Prediction of the Loudspeaker Total Harmonics Distortion Using COMSOL Multiphysics® Software

F. Malbos[1], M. Bogdanski[2], M. Strauss[3]

[1]Harman, Paris, France
[2]Harman Becker Automotive Systems, Straubing, Germany
[3]Harman Becker Automotive Systems, Harman Becker Automotive Systems, Straubing, Germany

Abstract

For automotive applications, simulation and equalization methods are used to optimize the position and orientation of speakers to get the best acoustic performance. Because a loudspeaker is a nonlinear device, the sound pressure in the vehicle includes harmonics. These harmonics will modify the tone of the musical instruments. In order to obtain the best audio performance, System Engineers at Harman are minimizing the level of the harmonics. These harmonics are mainly created by tree nonlinear speaker components (force factor, suspension stiffness and voice coil inductance). The goal of the study is to use COMSOL Multiphysics® (AC/DC Module and Structural Mechanics Module) to simulate those nonlinear components. Two different methods were used for validation. First of all, simulation data was compared with measurement data delivered by a professional loudspeaker measurement and analysis system (including a nonlinear Large Signal Identification module). Secondly, Total Harmonic Distortion (THD) was predicted based on COMSOL® and measurement system data sets. The comparison of the simulated THD below 1kHz using the loudspeaker simulation and measurement shows similar results. Using the anechoic THD measurement, it was demonstrated that measured and predicted THD are comparable. In this paper, it is shown that professional measurement tools can be successfully replaced by nonlinear speaker simulations with COMSOL. It is also demonstrated that the optimization of the nonlinear behavior of a loudspeaker can be realized in the virtual domain. This allows to reduce development times and costs and to have more freedom in loudspeaker design decisions to optimize any car audio system.

Reference

[1] W. Klippel, Distortion Analyser - a new tool for assessing and improving electrodynamic speaker, 108th Audio Engineering Society, Convention Paper 5109 (2000)
[2] R. Mihelich, Loudspeaker non linear parameter estimation: an optimization method, 111th Audio Engineering Society, Convention Paper 5419 (2001)
[3] W. Klippel, Prediction of speaker performance at high amplitudes, 111th Audio Engineering Society, Convention Paper 5418 (2001)

Figures used in the abstract

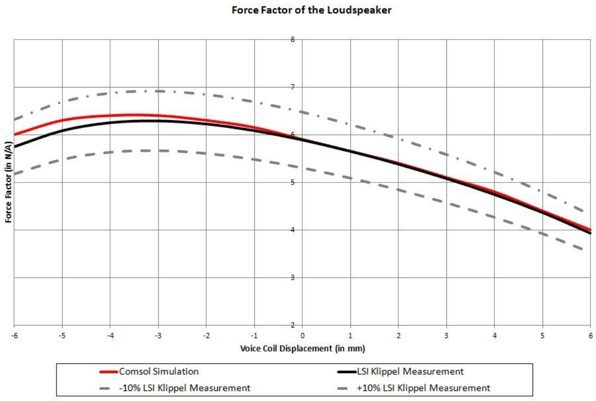

Figure 1: Force factor of the speaker.

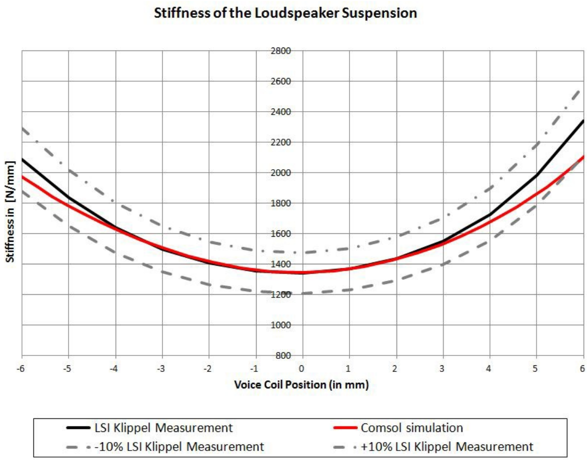

Figure 2: Stiffness of the speaker.

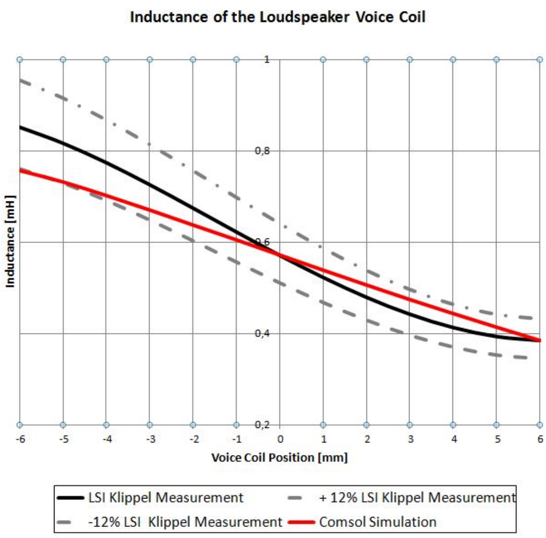

Figure 3: Inductance of the speaker.

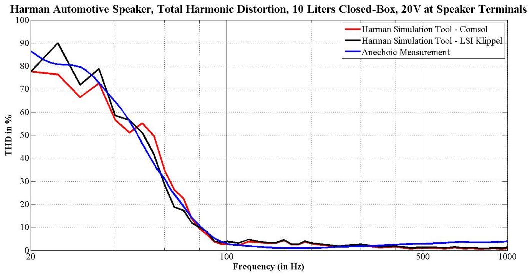

Figure 4: Total Harmonic Distortion (in Sound Pressure).