HELSINKI UNIVERSITY OF TECHNOLOGY **Exam, October 30th, 2007**
Signal Processing Laboratory
S-88.4175 Signal Processing in Wireless Communications (4 cr)

Write in each answer paper your name, department, student number, the course name and code, and the date. Number each paper you submit and denote the total no. of pages. 4 problems, 24 points total. Exam problems in English only. Please feel free to answer in Finnish or English. No additional material is allowed in the exam.

1. (1p each) Define/describe/discuss *briefly* the following concepts:
   (a) Channel coherence time
   (b) Pairwise error probability
   (c) Co-phase closed-loop transmit diversity
   (d) Optimal codeword design principle for closed-loop transmit diversity algorithms
   (e) Multiuser diversity
   (f) Opportunistic beam-forming
2. (6p) Consider a MIMO system with 2 transmit and 2 receive antennas. Show that the capacity of the system when employing transmit diversity only is smaller than that of the system when using spatial multiplexing (i.e., parallel data pipes).
3. (6p) Design an orthogonal space–time code for real symbols with four transmit antennas, symbol rate one, and diversity order four.
4. (6p) Consider two transmit antennas and closed-loop antenna selection algorithm. Show that the diversity of the antenna selection equals one in case of feedback errors.