Eurecom

Digital Communications

Final Examination

Date: February 15th, 2022

Duration: 2 hours

You are to complete ALL of the following questions. All documents are allowed. All questions should be answered with short and precise statements

1 General OFDM

For the first set of questions consider a 5G OFDM system configuration with sampling rate 245.76 Msamples/s using a 2048-point DFT with bandwidth stemming from the use of 1584 non-zero carriers (resource elements) carrying data and/o reference signals. Assume that the channel size is 200 MHz. The center carrier is not nulled out but the highest-frequency carriers are so that the non-zero carriers are equally spaced on both sides of the frequency spectrum. In total, there are 132 resource blocks containing 12 OFDM subcarriers (Reource Elements) each. There are 112 OFDM symbols per 1ms period. Symbols 0 and 56 have a cyclic-prefix of length 272 samples, and the remaining 110 symbols have a cyclic prefix of length 144 samples. Slots contain 14 time-consecutive symbols.

    a)   What are the two possible symbol durations and slot durations?
    b)   How many slots are there per 1ms subframe?
    c)   What is the carrier-spacing?
    d)   Assuming we use 64-QAM modulation, what is the the spectral-efficiency and maximum date rate of the system, assuming that we include the guard-band inside the channel?
    e)   What is the maximum channel duration of the system?
    f)   Would this system be more or less tolerant to multipath channel duration than the configuration we considered in the class lab sessions?

2 Understanding of the lab sessions

    a)   Explain why we said the three PSS signals are quasi-orthogonal.
    b)   In Lab1, we considered the random-delay and frequency-offset to be additional hypotheses. Why were these two unknown parameters quantized?
    c)   Explain why the output of the PSS correlator had one strong peak and sometimes several other smaller peaks.
    d)   What is the difference between the signal in c) and SSS channel estimates converted to the time-domain as we did in lab session 2?
    e)   What is the dimensionality and data-rate of the SSS trasmission?

f) Why would the SSS constellation after channel compensation be rotated?
g) What is the sub-carrier spacing and bandwidth of the PRACH waveform considered in Lab3
h) Explain how the trade-off between the number of sequences and cyclic-shifts controls the ability of the receiver to cope with time-delay in detecting the PRACH preamble.
i) Why would the basestation receiver want to estimate the time-delay of the PRACH preamble?