

COMM.SYS.450 Multicarrier and Multiantenna Techniques, 5 cr

Exam on Thursday 22.09.2022 / Prepared by Taneli Riihonen

Calculator or any material is not allowed.

You may answer in English or in Finnish.

1. [6 p] Explain briefly (2–3 sentences) what the concepts mean.
 - a) [1 p] **in-band distortion**
 - b) [1 p] **out-of-band emission**
 - c) [1 p] **discrete multitone (DMT)**
 - d) [1 p] **diversity gain**
 - e) [1 p] **multiplexing gain**
 - f) [1 p] **Alamouti scheme**

2. [6 p] (*Essay*) Explain the principles of common multicarrier techniques and compare their advantages and disadvantages to single-carrier transmission.

3. [6 p] Consider CP-OFDM transmission over a time- and frequency-selective channel.
 - a) [3 p] Assume bandwidth is 20 MHz, channel delay spread is 3 μ s at maximum, timing error is less than 1 μ s, and the design target is to have about 10% overhead due to the cyclic prefix. How would you choose the basic physical-layer OFDM parameters? Why?
 - b) [1 p] What prevents one from making the overhead due to the cyclic prefix vanishing by choosing the subcarrier spacing to be very narrow?
 - c) [2 p] Assume subcarrier spacing is 10 kHz and the cyclic prefix adds 10% overhead. How would you choose the time–frequency reference symbol grid efficiently if channel coherence time is 1 ms and coherence bandwidth is 200 kHz? Why?

4. [6 p] The signals, r_a and r_b , received through two antennas can be expressed for a certain multiantenna technique that transmits a single symbol, s_a , as follows:
$$r_a = h_1 w_1 s_a + n_a$$
$$r_b = h_2 w_2 s_a + n_b$$
 - a) [2 p] What kind of a multiantenna technique is this? What is its purpose?
 - b) [2 p] How w_1 and w_2 are chosen to benefit from multiantenna operation?
 - c) [2 p] What is the corresponding signal model for closed-loop transmit diversity?

5. [6 p] Mention two *different* modern standardized communication systems and explain in detail what/how multiantenna techniques are implemented therein.

Total maximum: 30 points.