
   d) Consider the two 8 level signal space diagrams below? Which one of those is more recommendable in AWGN channel and why (justify your answer). (3 p)
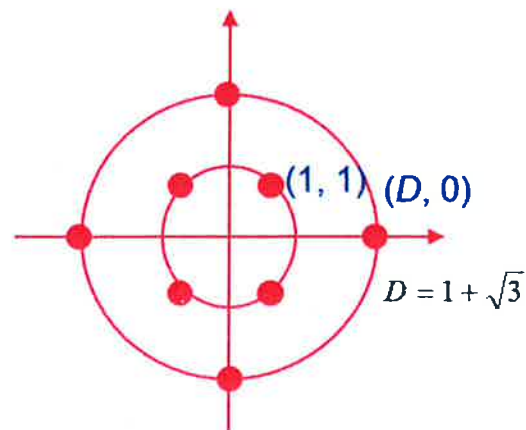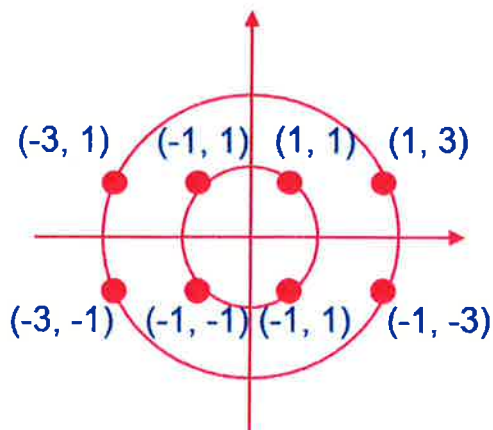
6. a) Explain the idea of diversity. (1 p)
   b) Explain three methods to implement diversity. (3 p)
   c) Explain three combining methods used to get benefit from diversity. (3 p)