Frequency-Domain Analysis of Vehicle Noise Emissions

Antonio Pascale[1, 2], Claudio Guarnaccia[3], Margarida C. Coelho[1, 2]

The increasing exposure of populations to hazardous road traffic noise has driven the scientific community to develop innovative mitigation strategies. While significant efforts have focused on real-time monitoring and predictive modeling in smart cities, less attention has been given to analyzing vehicle noise emissions in the frequency domain, particularly the impact of low-frequency components, which are known to have adverse health effects.

This study addresses this gap by investigating the sound power levels of a diesel and a Liquid Petroleum Gas-powered vehicle across a frequency range of 63 to 8,000 Hz. Controlled pass-by (CPB) tests were conducted on a private track following ISO 11819-1, ensuring the absence of external noise sources. Using a backward sound propagation model, frequency noise emissions in terms of sound power levels (Lw) were derived. Additionally, noise data were collected within the same frequency range at the exhaust system level, with the vehicle in neutral gear and the RPM increased using the throttle pedal.

Results from CPB tests indicate that low-frequency components (63-250 Hz) play a non-negligible role at low speeds, where engine noise dominates over tire-pavement interactions. The 1,000 Hz component was found to be predominant at all speeds, while the contribution of 8,000 Hz was negligible. A-weighting was applied to reflect human auditory perception, which de-emphasized low-frequency noise. Furthermore, resonance phenomena occurred at 63 Hz when the vehicle was stationary with the engine running.

These findings underscore the need for targeted noise reduction strategies in internal combustion engines and provide valuable insights for vehicle manufacturers seeking to isolate harmful low-frequency emissions. Moreover, the study lays the groundwork for future research on frequency-domain noise emissions from electric vehicles, which operate under different noise generation mechanisms and may alter the trends observed.

1 – TEMA & Department of Environment and Planning, University of Aveiro.
2 – LASI – Intelligent Systems Associate Laboratory, Guimarães.
3 – Department of Civil Engineering, University of Salerno, Italy.

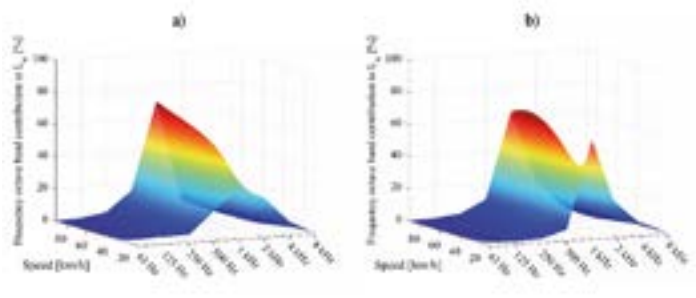

FIGURE 1
Noise emission spectra for a) diesel vehicle and b) LPG vehicle.

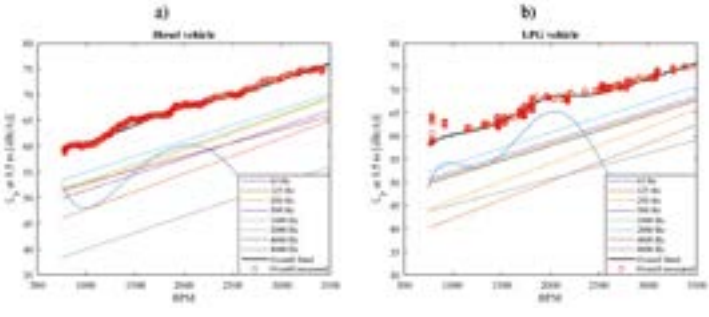

FIGURE 2
Exhaust sound pressure levels against RPM for a) diesel vehicle and b) LPG vehicle.