Final exam in

Modern Wireless Systems - LTE and Beyond (ETTN15)

on October 21, 2013, 08–13.

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- During this final exam, you are allowed to use a calculator and the course book.
- Each solution should be written on a separate sheet of paper.

  Please write Your name on each sheet, and number each sheet.
- Show the line of reasoning clearly, and use the methods presented in the course.

  If You use results from the course book, 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) "In LTE Rel-10 bit rates up to 600 Mbps can be obtained within a 20 MHz bandwidth."

b) "In LTE transmit diversity is supported in MBSFN transmission."

c) "In LTE both SRS and CRS can be used in the uplink."

d) "In LTE the terminal should never try to communicate with the base station before it has received an uplink timing command."

e) "In LTE code-book based precoding with eight transmitting antennas achieves very high bit rates if the channel is very good."

(10 points)

Problem 2:

Consider downlink transmission to a specific Rel-8/9 terminal in LTE, and assume that the normal cyclic prefix is used.

a) How large part, in %, of a resource block pair can be used for control- and information-signals if:

i) one transmitting antenna is used?

ii) two transmitting antennas are used?

iii) four transmitting antennas are used?

b) Give four examples of what kind of control information that can be contained in the control region, and also the purpose of that control information.

c) Here we consider downlink transmission in OFDM interval number 8 within a sub-frame, and for simplicity we assume contiguous frequency resource block allocation to the specific terminal.

In this OFDM interval let $s_i(n)$ denote the symbol that is sent in the n:th sub-carrier from the i:th transmitting antenna, n=1,...,N_c, i=1,...,N_t.

Consider OFDM interval number 8, and let $z_j(m)$ denote the output value from the DFT at the j:th receiving antenna, j=1,...,N_r, corresponding to the m:th sub-carrier.

Determine an expression for $z_j(m)$.

(10 points)

Problem 3:

Consider a cell containing several LTE-terminals.The current cell has four neighboring cells, denoted A, B, C and D.

It is known that:

Terminal 1 (T_1) is far from the base station and close to the cell edge (close to the cell border to neighboring cell A). The channel conditions to and from terminal 1 are very poor. Terminal 2 (T_2) is close to the base station, and the channel conditions to and from terminal 2 are very good. The channel conditions to and from terminal 3(T_3) are clearly better than for terminal 1, but clearly worse than for terminal 2.

a) Is it a reasonable scheduling strategy to assign many resource blocks within each of several sub-frames to terminal 1, in order to try to deliver a very high information bit rate to this user?

b) Explain in detail why the interference situation for terminal 1 is different in the downlink compared with the uplink.

c) Assume uplink transmissions from terminal 1 and terminal 2. Furthermore, assume errors in the uplink timing-advance commands. Explain in detail what kind of consequences these errors can cause.

(10 points)

Problem 4: Consider the uplink from a specific LTE Rel 8/9 terminal.

a) Assume that a specific UE is assigned 6 resource block pairs for uplink transmission in the current sub-frame, and that another terminal sends a wideband reference signal in the same sub-frame, aimed for uplink channel state estimation.

How many resource elements can then be used for PUSCH transmission in the current sub-frame?

b) Explain how L1/L2 control signals are sent in the uplink.

c) Here we consider the first OFDM interval within a specific subframe.

Let **a** denote the input vector of modulation symbols to the DFT in the terminal. Let **z** denote the corresponding vector obtained at the output of the DFT at receive antenna number four in the base station.

Determine the relationship between the vectors **z** and **a**. What are your conclusions?

(10 points)

Problem 5:

a) In LTE uplink the peak bit rate is 1.5 Gbps. Give examples of assumptions, the more the better, for which this peak bit rate is claimed to be reached.

b) In LTE downlink, there are several changes/differences between using non-codebook-based precoding and using codebook-based precoding.

Explain what changes/differences there are (the more the better).

c) Consider a MU-MIMO system with 2 transmitting antennas at the base-station. Furthermore, assume two suitable terminals each having one receiving antenna. Consider a specific resource-element. Assume that the QAM-symbol x_1 is aimed to terminal 1, and the QAM-symbol x_2 is aimed to terminal 2.

A 2x2 precoding matrix W is first applied to the vector $(x_1 x_2)^{tr}$ before transmission.

Determine the four elements in the precoding matrix W such that the QAM-symbol x_1 only appears in terminal 1, and not in terminal 2. Furthermore,the QAM-symbol x_2 should only appear in terminal 2, and not in terminal 1.

(10 points)
