# Radio Engineering: Second Lab Session

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## 1 Introduction

LTE (short for Long Term Evolution) is a mobile communication standard developed by the 3GPP (3rd Generation Partnership Project). It is a mobile communication standard of the 4th generation, meaning it is designed of all-IP data-only traffic. On the physical layer LTE uses OFDMA on the downlink and SC-FDMA on the uplink.

Eurecom has implemented a subset of the functionalities of the LTE physical layer on its experimental platform, the OpenAirInterface[1]. An extensive measurement campaign has been carried out in a rural environment in the TARN department in south-west France in collaboration with the French space agency (CNES).

In this lab session these measurements will be used to put the channel characterization methods from the lecture into practice.

## 2 Channel Measurements

### 2.1 Testbench Configuration

The LTE configuration used by the Eurecom testbench is given by the following parameters:

- 25 Resource Blocks (7.68MHz sampling rate, FFT size 512)
- Carrier frequency 859.6 MHz
- TDD UL/DL Frame Configuration 3 (6 DL subframes, 3 UL subframes, 1 S subframe)
- Special subframe configuration 0 (longest guard interval)
- OFDM symbol length 66.7 $\mu$s, cyclic prefix length 16.7 $\mu$s

### 2.2 Measurement Description

The measurement data is stored in the file `rx_power.mat`[2].

The file contains two variables:

- `rx_power_dBm` the received power in dBm, one sample per 10ms.

[1] `http://www.openairinterface.org`
[2] The file can also be downloaded from the course webpage

- `H2` the time-variant transfer function. The resolution is again 10ms in the time domain (second dimension). In the frequency domain (first dimension) the channel has been sampled using the LTE pilot pattern. This means that the total bandwidth of 7.68MHz has been divided into 512 subcarriers out of which 50 subcarriers contain pilots and can thus be measured. The pilots are spaced 6 subcarriers (corresponding to 90kHz) apart and are placed in the lower and higher subcarriers (excluding the DC subcarrier), corresponding middle 4.5MHz of the spectrum. More precisely, the position of the pilots (in terms of subcarriers, starting from the DC component) is given by[3]

  $$[2 + 6 * (0 : 24) + \nu, \quad 363 + 6 * (0 : 24) + \nu],$$

  where $\nu = 0$ in our case.

  The easiest way to convert the time-variant transfer function to the time-variant impulse response is by applying a simple ifft operation along the first dimension, using an ifft size of 50 (Since the first subcarrier is the DC we do not need to apply any additional ifftshift operation). Since the 50 samples occupy 4.5MHz, the resolution in the delay-time domain will be 1/4.5MHz $\approx$ 222ns.

# 3 Tasks

1. Use a moving average filer over 100 samples to extract the large scale fading from the power measurements (Hint: have a look at the function `smooth`). Substract the large scale fading from the measurements to get the small scale fading. Plot the measurements as well as the two extracted fading processes vs time in the same figure.
2. Plot a histogram of the large scale fading (on a log scale). Compute the mean and the variance and overlay the histogram with the pdf of a lognormal distribution of those parameters (Hint: have a look at function `histfit`). Discuss the result.
3. Plot a histogram of the small scale fading and and overlay the histogram with the pdf of a Rayleigh, a Ricean and a Nakagami distribution (Hint: have a look at function `histfit`). Discuss the results.
4. Using the original time-variant transfer function `H2`, calculate and plot the power delay profile making sure you label the axes correctly. Further compute the total power, the average mean delay, the average rms delay spread, and the coherence bandwidth. Explain how you calculated each value and discuss the results.

[3]We use Matlab notation, i.e., indexing starts at 1!