Wednesday 1 May 2013; Duration: 13h30 à 15h20
No documents allowed; a calculator is allowed

Problem 1 (25 points over 100)

The following is the generator matrix for an (8,4) block code.

$$G = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

error vector	syndrome
00000000	0000
00000001	
00000010	
00000100	
00001000	
00010000	
00100000	
01000000	
10000000	

A. (10 points) Complete <u>the sheet provided</u> (<u>last page of the exam)</u> and place the sheet in your blue exam booklet. Complete the syndrome table for error vectors with one bit in error.

B. (15 points) For the three received vectors given below,

1. $\begin{bmatrix} 0\,1\,1\,0\,0\,0\,1\,0 \end{bmatrix}$

2. $\begin{bmatrix} 1\,1\,1\,0\,0\,0\,0\,1 \end{bmatrix}$

3. $\begin{bmatrix} 0\,0\,1\,0\,0\,0\,0\,1 \end{bmatrix}$

specify the following.

- There are no errors and the transmitted message is _____
- There is one bit error and the transmitted message is _____
- There is more than one bit in error

Problem 3 (30 points over 100)

The following is the state diagram for a convolutional code. Code words are written next to each possible state transition. The initial state is "a", the state where all registers contain zero.
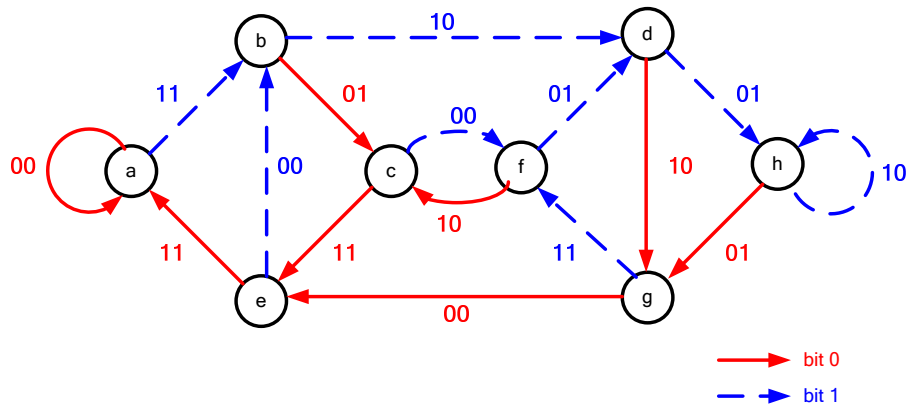
A. (5 points)   What is the constraint length of the code? What is the code rate?

B. (15 points)   Complete the sheet provided (last page of the exam) and place the sheet in your blue exam booklet. For each state, indicate the register contents in the boxes provided. For each transition in the trellis, indicate the code word in the box provided.

C. (10 points)   What is the Hamming distance for the path indicated below? In other words, what is the distance between the path indicated and the path made up exclusively of states "a"?
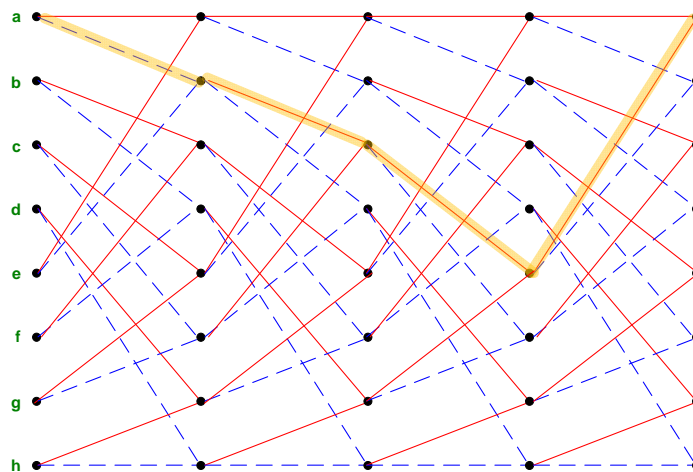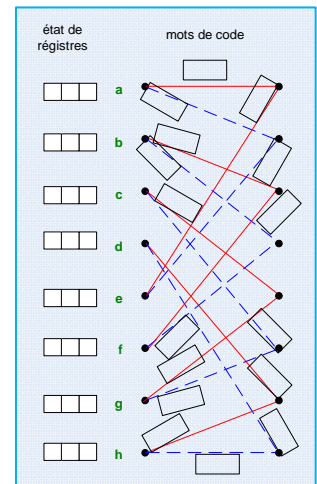
Problem 3 (25 points over 100) OFDM

An OFDM system uses

- 200 subcarriers for data transmission,
- 40 subcarriers for tones for channel estimation, and
- 20 subcarriers for guard bands.

16QAM is used on each subcarrier. The spacing between subcarriers is 15 kHz. A guard time of 20% is added (in the form of an cyclic extension) for all transmissions.

A. (5 points)   What is the total system bandwidth?

B. (10 points) What is the transmission rate if we do not use error correcting codes?

Now consider the possibility of adding error correcting codes and their impact on the transmission rate after coding (the useful transmission rate).

C. (10 points) Suppose the channel delay is 8 μs. What coding rate is required and what will be the useful transmission rate?

Problem 4 (25 points over 100) Spread spectrum

A. (20 points) Why and under what circumstances is a RAKE receiver used?

> The following points should be covered in your response
> - Is spread spectrum needed or not? Why?
> - The importance of channel delay,
> - Are multiple paths are needed or not? Why?

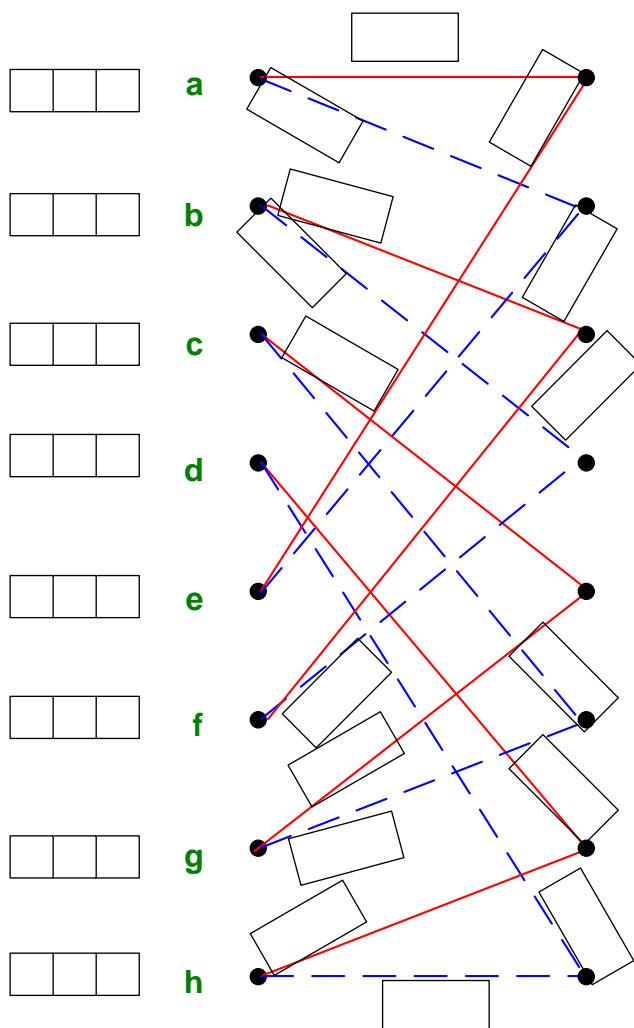B. (5 points) Give a sketch of a RAKE receiver for a channel with two reflections, i.e.,

$$h(t) = \delta(t - 3\ \mathrm{ms}) + .5\delta(t - 5\ \mathrm{ms})$$
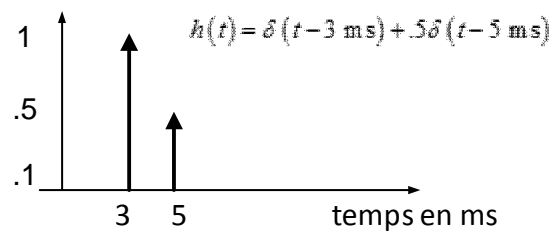
Sheet to return in blue exam booklet

Problem 1

error vector	syndrome
0 0 0 0 0 0 0 0	**0000**
0 0 0 0 0 0 0 1	
0 0 0 0 0 0 1 0	
0 0 0 0 0 1 0 0	
0 0 0 0 1 0 0 0	
0 0 0 1 0 0 0 0	
0 0 1 0 0 0 0 0	
0 1 0 0 0 0 0 0	
1 0 0 0 0 0 0 0	

Matricule :   **Name :**

Sheet to return in blue exam booklet

Problem 2

register states

code words

a

b

c

d

e

f

g

h

Matricule :   **Name :**