ACTIVE NOISE CONTROL – IDENTIFICATION EXPERIMENTS DESCRIPTION

Some initial experiments for active noise control in motorcycle helmets are described below. Two systems are tested: Chin/Ear Canal (Feedforward) and Headphone input/Ear Canal.

For the feedforward stage identification, an excitation system is integrated with a speaker, amplifier and sound pressure level (SPL) meter in front of the helmet. Each subject was placed in front of the excitation system. Two mics were placed: the first on the chin and the second in the ear canal. Figure 1 shows the experimental configuration. Figure 2 shows the mics position on the subject.

Figure 1. System Configuration.

At each experience, the room was excited by the system shown in Figure 1. Two excitation signals where applied: Sinusoidal sweeps from 20 Hz to 4 KHz and Filtered White Noise with a 6th order low pass filter with 5KHz cutoff frequency. Since the signals have been acquired with a stereo audio system, the channels have been assigned as follows:

Channel	Chin – Ear Canal (FF)	Headphone V- Ear Canal
Right Channel ⟷	Chin Mic	Headphone Voltage
Left Channel ⟷	Ear Canal Mic	Ear Canal Mic

Figure 3 shows the FF experimental configuration. The quantification was made with 16 bits, and the sampling rate was 44.1 KHz.

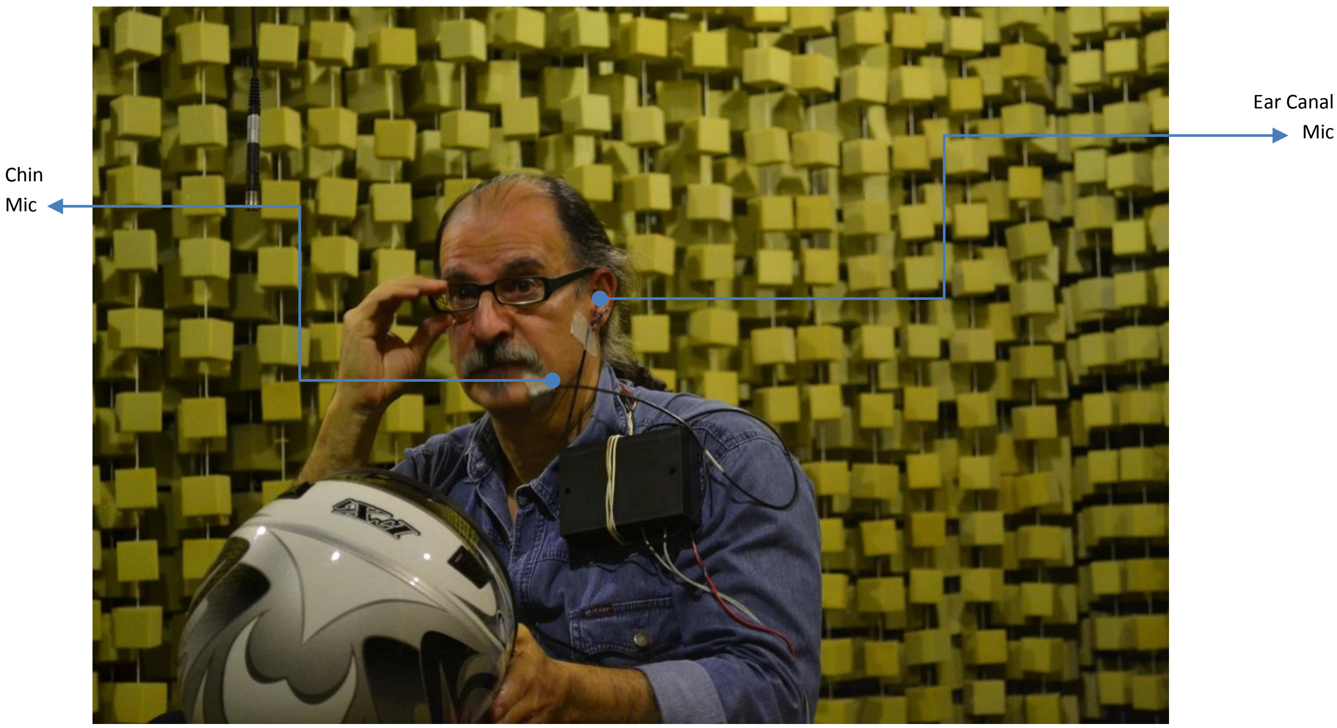


Figure 2. Mics position.

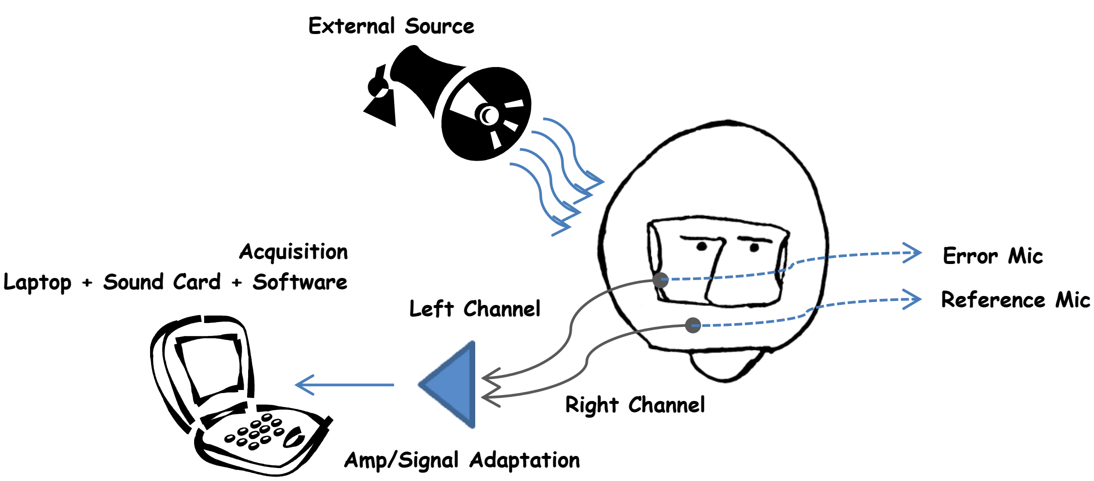


Figure 3. FF Experiments configuration scheme.

On the other hand the link between the acoustic pressure in the ear canal with the applied voltage in the headphone, was measured. For this experience, the same input signals as those used in the FF experiments were used. The experience is described in Figure 4 and denoted as FB.

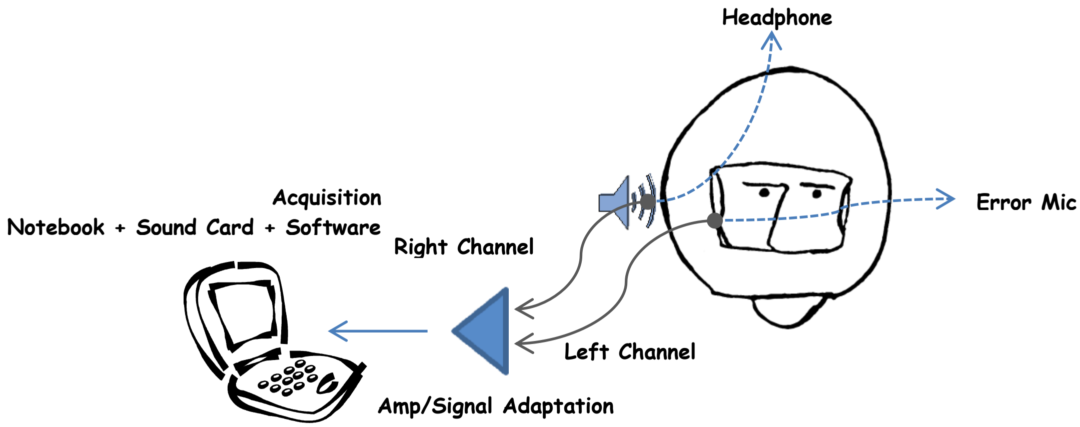


Figure 4. Headphone – Ear Canal Pressure experiments scheme

Once the experiments were carried out, time signals were saved and processed with Matlab. Figure 5 and 6 show the time responses of the feedforward system excitation with sweeps and filtered white noise respectively.

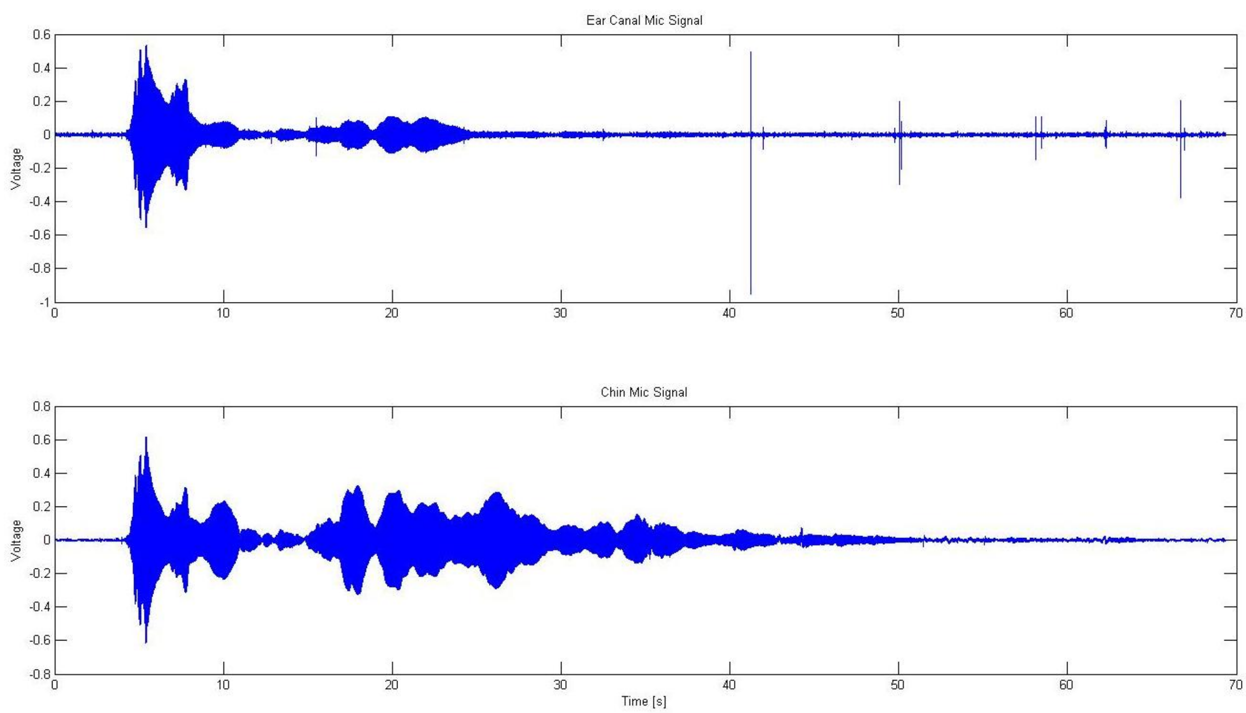


Figure 5. Sweep time response in the Feedforward system experience.

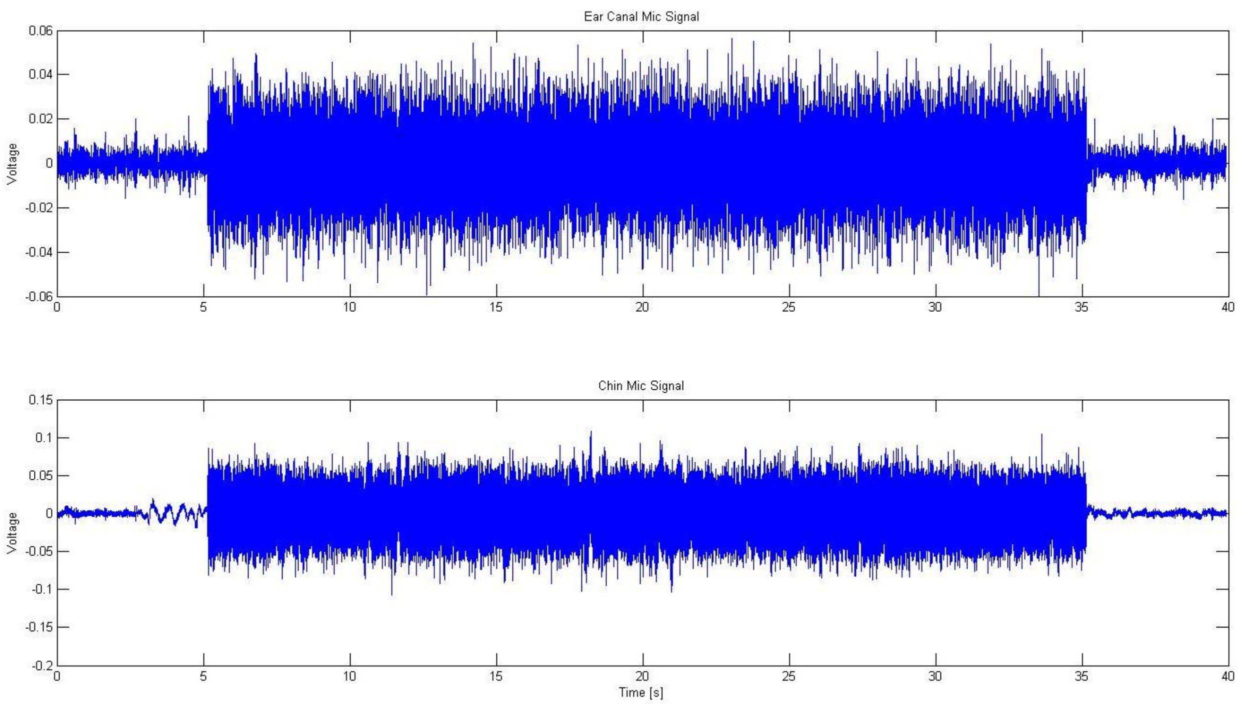


Figure 6. Filtered white noise time response in the Feedforward system experience.

In both cases (FF and FB), the right channel works as the input (chin and voltage in the headphone, respectively) and the left channel works as the output (both in ear canal).

General Remarks.

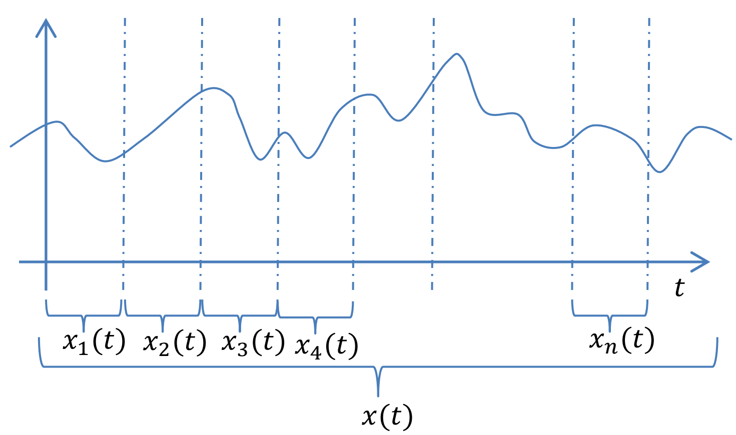
1. Signals

In order to improve the responses, the following procedure was applied:

- **Sweeps**. Here, two differents sweeps were applied to each subject. Let $x_i(t)$ be the *i*-th sweep time signal with $X_i(j\omega)$ Fourier transform, then:

$$|\bar{X}_i(j\omega)|=\frac{\sum_{i=1}^{2}|\mathrm{X}_i(j\omega)|}{2}$$

- **Filtered White Noise**. Only one experience was performed, but taking advantage of the constant spectral feature, the signal was divided in *n* subsignals and averaged:



Then,

$$|\bar{X}_i(j\omega)| = \frac{\sum_{i=1}^{n} |X_i(j\omega)|}{n}$$

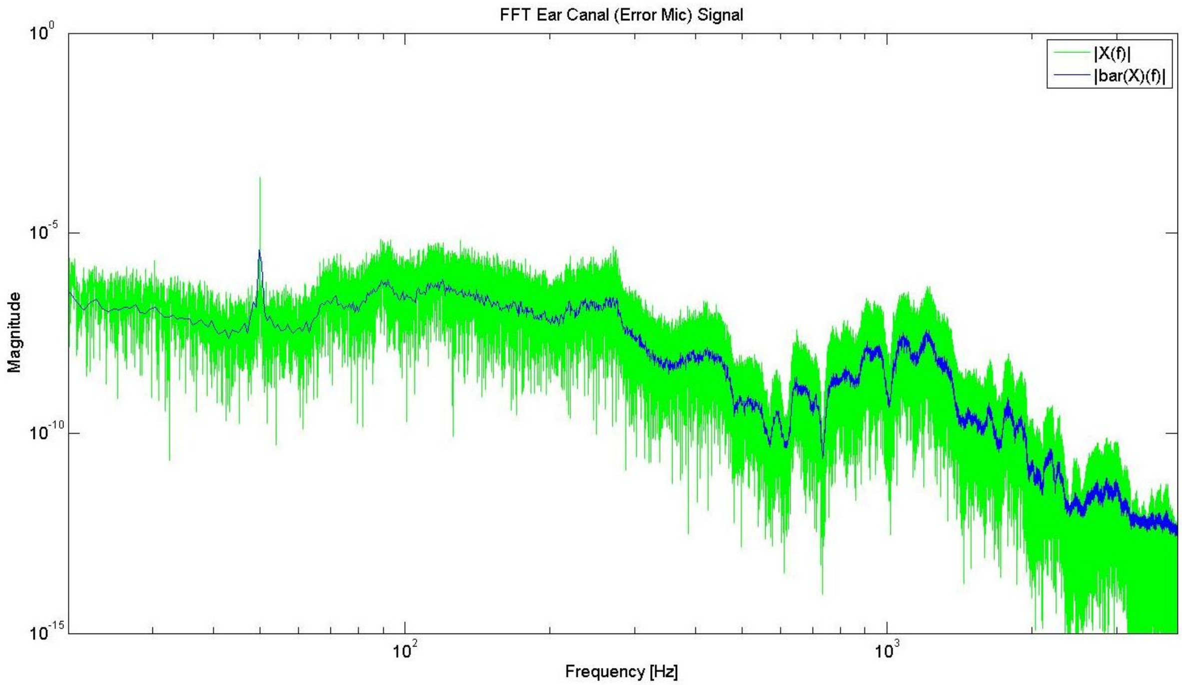


Figure 8. Ear Canal Signal averaged.

2. In Patricio's case (subject n°2), an offset in the frequency band from the 10 Hz to 100 Hz can be observed. This could be due to the contact of the error microphone with the skin of the ear canal.
3. A relationship between the results and the helmet fit on each subject was observed, which relates to the repeatability of the experiments:
    - Ricardo (subject n°1) had the most comfortable helmet fit and the results were the most repeatable.
    - Patricio (subject n°2) had an intermediate confortable helmet fit and less repeatability of the results were observed.
    - Demián (subject n°3) had the worst comfortable helmet fit and the results where far less repeatable.
4. Each experience was repeated twice with different input powers. From the spectral analysis point of view, no change in the frequency response due to input changes was observed. For this reason, the convenience to work with more power in order to improve the signal-to-noise relation was concluded.