Final exam in

Digital Communications, Advanced Course (ETTN01)

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on December 19, 2013, 14–19.

- During this final exam, you are allowed to use a calculator and the textbook.
- Each solution should be written on a separate sheet of paper.
  Please add Your name on each sheet.
- Show the line of reasoning clearly, and use the methods presented in the course.
  If You use results from the textbook, add a reference in Your solution.
- If any data is lacking, make reasonable presumptions.

Good Luck!

Problem 1:

Determine for each of the five statements below if it is true or false.
Observe! As always, motivations to your answers should be given.

a) " A rate 3/4 encoder in combination with 32-ary PSK has a smaller bandwidth efficiency than a rate 4/5 encoder with 16-ary QAM."

b) "An encoder in combination with M-QAM can improve both energy efficiency and bandwidth efficiency, compared to uncoded M-QAM."

c) "If the received signal constellation is M-PSK with equally likely signal alternatives, then the implementation of the ML-receiver can be significantly simplified, compared with the receiver for M-QAM (also with equally likely signal alternatives)."

d) "Channel knowledge is always needed at the transmitter and at the receiver."

e) "Attenuation and rotation can be compensated for (equalized) at the receiver, such that the symbol error probability remains approximatly unchanged."

(10 points)

Problem 2:
Consider a communication link where the eight equally likely received signal alternatives are represented in a one-dimensional signal space as:

$$\mathbf{z_0} = -\mathbf{z_7} = a$$
$$\mathbf{z_1} = -\mathbf{z_6} = 2a$$
$$\mathbf{z_2} = -\mathbf{z_5} = 3a$$
$$\mathbf{z_3} = -\mathbf{z_4} = 7a$$

where a is a positive value. AWGN and ML symbol receiver are assumed.

Calculate the exact value of the symbol error probability if $\mathcal{E}_b/N_0$ is 20 dB.

(10 points)

Problem 3:

a)
Consider the basic Shannon capacity equation. Strongly connected to this equation are several important parameters, e.g., $SNR = P_z/(N_0W)$ and $\mathcal{E}_b/N_0$.

Determine and sketch $\mathcal{E}_b/N_0$ versus SNR, for $10 \leq SNR \leq 130$.

What are your conclusions?

b)
Explain in detail with your own words:

i) What is meant by "a time-selective channel"?

ii) Why is diversity needed in Rayleigh fading channels?

iii) Determine at least two important properties of CPM-signals.

(10 points)

Problem 4:

a)
Consider the transmitter in Figure 8.6a) on page 510 in the compendium. It is here assumed that the received signal $r(t)$ is $r(t) = -0.5s(t) + N(t)$, where $N(t)$ is AWGN.

It is known that the accumulated squared Euclidean distances below are saved by the VA after processing the received vector $r[i]$.

The saved value at state 0,1,...,7 is, $6.5a^2, 6.6a^2, 6.8a^2, 6.4a^2, 6.7a^2, 6.55a^2, 6.75a^2$, and $6.45a^2$, respectively.

Assume now that the next received vector $r[i+1]$ is such that $r_1[i+1] = 0$ and $r_2[i+1] = 0.25a$.

Calculate what will be stored by the VA in state number 4 after processing the received vector $r[i+1]$.

b)
Consider the transmitter in Figure 8.6a) on page 510 in the compendium. A person claims that the corresponding VA at the receiver side will never produce a signal sequence decision that contains the sub-sequence: $s_7, s_2, s_5, s_1, s_0, s_2$.

Determine if the person is correct, or not.

(10 points)

Problem 5:
Consider a communication link where the eight equally likely received signal alternatives are represented in a two-dimensional signal space as ("tr" means transpose):

$$\mathbf{z_0} = -\mathbf{z_2} = (6a, 6a)^{tr}$$
$$\mathbf{z_1} = -\mathbf{z_3} = (-6a, 6a)^{tr}$$
$$\mathbf{z_4} = -\mathbf{z_6} = (3a, 0)^{tr}$$
$$\mathbf{z_5} = -\mathbf{z_7} = (0, 3a)^{tr}$$

where a is a positive value. AWGN and ML symbol receiver are assumed.

i) Determine the decision region for message 4.

ii) Assume that message 4 is sent, and also that the noise component $w_2 = -2a$. For which values of w_1 will then a symbol error be obtained? The more precise your answer is, the better.

iii) Assume that message 3 is sent, and also that the noise component $w_2 = -2.5a$. For which values of w_1 will then a symbol error be obtained? The more precise your answer is, the better.

(10 points)
