ROOM MODAL EQUALIZATION

WITH ELECTROACOUSTIC ABSORBERS

Etienne Rivet, Sami Karkar & Hervé Lissek

« How to improve the sound reproduction in a room at low frequencies? »

Context

- Sound rendering quality in a listening room is determined by the combined effects of the audio system quality and the acoustic properties due to the room geometry and surface materials.
- At low-frequencies, standing waves cause spatial and frequency dependencies and alter the reproduced signal.

➡ Need for acoustic treatment and correction.

Motivation

Several methods have already been considered in order to tackle this problem:

- Passive absorption,
- Room size ratio and optimal placement of source / listener positions,
- Parametric equalization,
- Multiple point equalization / Modal active control,

But they all have some limitations (bulkiness,...).

➡ Solution: Acoustic impedance control

- Control the room boundary conditions using Electroacoustic Absorbers (EA).
- Concept of EA: closed-box loudspeaker connected to a dedicated electrical control circuit, providing a high damping to the room resonance modes on a relatively wide frequency band, by achieving a specific target acoustic impedance.

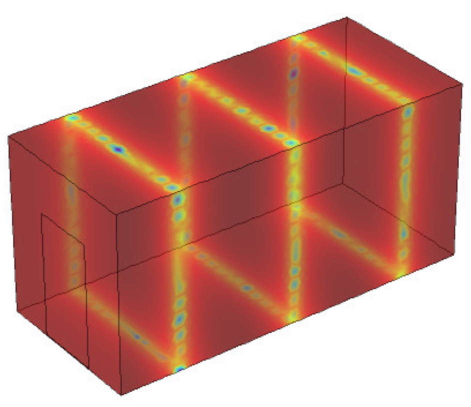
Methodology for room correction at low frequencies:

1. Room specifications

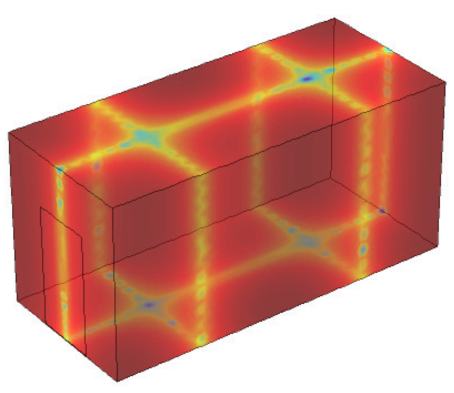
Computations with a simulation environment [1]:

- Low-frequency modes;

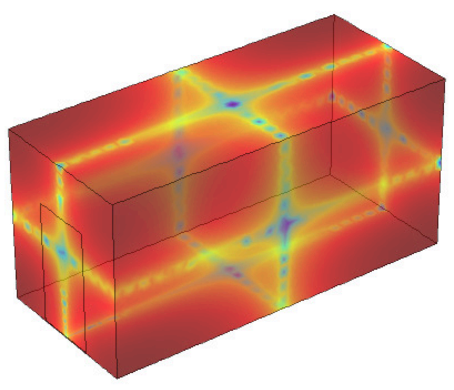
Room with rigid walls:
- Lx: 5.98 m, Ly: 2.61 m, Lz: 2.88 m;
- Surface: 80.86 m²
- Volume: 45.1 m³



Mode 3,0,0 86.1 Hz



Mode 2,1,0 87.2 Hz

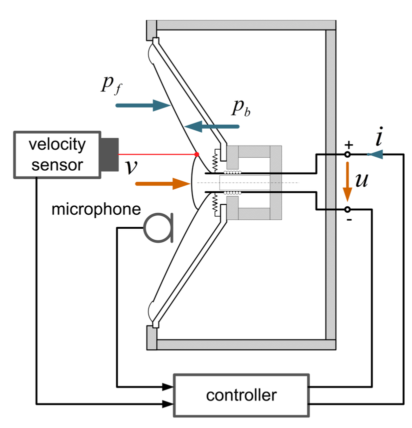


Mode 1,1,1 93.1 Hz

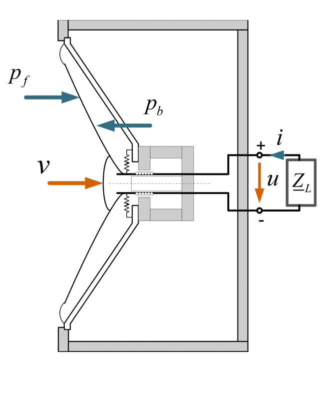
- Acoustic target impedance dependent on the absorption surface ratio and room specifications (geometry, acoustic impedance of the walls,...), in view of optimizing the efficiency of mode damping [2].

2. Design of Electroacoustic Absorbers

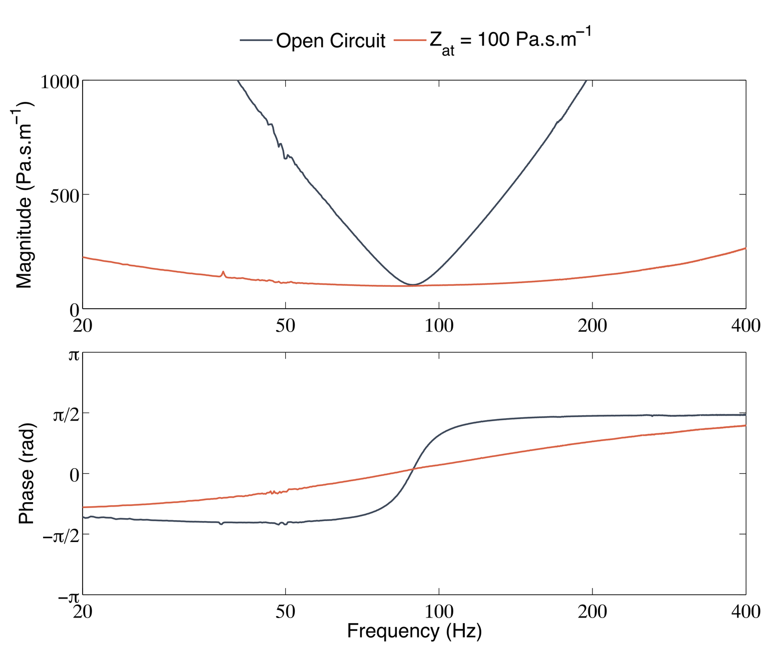
- Implementation of the dedicated electrical control circuit in order to match the diaphragm impedance with the desired target acoustic impedance Z_{at};
- Use of feedback control [3] or shunt loudspeakers [4].



Feedback control



Shunt loudspeaker

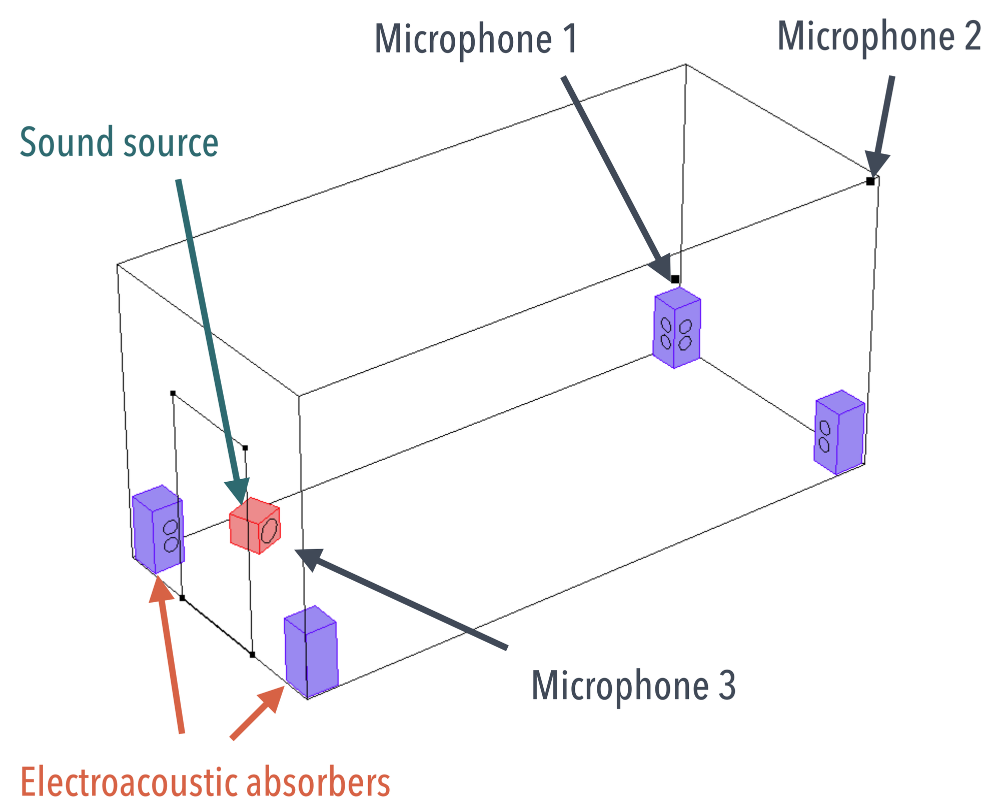


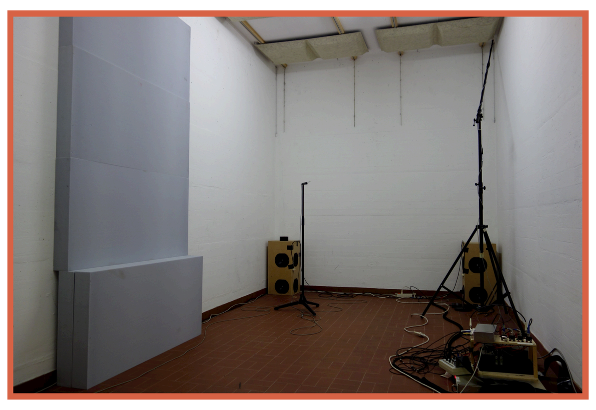
Measurement of specific acoustic impedance at the diaphragm surface

3. Damping of Low-Frequency Modes

a. Experimental setup

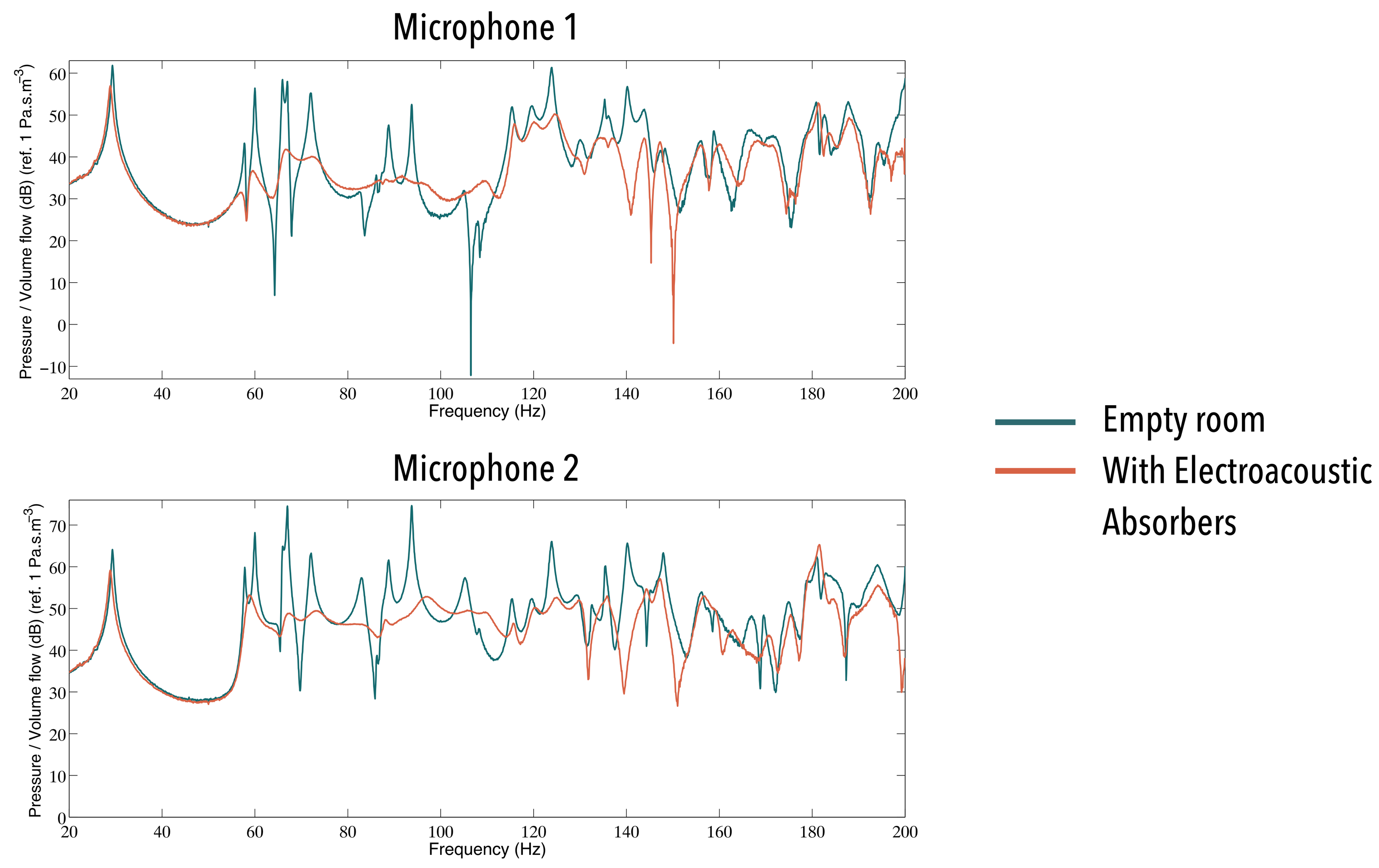
- Configuration of electroacoustic absorbers:
  - 4 cabinets, each comprising 4 loudspeakers with dedicated control circuits;
  - Located in bottom corners, diaphragms directed towards the room center;
- Effective absorption area: 0.225 m².



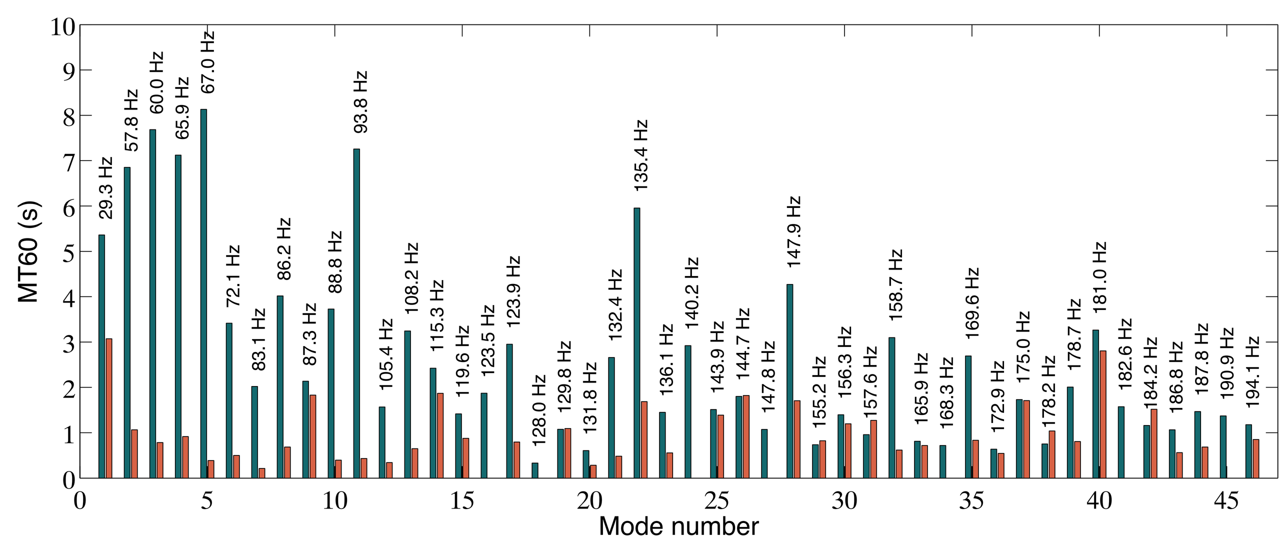


b. Results

- Measurements of transfer functions between the pressure (received by the microphones) and volume flow of the source loudspeaker.



- Estimation of modal decay times (MT60) from measured transfer functions using the method of rational fraction polynomials [5].



Conclusion

- Significant damping of low-frequency room modes can be achieved through wise control of acoustic impedance using electroacoustic absorbers.
- Subjective assessment with listening tests will be performed in view of a global evaluation of electroacoustic absorber performances.

Acknowledgments

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References

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