Eurecom

Digital Communications

Final Examination

Date: February 14th, 2023

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 30.72 Msamples/s using a 1024-point DFT with bandwidth stemming from the use of 612 non-zero carriers (resource elements) carrying data and/o reference signals. Assume that the channel size is 20 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 51 resource blocks containing 12 OFDM subcarriers (Reource Elements) each.   There are 28 OFDM symbols per 1ms period. Symbols 0 and 14 have a cyclic-prefix of length 88 samples, and the remaining symbols have a cyclic prefix of length 72 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 256-QAM modulation, what is 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 there are some time-delays where we are more likely make a wrong decision in the receiver for PSS signals.
   b) In Lab1, we considered the random-delay and frequency-offset to be additional hypotheses. Do you think it would help to consider finer quantization of either time or frequency?
   c) Explain why there were secondary peaks at the output of the PSS correlator compared to the dominant one.
   d) What is the difference between the signal in c) and the frequency-domain channel estimates using the correct PSS signal converted to the time-domain via the IFFT as we did in lab session 2?

e) Is all the possible SSS transmissions linearly independent of each other?
f) How did we suggest to remove any residual rotation of the SSS constellation after channel compensation in lab 2?
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?