Modeling the Electrical Parameters of a Loudspeaker Motor System with the AC/DC Module

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Abstract

The main purpose of a drive unit is to transform the electrical signal at its terminals into acoustic waves. To do so, a loudspeaker uses two transduction mechanisms:
- Electro-mechanical, through the interaction of the AC current in the voice coil with the static magnetic field in the magnet assembly (iron parts and magnet).
- Mechano-acoustical through the membrane and its suspensions.

In this paper only the electro-mechanical transformation is discussed. The focus is on the modelling, in view of a future optimization of the main electrical parameters for a loudspeaker motor: the Force Factor (Bl) and the Blocked Impedance (Zb) as functions of the voice coil position.
The optimisation of the motor is the first step in the design of a loudspeaker to define its linearity, efficiency and bandwidth. Figure 1 shows a typical motor topology.

Here, the COMSOL Multiphysics® model is fully described and then compared to the implementation of a similar model in the widespread software FEMM (Finite Element Method Magnetics).
The motor was first modeled as a purely magnetostatic problem, solving for a stationary study, and a linear perturbation approach was then used for the frequency domain analysis.
Different constitutive relationships for the materials magnetic properties were tested to find the best compromise between computation time and accuracy.

The experimental validation of the model is presented by comparing the "Force Factor (Bl) versus displacement" (Figure 2) and "Blocked Impedance versus displacement" (Figure 3) curves to the same quantities measured with a tensile test machine in a quasi-static setup (Figure 4) and the Klippel distortion analyser in a dynamic setup.

Reference

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Figures used in the abstract

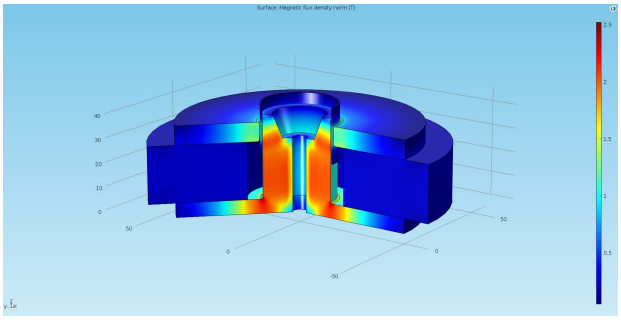

Figure 1: Typical speaker motor

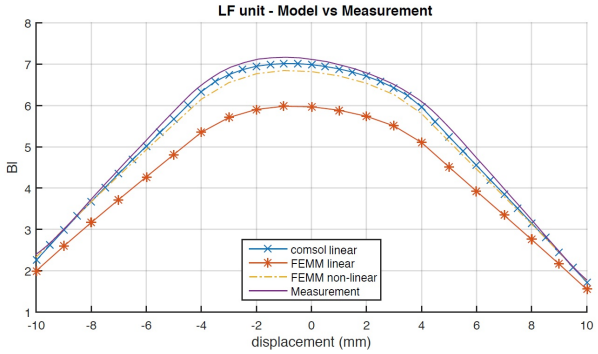

Figure 2: BxL versus displacement validation

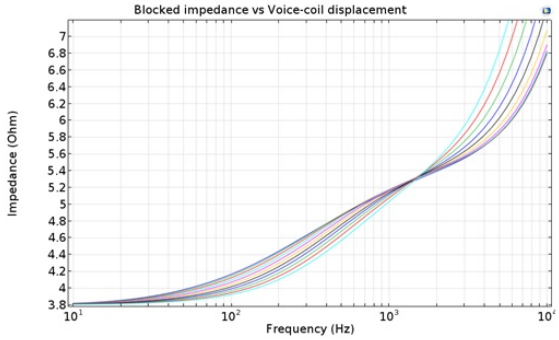

Figure 3: Impedance versus frequency and displacement

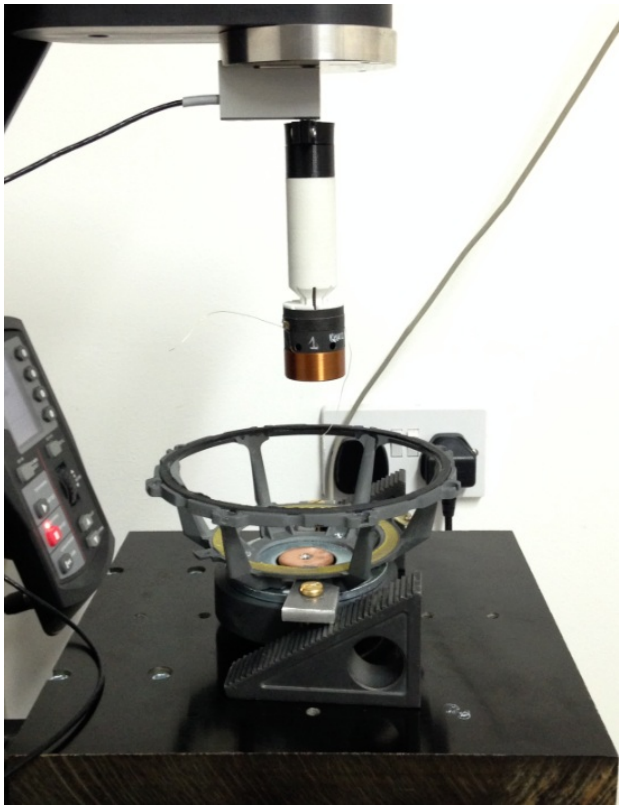

Figure 4: Tensile test machine for direct force measurement