ELEC-H-415 Communication channels
Labs

1 Objectives

This lab consists in measuring and modeling the GSM channel. The power of a GSM-BCCH channel will be measured in a urban environment, and then analyzed and modeled.

2 Assessment

You have to submit a report by Friday 27th May. This report will be 15 pages long max. It must include the experimental procedure, all results, analyzes and models.

3 Measurements

3.1 Lab 1 : Preparation

Measurements are carried out by using a *Rohde & Schwarz TSMQ Radio Network Analyzer* driven by a computer with the software ROMES 3NG. At the end of this session be sure to have an experimental procedure, and also to be able to use the software ROMES 3NG. The experimental procedure must contain all information about the base station, the operator and the available channels. All details on how to find the information and how to prepare the campaign will be given during the lab.

Work

– Prepare the route for the measurement
– Define the experimental procedure as a step-by-step process.

3.2 Lab 2 : Measurements

Measurements will be done on appointment. Each group has to be present at the fixed time to start the measurement campaign.

TABLE 1 – Measurement timetable for Friday, April 15

12.30am	1.15pm	2pm	2.45pm	3.30pm	4.15pm
Group 1	Group 2	Group 3	Group 4	Group 5	Group 6

Table 2 – Measurement timetable for Tuesday, April 19

8.45am	9.30am	10.15am	11am	11.45am	12.30am
Group 7	Group 8	Group 9	Group 10	Group 11	Group 12

4 Path loss and shadowing

A MATLAB code will be provided to extract the power, the latitude and longitude of every measurement points. It will also plot the received power on a *Google map* just as in Figure 1.

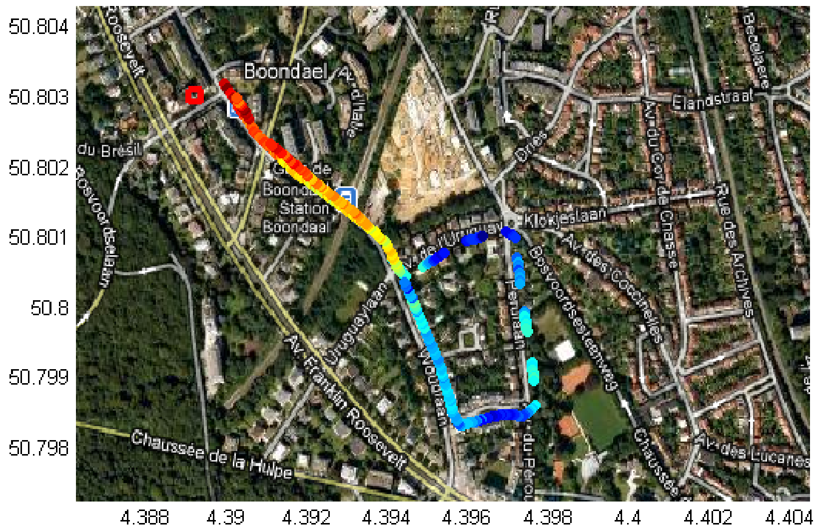

Figure 1 – Received power from a base station near ULB.

4.1 Post-processing

Work

- Extract the valid data's, by removing events like stops or red lights.
- Plot your measurements on a Google Map and as a function of distance to the base station.

4.2 Path loss

Work

- Extract the Path Loss
- Give an empirical path loss model
- Deduce the maximal cell radius (without shadowing)

4.3 Shadowing

Work

- Extract the Shadowing
- Give a statistical shadowing model
- Evaluate the shadowing correlation distance r_c (for $\rho < 0.37$)
- What is the maximal cell radius if a 90% connection probability at the cell edge is chosen ? What is the maximal cell radius if 95% connection probability is required through the whole cell ?

4.4 Correlated shadowing model

Figure 2 gives a method for generating a correlated shadowing process where v is the speed of the mobile, σ_L the variability in dB, r_c the correlation distance, and a is defined as $a = e^{-vT/r_c}$

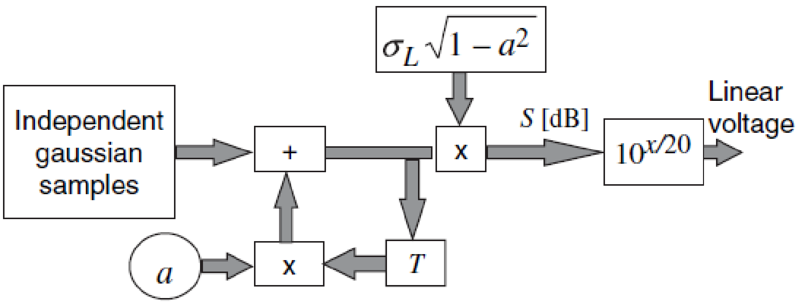

FIGURE 2 – Method for generating correlated shadowing process. Source : S.R. Saunders, *Antennas and Propagation for Wireless Communication Systems*, Wiley, 2007.

Work

- Develop a model that reproduces your measured path loss and shadowing.

5 Fast fading

5.1 Statistical model

Work

For several local areas :
- Extract the fast fading.
- Define a statistical model for the fast fading and compute the K-factor.
- Evaluate the channel coherence time.
- Evaluate the channel LCR and AFD as a function of the threshold.

MATLAB Tips For fitting the curve, you can use *Dfittool*. For calculating the K-factor, use $K = s^2/2\sigma^2$ where s and σ are the distribution parameters.

5.2 Doppler shift

The aim of this section is to evaluate the radial speed of the mobile (here the projected speed of the car) by identifying the main peak in the Doppler spectrum. In order to calculate the Doppler spectrum, you have to calculate the signal Power Spectral Density (PSD). If the signal is affected by a Doppler shift, its PSD will present a peak at the Doppler frequency of the signal. The *Blackman-Turkey* method can be used to find the Doppler spectrum. First normalize the received power (in a local area) from which the mean has been removed. Because the signal is finite, you have to use a Blackman window. Then compute the autocorrelation. Finally, compute the FFT of the result but notice that the PSD will be symmetrical around zero because we don't have the phase of the signal.

Work

– Evaluate the speed of the car during measurements by computing the Doppler spectrum

5.3 Impact on BER

The last step consists in evaluating the impact of the channel on the BER. For this purpose, you can take back your communication chain from *ELEC-H-401 Modulation and coding* with the BPSK modulation. Figure 3 shows the BER of Rice channels for different K-factors. As seen in *Chapter 4*, the Rayleigh channel case (K=0) can be understood by the "Railway hall effect".

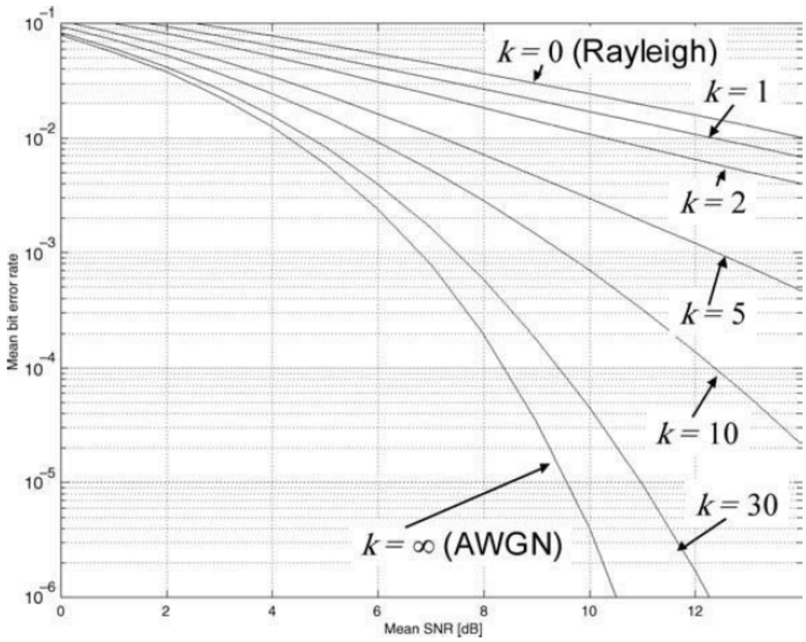

FIGURE 3 – BER for BPSK in Rice channel with $K = 0, 1, 2, 5, 10, 30$ *and* ∞. Source : S.R. Saunders, *Antennas and Propagation for Wireless Communication Systems*, Wiley, 2007.

Work

– Simulate the BER of a BPSK modulation for various channel K-factors