Final exam in

Digital Communications, Advanced Course (ETTN01)

on April 20, 2020.

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- 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 5/6 encoder in combination with 64-ary bandpass PAM has a smaller bandwidth efficiency than a rate 3/4 encoder with 16-ary QAM."

b) "In MIMO the N_t transmitted signals occupy the same frequency interval, and also the same time interval."

c) "The decision regions for an ML-receiver will depend on the signal attenuation, for all conventional (square) M-ary QAM received signal constellations."

d) "For a rate 3/4 encoder in combination with 32-PSK, 3.75 information bits are transmitted each signaling (symbol) interval."

e) "Diversity should be used if the channel-parameters are known at the transmitter."

(10 points)

Problem 2:

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

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

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

i) Assume that message 1 is sent, and that the noise component $w_1 = a/4$. For which values of the noise component w_2 will the receiver decide that message 4 was sent?

ii) Assume that message 3 is sent. Calculate the probability that the receiver decides that message 7 was sent if a^2/N_0 is 8.585372 dB.

b) Consider a communication link where the two equally likely received signal alternatives are represented in a four-dimensional signal space as:

$\mathbf{z_0} = (-a/4, 2a, a/2, -a/4)^{tr}$
$\mathbf{z_1} = (a, a, -a/2, -a/2)^{tr}$

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

Calculate the bit error probability if $\mathcal{E}_b/N_0$ is 12.9 dB.

(10 points)

Problem 3:

Consider the basic Shannon capacity expression.

a) The communication link to a user is such that the ratio $P_z/N_0 = 10^9$.

i) Here $C/W = 2.5$. Calculate C and W.

ii) Make a plot that shows C versus W, for $0 \leq W \leq 2Ghz$.

b) The communication link to the same user is now such that the ratio $P_z/N_0 = 10^9/4$.

i) If possible, determine an approximate value of W such that the capacity is 435 Mbps.

ii) If possible, determine an approximate value of W such that the capacty is 270 Mbps.