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

After having completed all the tasks presented here, you will give an oral presentation of your work at the last lab session. It will be a 15 minutes presentation about the lab and the FDTD project, followed by approximately 5 minutes of discussion.

3 Measurements

3.1 Lab 1 : Introduction

Lab objectives and tasks are briefly presented. An introduction to telecommunication services (GSM, UMTS, LTE) is given. Materials and methods for this lab are also presented : measurements will be carried out by using a *Rohde & Schwarz FSH8 Spectrum Analyzer*. Details about the base station antenna that will be measured are presented. Make sure to include some of this information in your presentation.

3.2 Lab 2 : Measurements

Measurements are done on appointment. See the introductory slides for the timetable.

4 Path loss and shadowing

Measurement data (time, latitude, longitude, received power) will be provided, as well as a MATLAB function to plot the received power on a *Google map* just as in Figure 1.

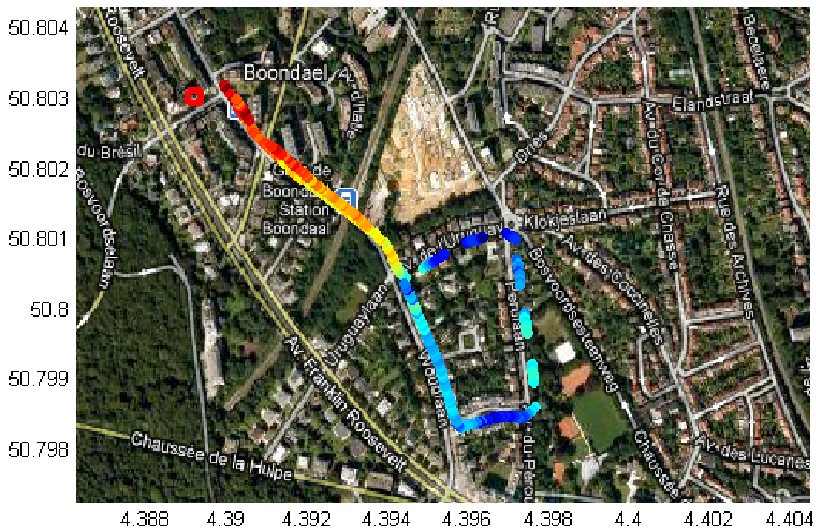

FIGURE 1 – Received power from a base station near ULB.

4.1 Post-processing

Work

- Plot the received power on a Google Map.
- Plot the received power as a function of the distance to the base station.

Tip The Haversine fomula gives the distance between two points given by their geographical coordinates. If $R = 6.371 \times 10^6 m$ is the earth radius, ϕ_1, ϕ_2 are the latitudes of points 1 and 2 in RADIANS, λ_1, λ_2 are the longitudes of points 1 and 2 in RADIANS, the distance d between point 1 and 2 is given by :

$$d = 2R\, arcsin\left(\sqrt{sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + cos(\phi_1)cos(\phi_2)sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right)$$

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 $a = e^{-vT/r_c}$

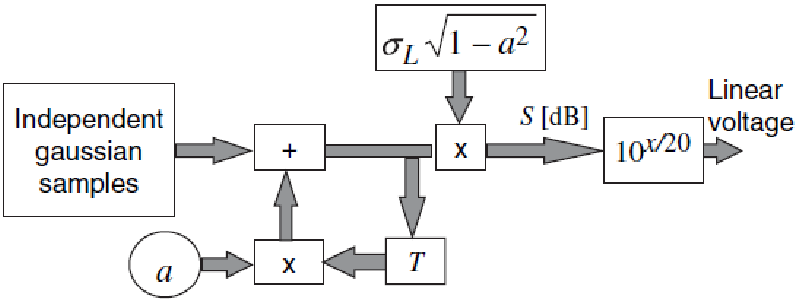

FIGURE 2 – Method for generating correlated shadowing process. Source : S.R. Saunders, *Antennas and Propagation for Wireless Communication Systems*, Wiley, 2007.

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 Tip 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 Impact on BER

The last step consists in evaluating the impact of the channel on the BER. For this purpose, you can reuse the communication chain that you designed for *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".

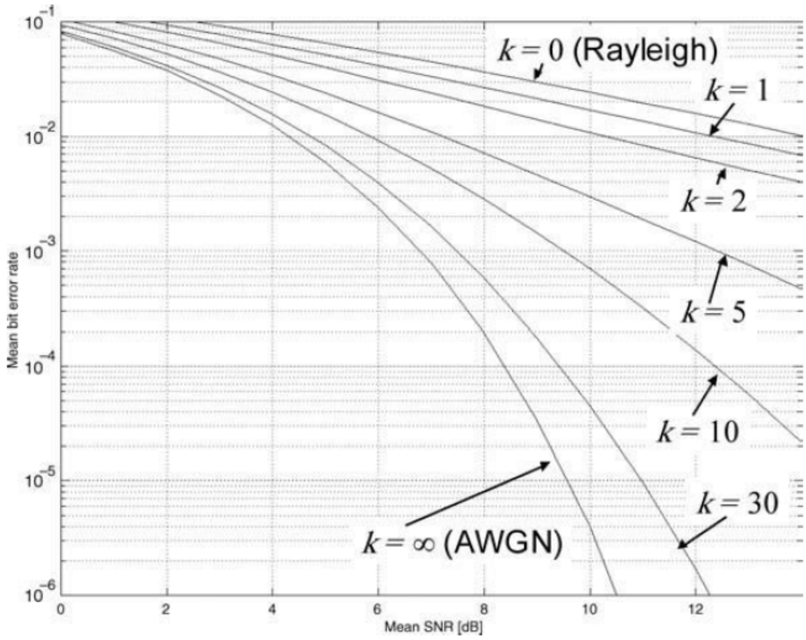

FIGURE 3 – BER for BPSK in Rice channel with $K = 0, 1, 2, 5, 10, 30$ *and* ∞. Source : S.R. Saunders, *Antennas and Propagation for Wireless Communication Systems*, Wiley, 2007.

Work

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