Eurecom
Digital Communications

Final Examination

Date: February 11th, 2020

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 122.88 Msamples/s using a 1024-point DFT with bandwidth stemming from the use of 792 non-zero carriers (resource elements) carrying data and/or reference signals. Assume that the channel size is 100 MHz. The center carrier is **NOT** nulled out but the highest-frequency carriers are so that the non-zero carriers are in positions $k = 0, 1, \cdots, 395, 628, 629, \cdots, 1023$ in the FFT vector. There are 112 OFDM symbols per 1ms period. Symbols 0 and 56 have a cyclic-prefix of length 80 samples, and the remaining 110 symbols have a cyclic prefix of length 72 samples. Slots contain 14 time-consecutive symbols. Zero samples are inserted in between subframes in the time-domain to fit a 1ms subframe duration.

1. What are the two possible symbol durations and slot durations?
2. How many slots are there per 1ms subframe?
3. How many zero samples need to be inserted between subframes?
4. What is the carrier-spacing?
5. 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?

6. What is the maximum channel duration of the system?

7. Would this system be more or less tolerant to multipath channel duration than 4G (i.e. the numbers we considered in the class lab sessions)?

2 Understanding of the lab sessions

1. What is the dimensionality and data-rate of the PSS transmission?

2. In Lab1, we considered the random-delay to be an additional hypothesis. How many resulting hypotheses were there?

3. What were we trying to see when we transformed the output of the PSS correlator to the time-domain?

4. Explain why we converted the SSS and PBCH channel estimates to the time-domain.

5. How did we control the accuracy in measuring the frequency-offset of the receiver using the PSS?

6. What is the dimensionality and data-rate of the SSS trasmission?

7. How did we augment the number of detection hypostheses of the SSS to resolve the 5 ms ambiguity after detecting the PSS.

8. In order to esimtate the channel for detection of the PBCH, why did we need to interpolate both in time and frequency? What interpolation methods could be used?

9. How was the transmit signal designed so that the reference signals for the two transmit antennas do not interfere with each other?

10. If the channel from one of the antennas is severely attenuated and not the other, explain why the system is robust with respect to detection of the PBCH.

11. Explain heuristically what you should do to detect PSS/SSS/PBCH if the receiver has 2 antennas instead of one. Assume that both the noise and channel impulse responses is independent and identically distributed on both antenna ports.