

Final exam in Modern Wireless Systems - LTE and Beyond (ETTN15)



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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 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.

- “There are no applications in LTE that uses only a single transmitting antenna.”
- “Down-link channel-dependent scheduling is always used in LTE.”
- “Roughly 2/3 of the total communication resources in LTE can at most be used for up-link data communication.”
- “The use of MIMO (e.g., 4x4) implies a high spatial multiplexing gain.”
- “In LTE L1/L2 control signals are always sent in the beginning of a sub-frame.”

Problem 2:

- a) Specify specific advantages, the more the better, of the OFDM technique that makes it suitable for LTE applications.
- b) Assume LTE DL using codebook-based antenna precoding. 4 transmit antennas and 2 receive antennas are assumed. Let $y_{0,1}, y_{0,2}, y_{0,3}, y_{0,4}$ denote the values present at the corresponding transmit antennas (and which are sent in the same specific resource element).
 - i) Specify in detail the values that are obtained in the receiver corresponding to the same specific resource element as above.
 - ii) Extend the answer in i) such that also the precoder is visible in the description of the values that are obtained in the receiver.

(10 points)

Problem 3:

- a) Some special kind of signals in LTE occupy resource blocks, and hence these resource blocks cannot be used for user-data communication.

Give examples of such special signals, the more the better, and also explain the purpose of these signals.

- b) Explain in detail how, in LTE, the OFDM time-frequency grid is organized and used:
 - i) in the DL. ii) in the UL.

- c) An important concept in LTE is channel-state information.

- i) Explain in detail why channel-state information is important.
- ii) Explain in detail how channel-state information is obtained.

(10 points)

Problem 4:

- a) Assume DL communication to Rel-8/9 Category 4 terminals. DL data to 25 terminals need to be communicated. The amount of data to each terminal corresponds to 9 RB pairs.

- i) Suggest how to organize the DL-communication to these 25 terminals.
- ii) For one of the users (terminals), estimate the user-data carrying coded bit rate if 16-QAM is used. The assumptions that you make should, as usual, be clearly stated.

- b) Explain why, and how:

- i) CRS are used in LTE. ii) DM-RS are used in LTE.

(10 points)

Problem 5:

a) The spectrum emission mask is of considerable importance.

i) What is the reason why the spectrum emission mask is needed?

ii) Why is the spectrum emission mask important.

b) Consider a terminal at the cell-edge. If no counter-measures are made:

i) What kind of disturbances may then disturb up-link communication from this terminal.

ii) What kind of disturbances may then disturb down-link communication to this terminal.

iii) Suggest counter-measures to reduce the disturbances in i).

c) Within roughly the last 1.5 years several new Rel-11 and Rel-12 UE Categories have been defined by 3GPP. One of them is Rel-11 Category 9 (which is commercialized in some countries).

The peak DL information bit rate for this category is 450 Mbps.

Suggest at least two possible technical solutions such that this peak data rate can be achieved.

Which of your solutions do you recommend, and why?

(10 points)
