INSTITUTE OF TECHNOLOGY
LINKÖPINGS UNIVERSITET

Exam in TSKS04 Digital Communication Continuation Course

Exam code: TEN1

Date: 2014-03-17 **Time:** 8:00–12:00

Place: U3

Teacher: Mikael Olofsson, tel: 281343

Visiting exam: 9 and 11

Administrator: Carina Lindström, 013-284423, carina.e.lindstrom@liu.se

Department: ISY

Allowed aids: Olofsson: *Tables and Formulas for Signal Theory*
Upamanyo Madhow: *Fundamentals of Digital Communication*, Cambridge University Press, 2008.

Number of tasks: 5

Solutions: Will be published within three days after the exam at http://www.commsys.isy.liu.se/TSKS04

Result: You get a message about your result via an automatic email from Ladok. Note that we cannot file your result if you are not registered on the course. That also means that you will not get an automated email about your result if you are not registered on the course.

Exam return: 2014-04-07, 12.15–13.00, Mikael Olofssons office, Building B, top floor, corridor A between entrances 27–29. After that in the student office of Dept. of EE. (ISY), Building B, Corridor D, between Entrances 27–29, right next to Café Java.

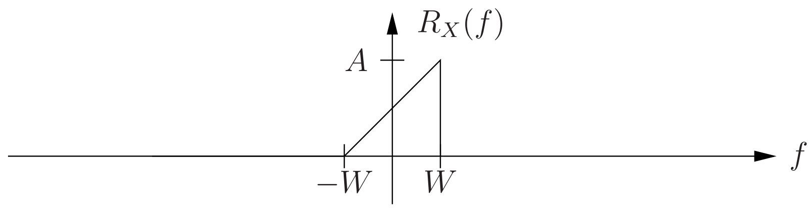
Important: Solutions and answers must be given in English.

Grading: This exam consists of five problems. You can get up to five points from each problem. Thus, at most 25 points are available. Grade limits:

- Grade three: 12 points,
- Grade four: 16 points,
- Grade five: 20 points.

Sloppy solutions and solutions that are hard to read are subject to hard judgement, as are unreasonable answers.

1 A complex baseband process with PSD according to the graph below is upconverted as in the left half of Figure 2.9 in Madhow. (5p)

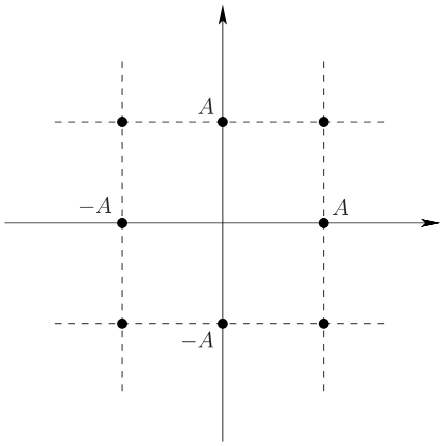


The resulting passband signal is subject to additive WGN with PSD $N_0/2$. This disturbed signal is then downconverted to a complex baseband signal according to the right half of Figure 2.9 in Madhow. The signal and the noise are of course independent.

Determine the SNR of the resulting baseband signal.

2 Solve task 4.3 a and b on pages 190-191 in Madhow. (5p)

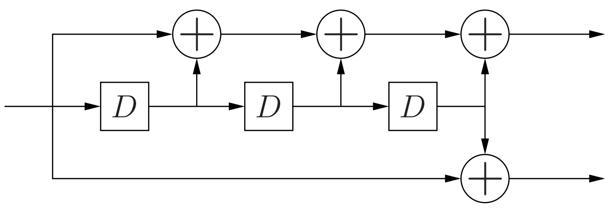
3 The eight signal points (symbols) in the following constellation are equally probable, and subsequent symbols are independent. (5p)



Determine the PSD of the process if the two basis functions are

$$\phi_1(t) = \sqrt{\frac{1}{T}}\,\mathrm{rect}\left(\frac{t}{T}\right)$$
$$\phi_2(t) = \sqrt{\frac{1}{T}}\left(\mathrm{rect}\left(\frac{t+T}{2T}\right) - \mathrm{rect}\left(\frac{t-T}{2T}\right)\right)$$

4 Consider the following convolutional encoder. (5p)



a. Show that the corresponding generator matrix is catastrophic.

b. Give a non-catastrophic generator matrix and encoder of the same code.

c. Determine the free distance of the code.

5 Consider communicating data using 8-ASK with symbol rate $1/T$. The transmit filter, channel and receive filter have the impulse responses (5p)

$$g_{\mathrm{TX}}(t) = \mathrm{rect}\left(\frac{t}{T/2}\right), \quad g_{\mathrm{C}}(t) = \mathrm{rect}\left(\frac{t}{3T/2}\right), \quad g_{\mathrm{RX}}(t) = \mathrm{triangle}\left(\frac{t}{T/2}\right),$$

respectively. The channel also adds white Gaussian Noise. Let $z[k]$ denote the receive filter output sampled at time instance $kT_{\mathrm{s}} + \tau$, where T_{s} is a sampling interval to be chosen and τ is some time-shift, also to be chosen.

a. Show that ML sequence detection using the samples $\{z[k]\}$ is possible, given an appropriate choice of T_{s} and τ. Specify the corresponding choice of T_{s} and τ.

If ML sequence detection is not possible for any choice of T_{s} and τ, then show that that is the case.

b. How many states are needed in the trellis for implementing ML sequence detection using the Viterbi algorithm?

In the case that ML detection is not possible, suggest an alternative choice of sender and/or receiver filter to make ML sequence detection possible.

Note: There may very well be more than one solution to this problem. It is enough to find one of them.