Politecnico di Milano
M.Sc. in Mechanical Engineering

VEHICLE ACOUSTICS

Lab. 02: Airborne Noise of a car cabin, experimental analysis

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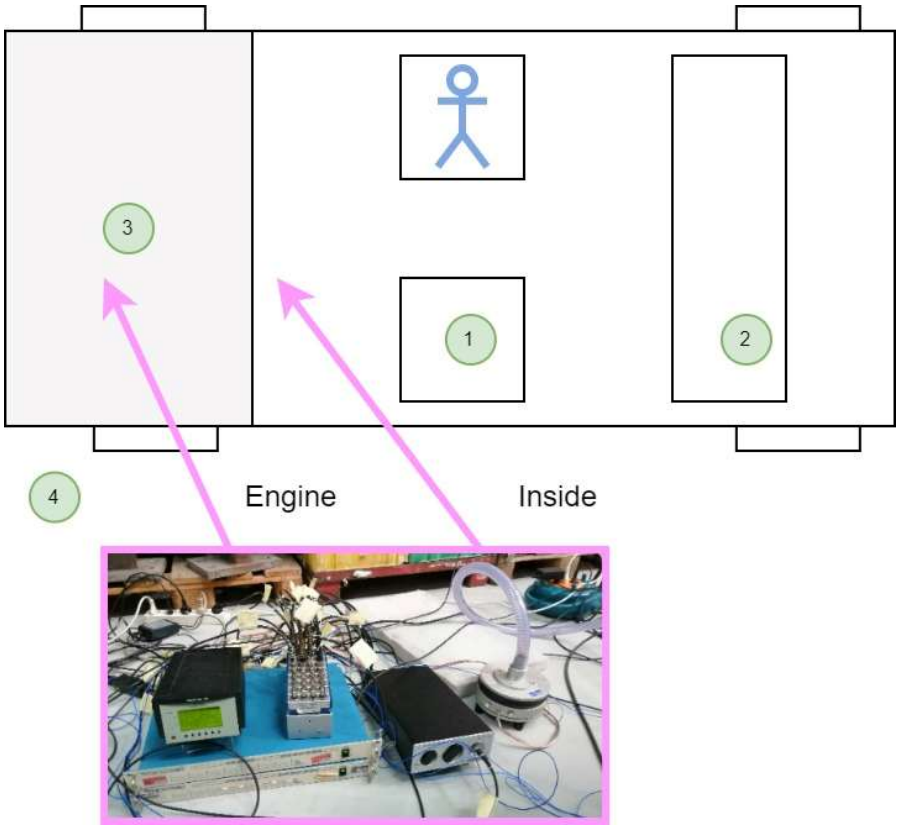
Experimental layout



Sensors

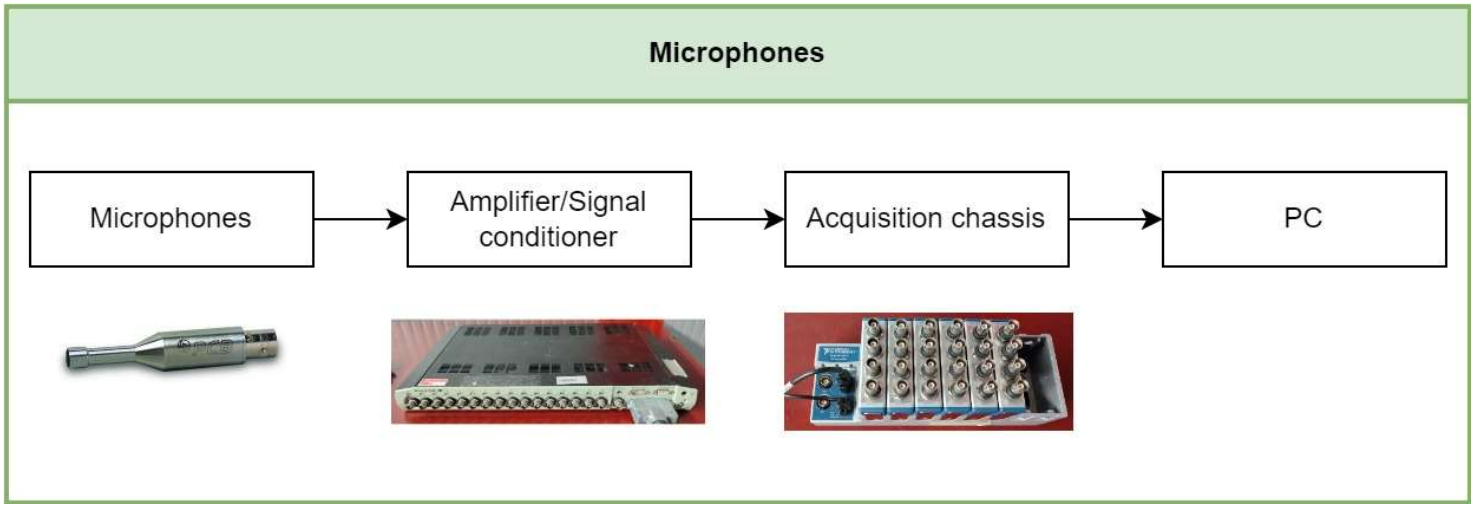
- 4 Microphones: driver position, rear left passenger position, external position (close to front left wheel), below the car's bonnet.
- 1 Head & Torso Simulator at the front passenger location.
- SIEMENS Mid-High frequency omnidirectional acoustic source (Qsource)

Head & Torso Simulator

1 *Microphone*

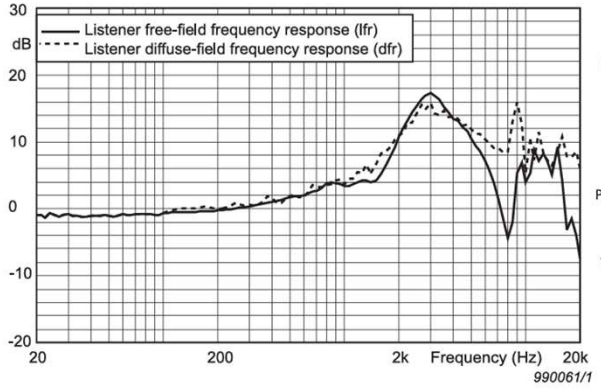
Experimental layout

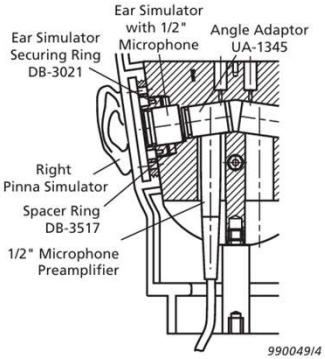
Microphones: in this experimental setup, ¼ inch microphones are used to quantify the acoustic pressure. These devices require a proper calibration. Moreover, since the sensitivity of the microphones can significantly vary in time, it is necessary to calibrate them by means of a calibrating device. These sensors provide a ±10V signal proportional to the acoustic pressure, and do not show asymmetric response.

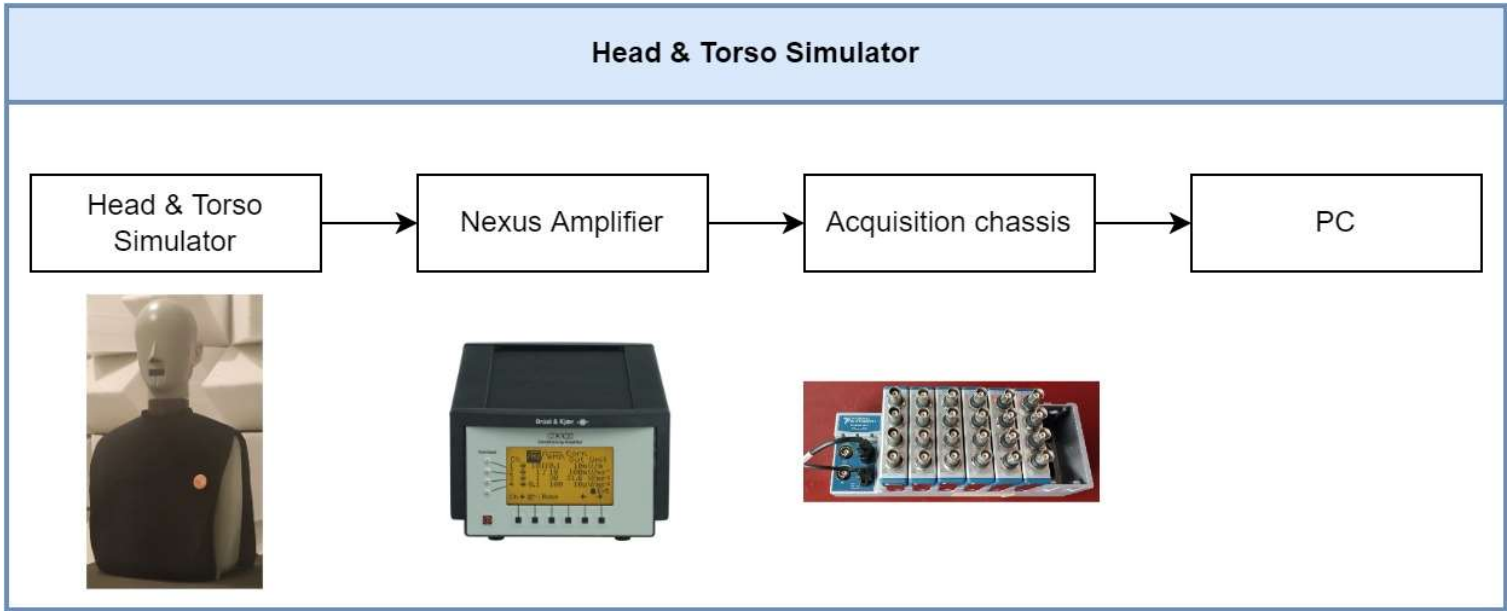


Experimental layout

Head & Torso Simulator: this system aims to emulate the acoustic features of the human head & torso. It features two internal ½ microphones at ears position. The response of the HTS is therefore aligned to that of a typical human listener.

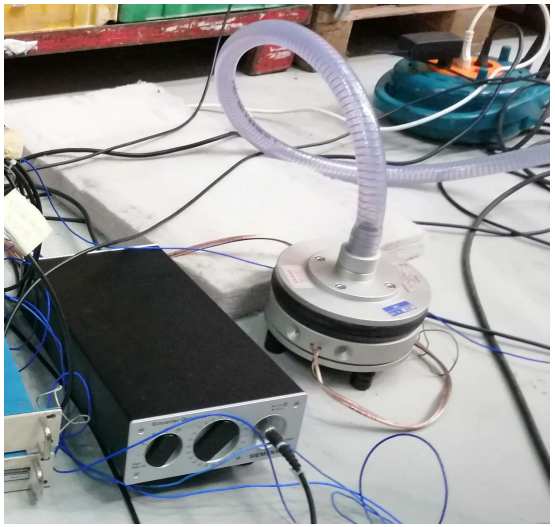


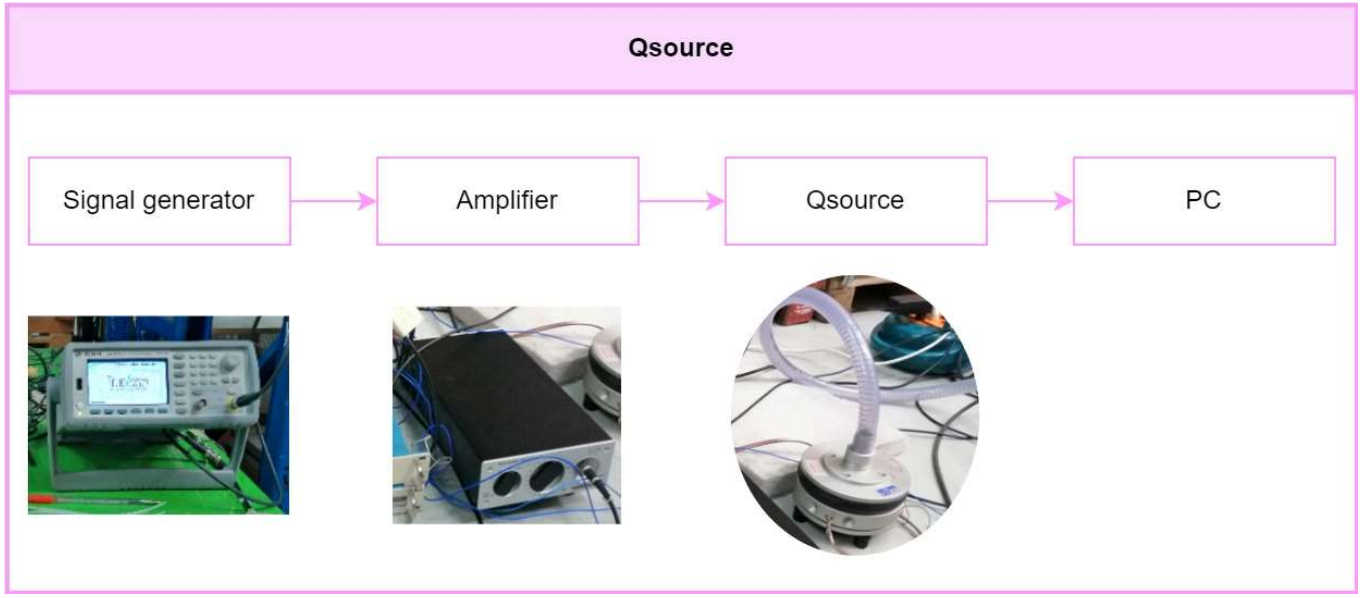




Experimental layout

Qsource: the SIEMENS Mid-High frequency omnidirectional acoustic source (Qsource) is time stable and virtually independent of the acoustic field in which it is being used, resulting in accurate input measurement. The input is measured as a calibrated volume acceleration (m^3s^2).

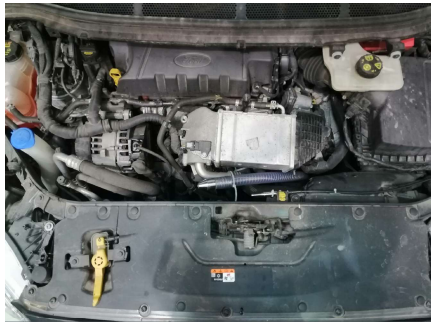


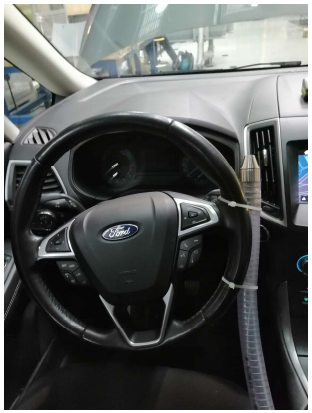


Experimental layout

In this experimental tests, the Qsource is placet at two different locations to measure the noise insider the car cabin. The sensitivity of the Qsource is 1.2e-3 V/(m^3s^2).

- The Qsource is placed in the car hood, with the aim of assessing the transfer function between the airborne engine noise and the acoustic pressure in the car cabin.
- Then, the Qsource is placed inside the car cabin with the aim of assessing the acoustic response of the cabin volume.





The tests performed in this analysis are summarized:

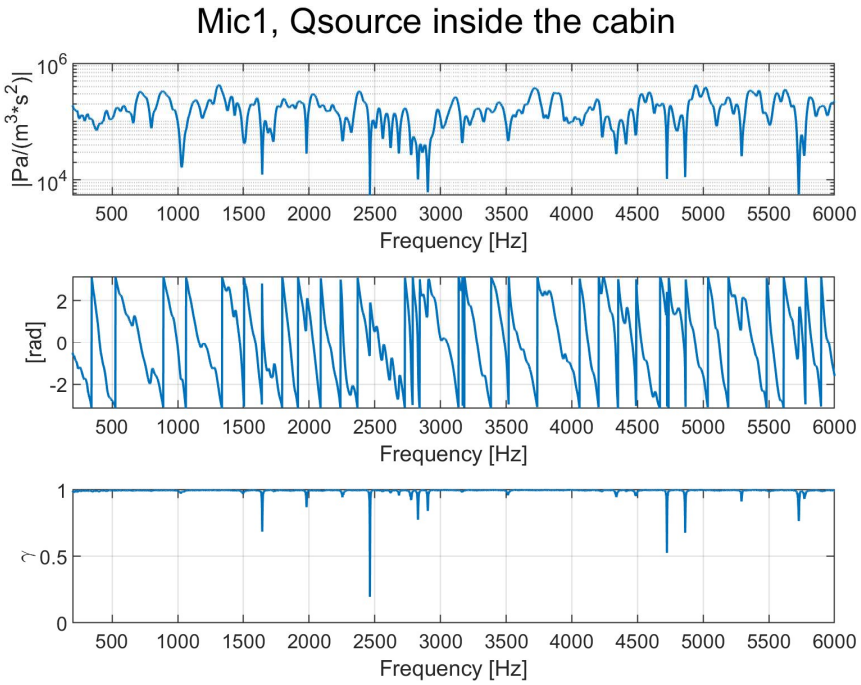
- **Test 1**: Qsource is placed in the car hood, no passengers in the car
- **Test 2**: Qsource is placed in the car hood, two passengers in the car

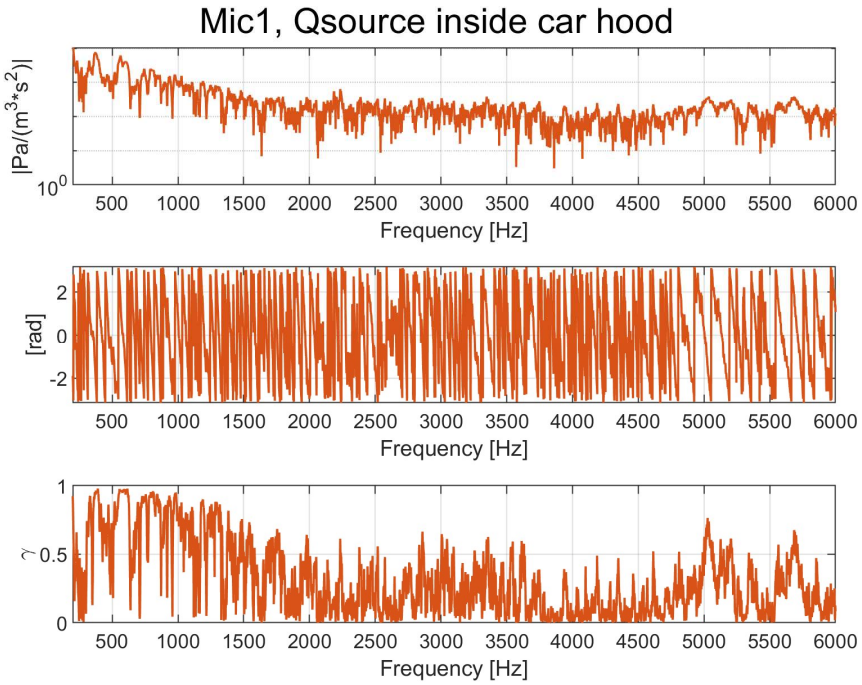
- **Test 3**: Qsource is placed inside the cabin, no passengers in the car
- **Test 4**: Qsource is placed inside the cabin, two passengers in the car

Experimental layout

Transfer functions (Mic 1), Test 1 vs Test 3

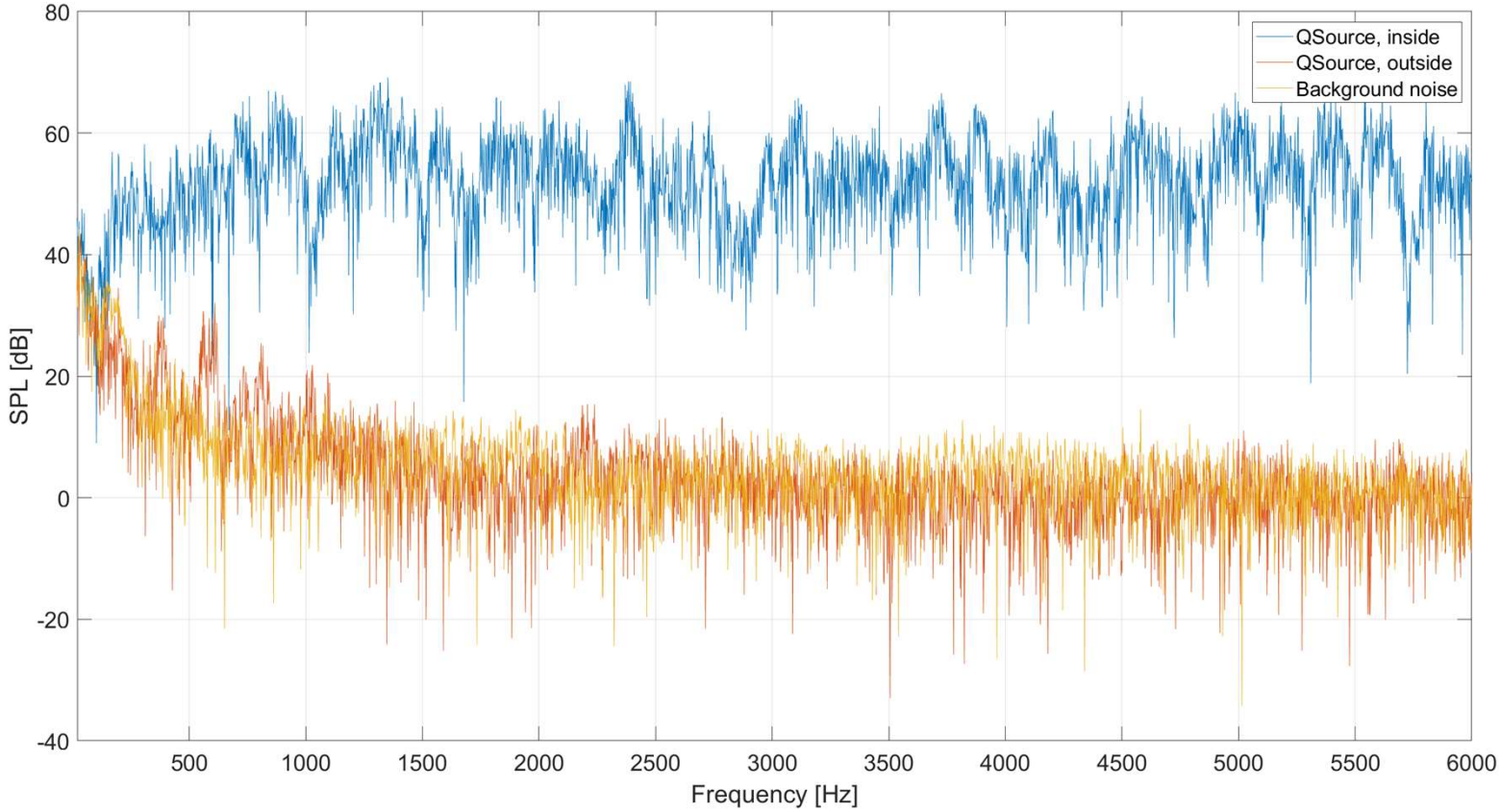
Compare the acoustic transfer functions between Qsource and Mic1 considering Test 1 & Test 3. In this analysis, the car cabin is always empty and the Qsource is moved from the car hood to the car cabin.





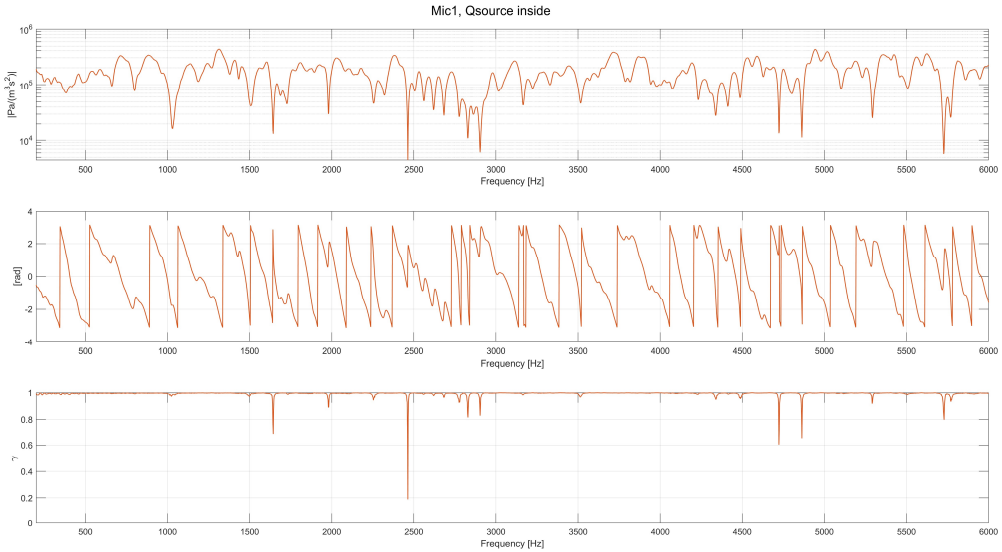
Transfer functions (Mic 1), Test 1 vs Test 3

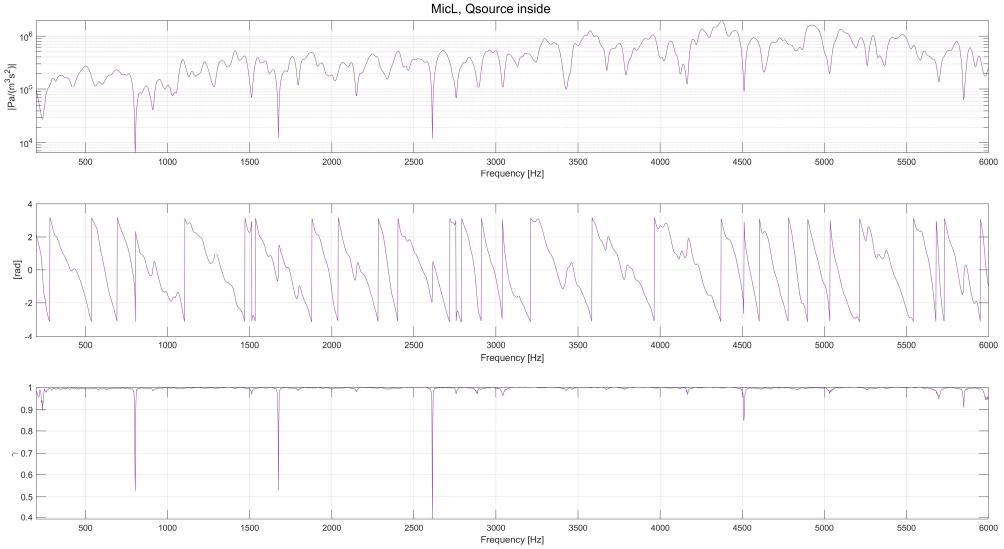
The coherence of the transfer function between Qsource and Mic1 is not optimal when the omnidirectional acoustic source is placed in the car hood. The reduced coherence level can be correlated to the comparative analysis between the spectrum of Mic1 obtained during the Qsource tests and the spectrum of the background noise.



Test 3: Transfer functions (Mic 1 VS MicL), Qsource inside

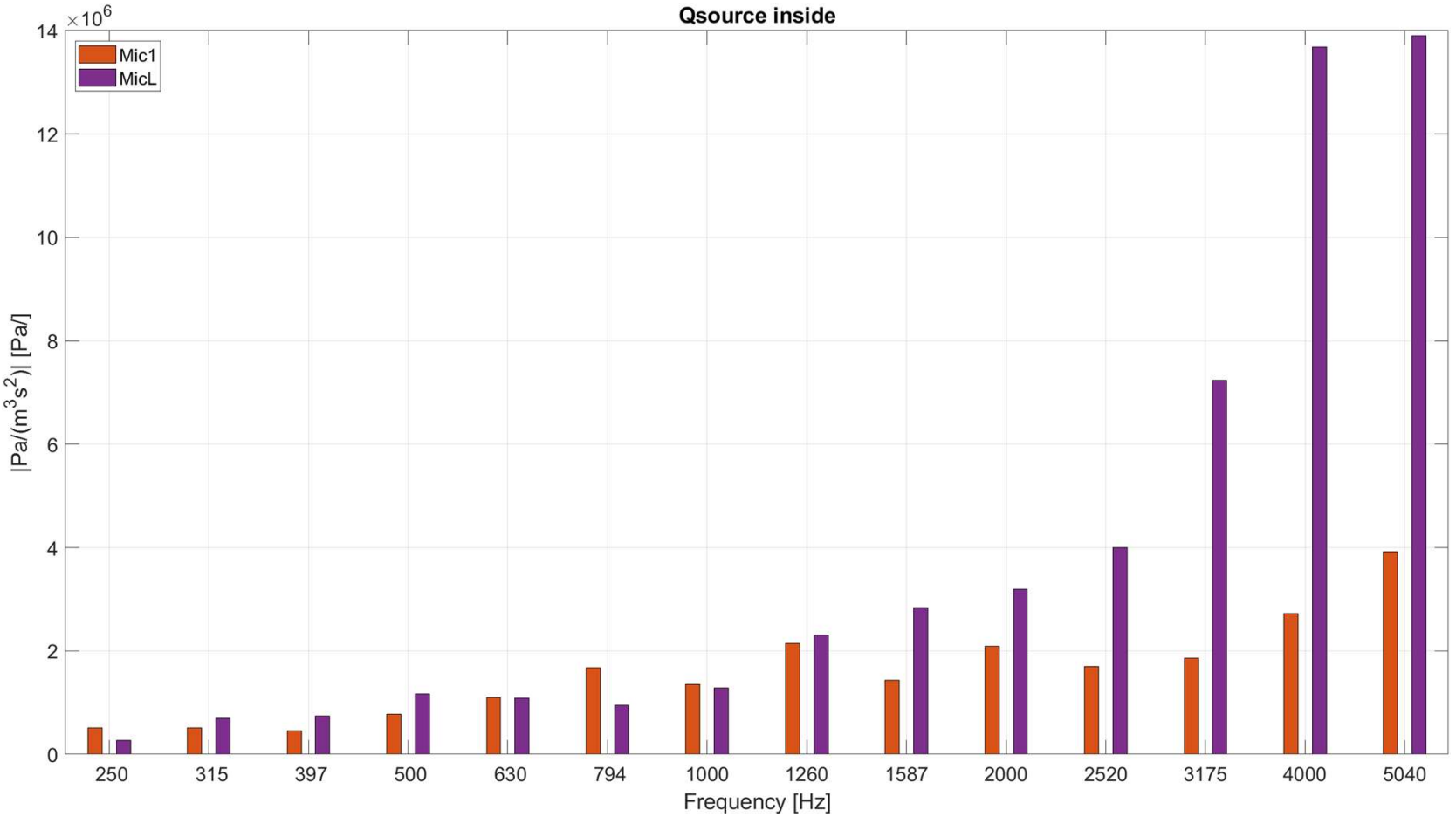
The transfer functions between the Qsource inside the cabin and Mic1, MicL can be compared to assess the influence of the Head & Torso Simulator on the perceived response of the microphones. The Test 3 is considered.





Test 3: Transfer functions (Mic 1 VS MicL), Qsource inside

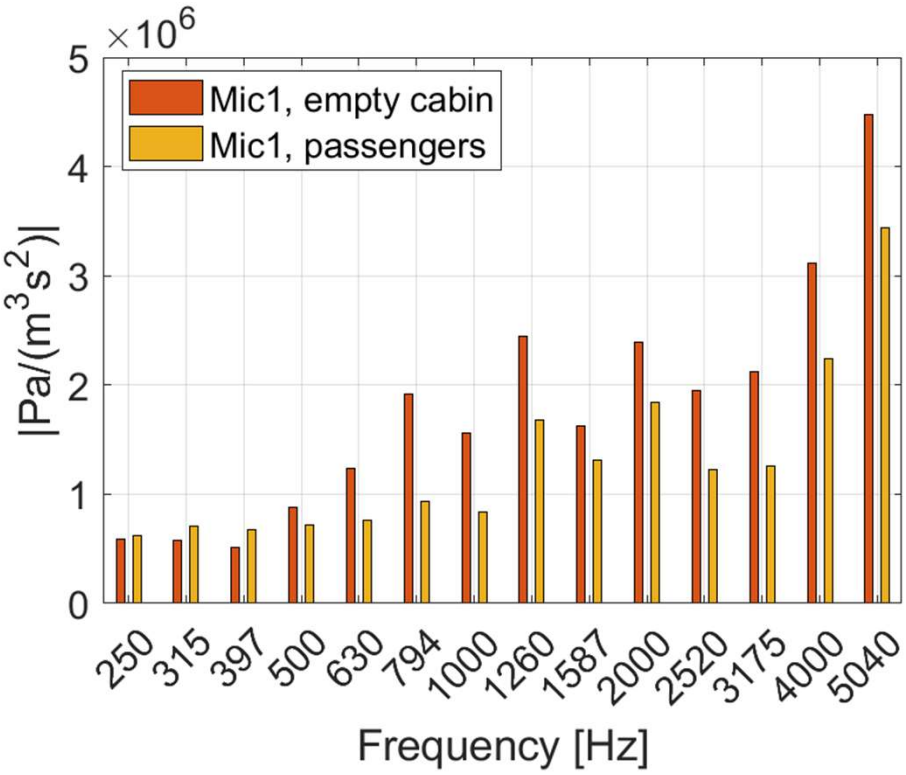
The transfer functions can be further compared by converting them to one-third octave bands to highlight the frequency weighting function of the Head & Torso simulator.



Test 3 vs Test 4: effect of passengers

Finally, the effect of the passengers inside the cabin can be compared by looking at the one-third octave band transfer functions between Qsource and Mic1 when considering:

- Qsource inside, empty cabin, Test 3
- Qsource inside, two passengers, Test 4



Assignment

1. Compare the transfer functions measured at Mic1, Mic2 with respect to Qsource excitation coming from the engine and inside. Comment the results and the reliability of the data (Test 1 vs Test 3).

2. Comparison of Mic1 and Head & Torso measurement. Obtain the transfer functions measured at Mic1, MicL with internal Qsource. Compare the one-third octave bands response of Mic1 and MicL (Test 3).

3. Comparative analysis of the effect of passengers on the response measured at Mic1. Compare the one-third octave bands responses of Mic1 when exciting an empty cabin or a cabin with two passengers inside (Test 3 vs Test 4).

4. BONUS: compare the transfer functions between the microphone in the car hood and Mic1 measured during ramp test and Test 2. Comment the differences in the transfer functions.

Bonus: ramp test vs Test 2

The narrow-bands transfer functions between the microphone in the car hood (Mic3) and the microphone in the car cabin (Mic1) can be compared between the ramp test (with two passengers inside) and the Test 2 (external Qsource with two passengers).