



## Exam in TSKS04 Digital Communication Continuation Course

- Exam code:** TEN1
- Date:** 2014-08-22      **Time:** 8:00–12:00
- Place:** TER2
- 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:** 2014-09-16, 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 Consider communicating data using 4-ASK with symbol rate  $1/T$ . The transmit filter, channel and receive filter have the impulse responses (5 p)

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

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

- Show that ML sequence detection using the samples  $\{z[k]\}$  is possible, given an appropriate choice of  $T_s$  and  $\tau$ . Specify the corresponding choice of  $T_s$  and  $\tau$ . *If ML sequence detection is not possible for any choice of  $T_s$  and  $\tau$ , then show that that is the case.*
- 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.

- 2 Solve task 3.8 on page 139 in Madhow. (5 p)
- 3 Solve task 4.12 (parts a and b) on page 197 in Madhow. (5 p)
- 4 Solve task 5.9 (parts c and d) on page 247 in Madhow. (5 p)

5 Consider the two generator matrices

(5 p)

$$G_1(D) = \begin{pmatrix} 1+D & D & 1 \\ D^2 & 1 & 1+D+D^2 \end{pmatrix},$$
$$G_2(D) = \begin{pmatrix} 1 & 1+D+D^2 & D^2 \\ 1+D & D & 1 \end{pmatrix}.$$

- a. Show that the matrices are equivalent in the sense that they generate the same convolutional code.
- b. Is any of the two generator matrices catastrophic?
- c. Draw an encoder that is defined by  $G_1(D)$ .