Modelling the Electrical Parameters Of A Loudspeaker Motor System With The AC-DC Module

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Introduction

The aim of this project is to improve the modelling and measurement process for loudspeaker motor systems. Here one typical motor was simulated in COMSOL 5.1 and FEMM 4.2 to assess the physics implementation and software impact on the main electrical parameters estimation (Bl & electrical impedance) as well as to see which method is best suited for a development work (computation time).

Figure 1. Drive unit under study.

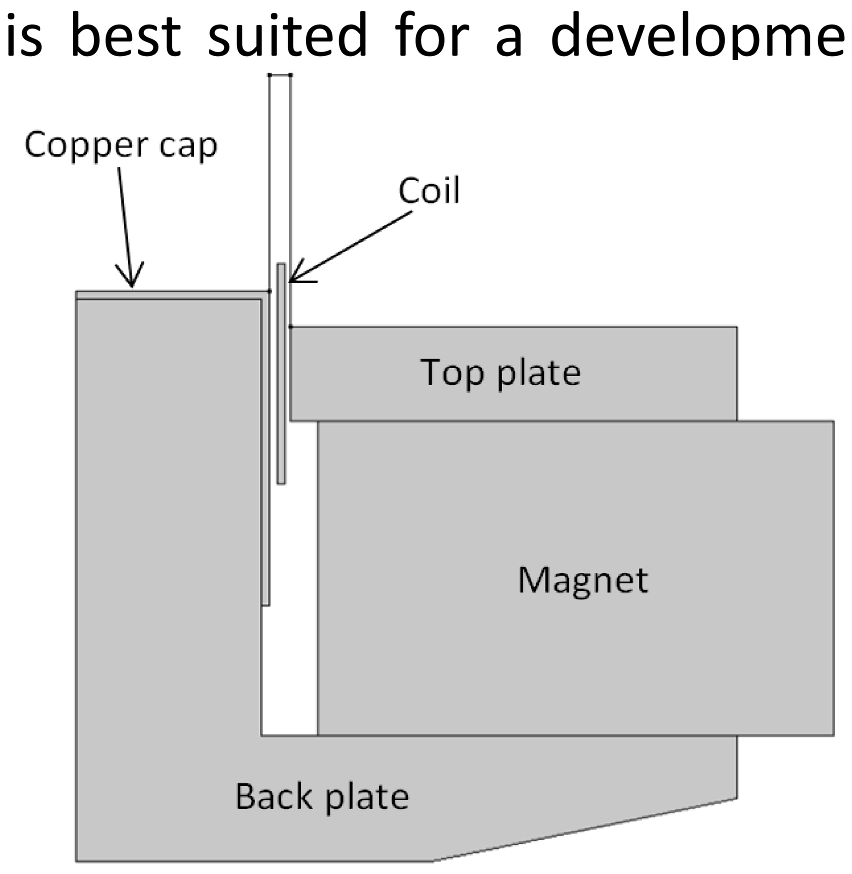


Figure 2. 2D axisymmetric model

Computational Methods

The model is a 2D axisymmetric problem where all the geometrical dimensions are parametrized in view of a future optimization.
The AC/DC module - Magnetic Field (mf) is used with a stationary study (for the force factor), then a frequency domain analysis is implemented to simulate the blocked impedance.

The AC/DC module - Magnetic Field (mf) is used. In order to be able to compare the results with FiniteElementMethodMagnetics package which is using first order triangular elements for the discretization, a linear discretization was used to perform the computation in COMSOL as well.

Results

The study has been divided in two parts:
First the force factor has been modelled both in COMSOL and FEMM. Then these simulations results have been compared to measurement realized on a tensile test machine (quasi-static setup) and the Klippel DA using the LSI module (dynamic setup).
In order to compare fairly the two simulation packages, the same geometry, the same number of elements and the same material properties have been used.
Then the blocked impedance has been modelled in COMSOL only and then compared to measurement realized with a custom setup relying on the tensile test machine for the coil displacement and the log sweep technique for the impedance measurement.

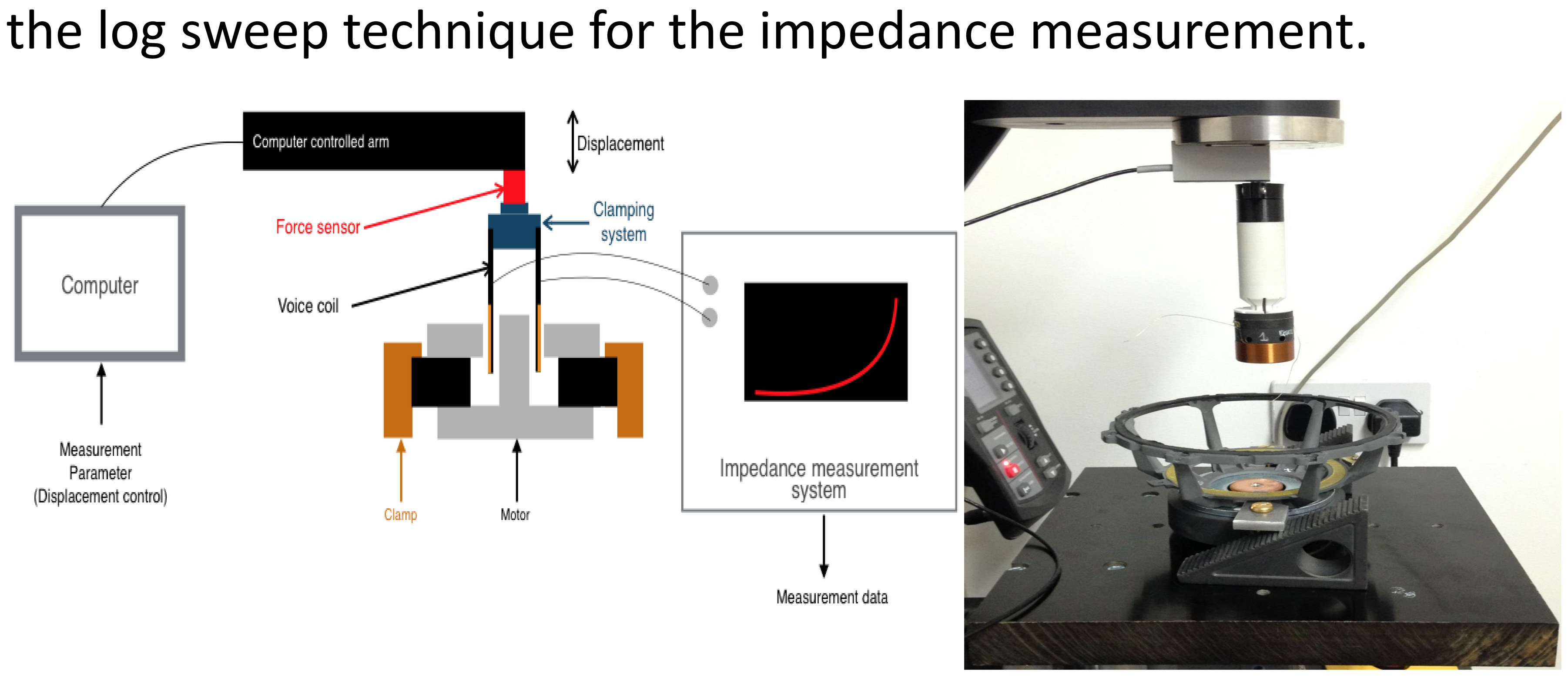
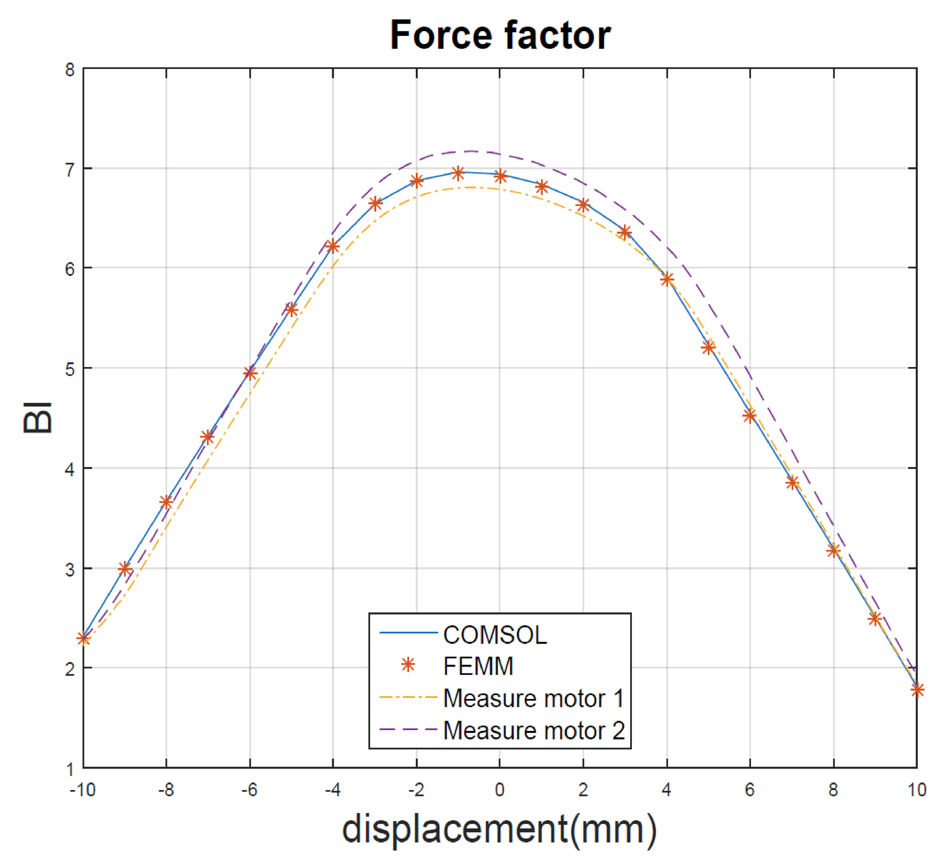
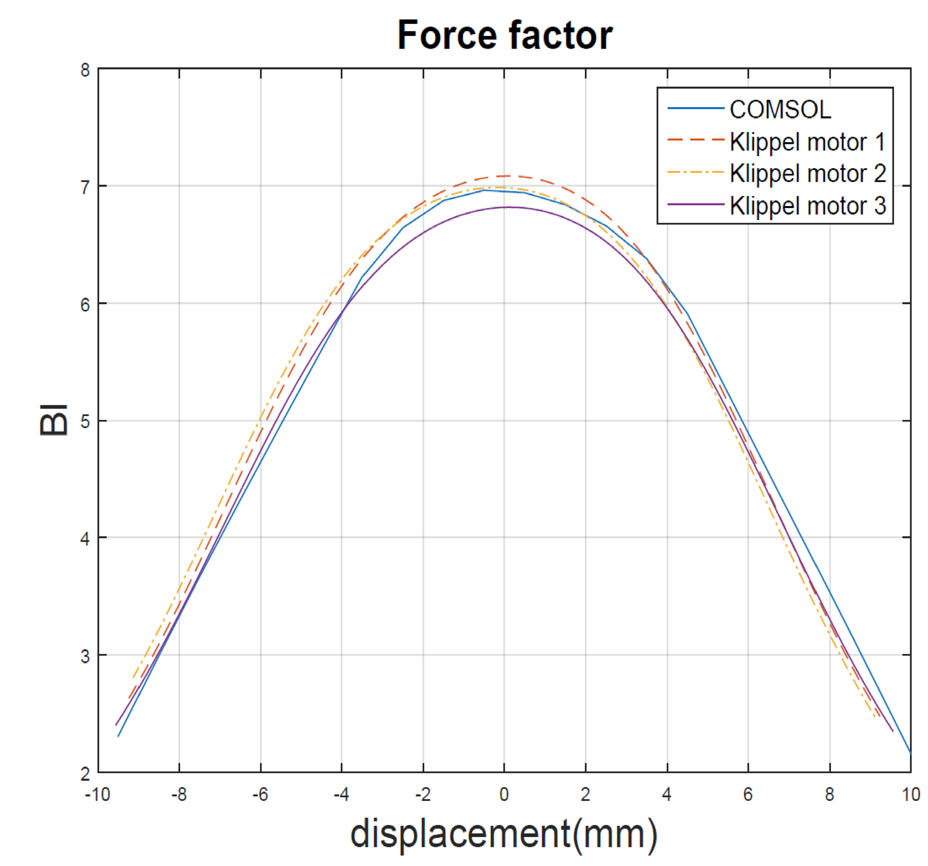


Figure 3. Tensile test machine setup for Bl and Blocked Impedance



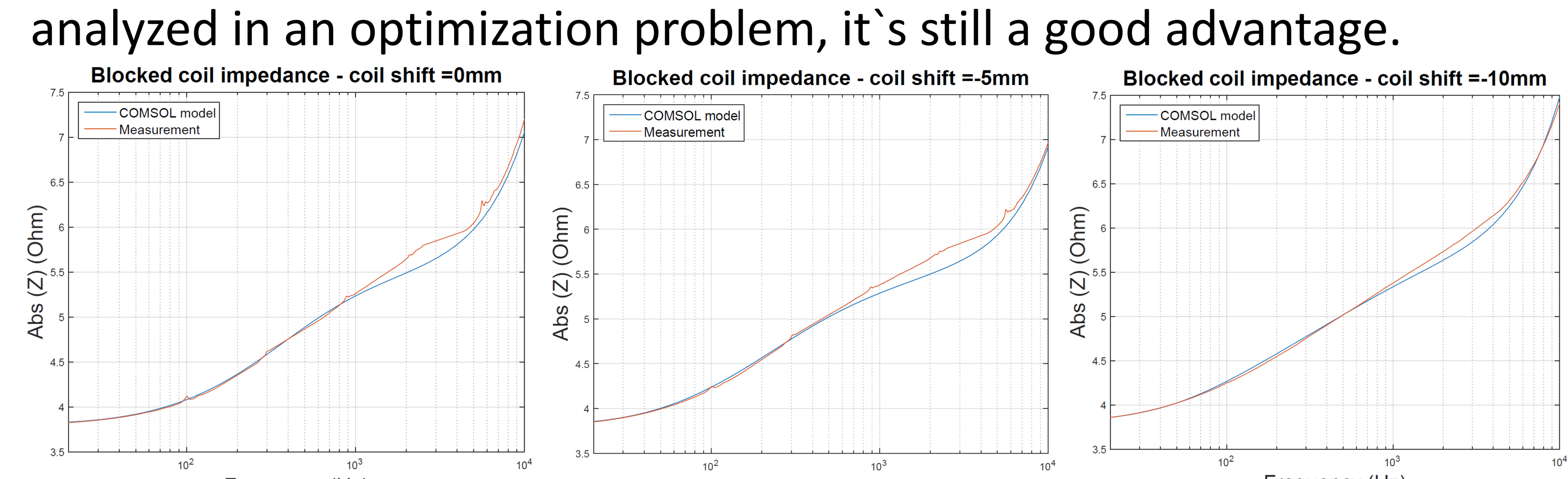
COMSOL and FEMM models give very similar results with a difference between them of less than 1%.
The models have an error of respectively 2% and 3% compared to the measured values of motor 1 and 2 which have been chosen as representative of the maximum spread still within tolerance within our production.

	Computation time (model)
COMSOL	1 minute 04 seconds
FEMM	1 minutes 20 seconds

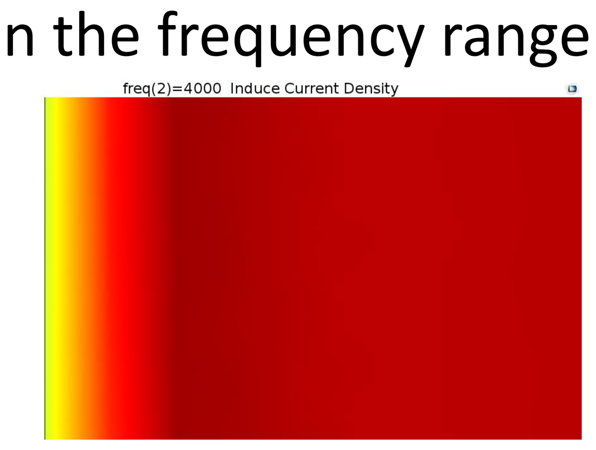


In this case the dynamic Bl is very close to the static one, and the fitting is very good, but it`s worth mentioning that some more elaborate motor configurations tested during this study resulted in a Bl curve which couldn`t be represented accurately by an 8th order polynomial, and thus the fitted Bl curve measured with the Klippel LSI module showed some artefacts which were not visible in the tensile test measurement.

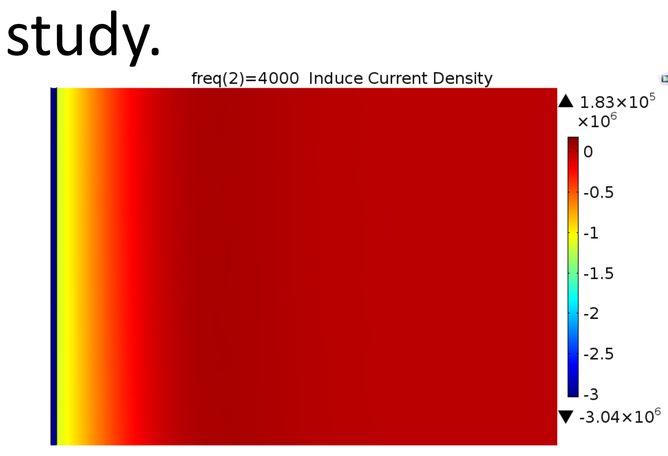
COMSOL resulted as the fastest by 16 seconds, which means it takes 80% of the computation time used by FEMM. Although the difference on a single computation is small, on several models analyzed in an optimization problem, it`s still a good advantage.



The model and the measurement are matching within an error of 4 % within the frequency range under study.



4000 Hz – without plating



4000 Hz – with plating

When the zinc plating is present, due to the high electrical conductivity of the material and its diamagnetic properties, higher currents are flowing in the plating, but similar currents are flowing in the iron.

Conclusions

Both COMSOL and FEMM gave very accurate results for the flux density and the force factor. COMSOL has proven a little faster and the possibility to implement a parameterized geometry is probably better suited for a development work and automatic optimization. Concerning the blocked impedance the results match each other within an error of 4%.

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