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Bowers & Wilkins

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

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Introduction

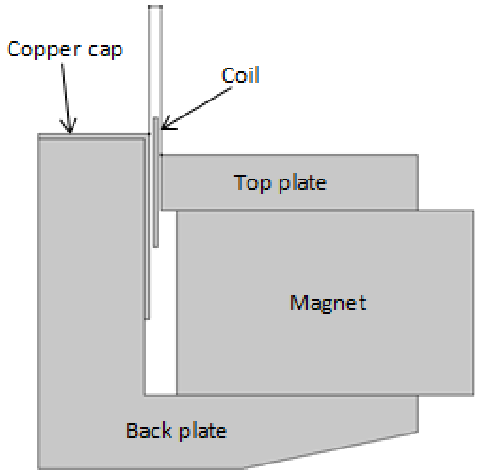
The main purpose of a drive unit is to transform the electrical signal at its terminals into acoustic waves via two transduction mechanisms:

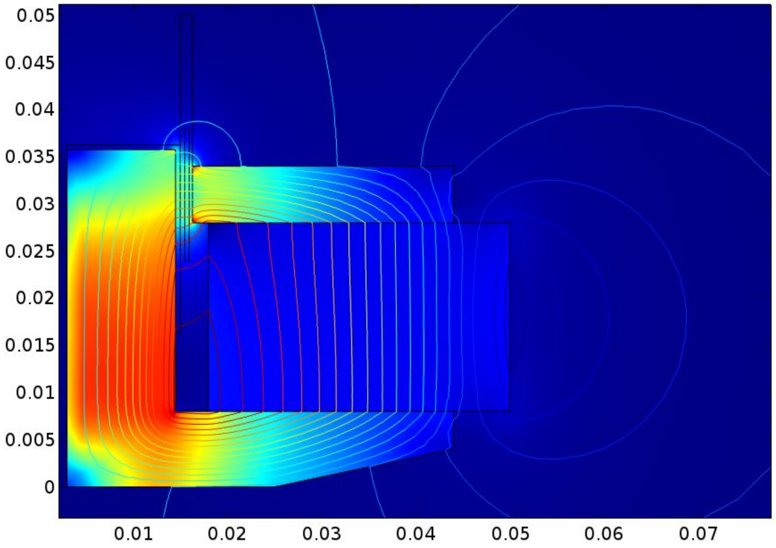
- Electro-mechanical, through the voice coil with the static magnetic field in the motor assembly.
- Mechano-acoustical through the membrane and its suspensions.

In this presentation the electro-mechanical transformation is discussed for the optimization of the Force Factor (Bl) and the Blocked Impedance (Zb) as functions of the voice coil position.

Here the results on Comsol and FEMM are compared to measurements performed on a tensile test machine and on the Klippel system.

System under study



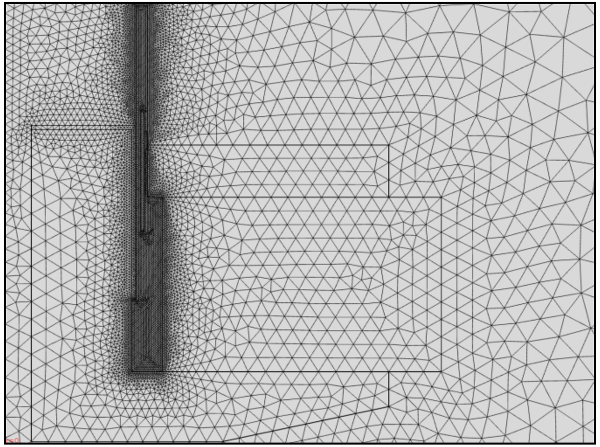


6.5 inch simple ferrite motor

Modelling

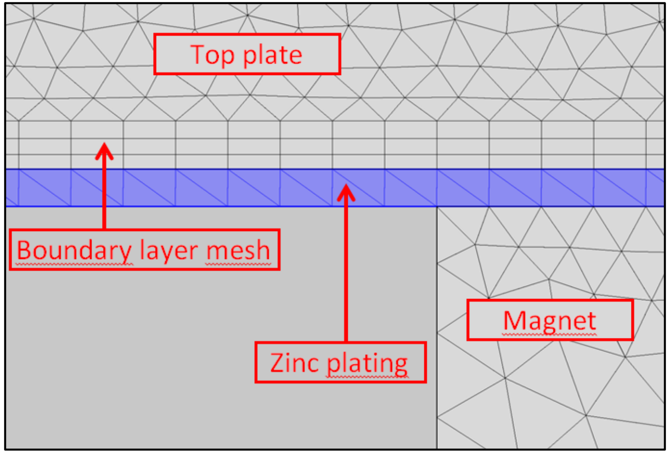
- Magneto static analysis

▪ Magnet: Linear B-H relationship
▪ Voice Coil: Multi-turn Formulation
▪ Steel parts: Ampere's law (HB curve defined by the material).
▪ Parametric sweep for the voice coil displacement
▪ Linear discretization



- Frequency domain analysis

▪ Voice coil: harmonic excitation in the multi-turn formulation
▪ Modelling of the plating (eddy currents)
▪ Refined Mesh with boundary layers (eddy current flow)



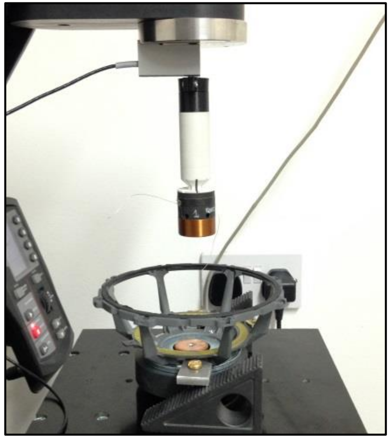
Measurements

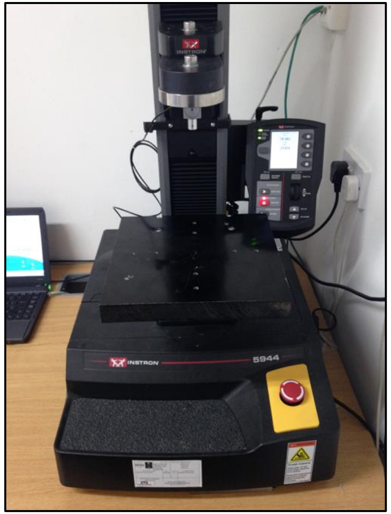
- Tensile Test Machine

Originally used for material properties testing (tensile strength, maximum elongation, reduction area etc.) this machine is computer controlled and very versatile.
The force factor measured is purely static, with no eddy currents impact on the results, thus matching exactly the assumptions of a magnetostatic model.

- Klippel System

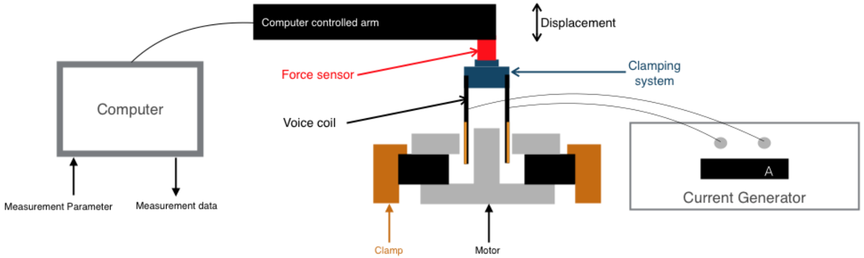
The motors have also been measured with a LSI operation in the Klippel system, a widespread tool for drive units assessment which relies on the fitting of the electrical impedance at various levels to identify the non-linear parameters. The measurement is done in a dynamic setup with band-pass pink noise and is thus affected by eddy currents.





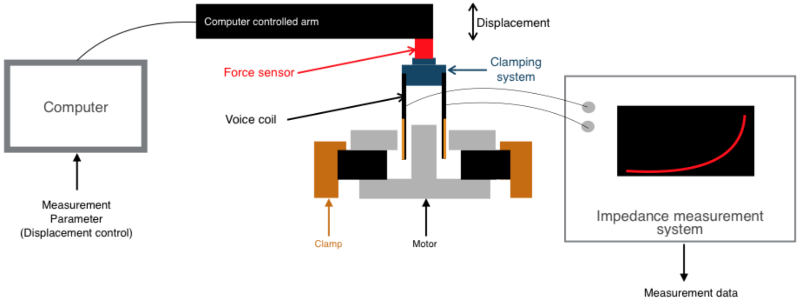
Measurement – set up

- Force factor measurement



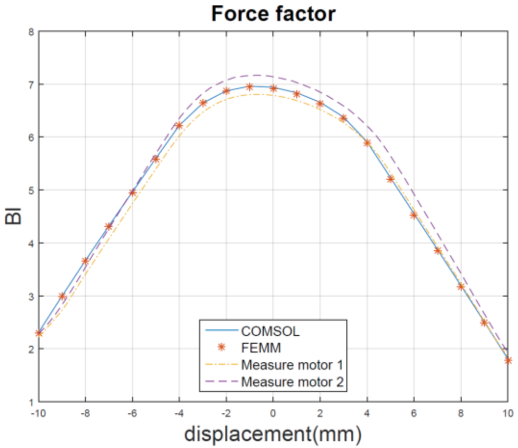
- Constant speed: 5mm/s
- Constant current: 1A

- Blocked impedance measurement



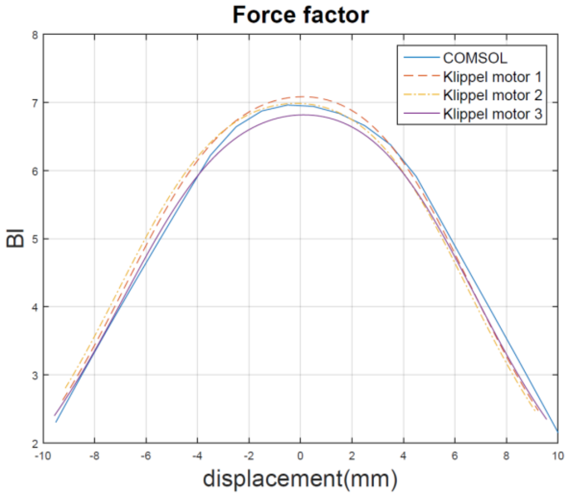
- Take into account the resistance of the tinsels and speaker plate

Results – Force Factor



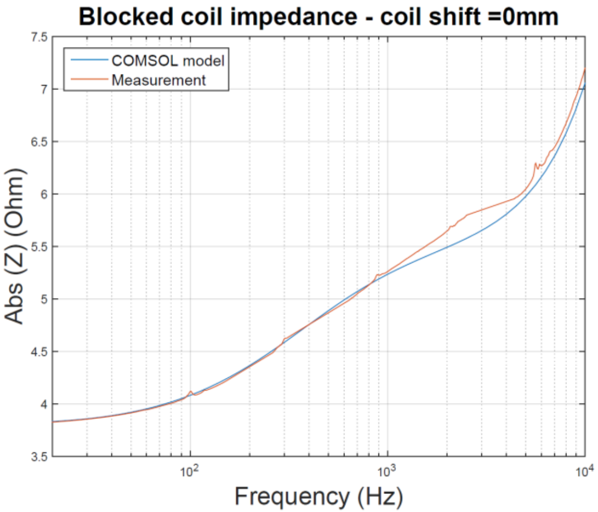
	Computation time (model)
COMSOL	1 minute 04 seconds
FEMM	1 minutes 20 seconds

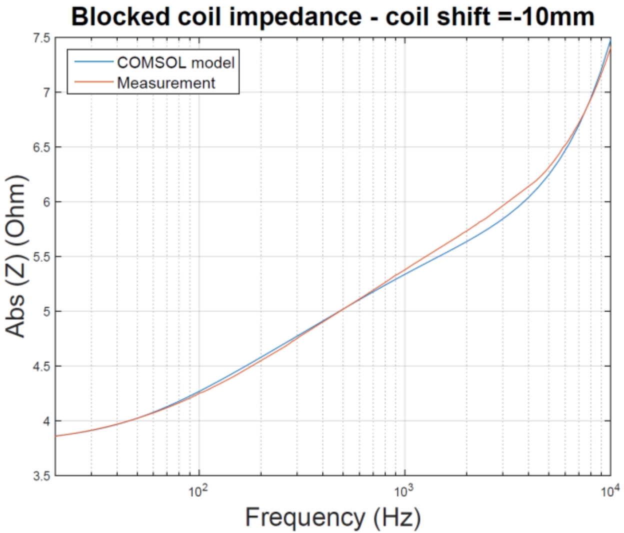
- Difference between models less than 1%.
- The models have an error of respectively 2% and 3% compared to the measured values of motor 1 and 2.



- Comsol model and dynamic setup (Klippel LSI) give very close results as well.
- Please note that this doesn`t apply to every motor configuration: some more elaborate designs result in BxL shapes which are not accurately modelled through polynomial fitting even of the 8th order used by Klippel

Results – Blocked impedance





- Error at 10 kHz: 1.9%
- Model and measurement are fitting within an error of 4 % on the frequency range under study.

The difference at 3 kHz could be due to a low Q mechanical resonance not filtered out or electromagnetic effects not included in the model.

Conclusions

- Both COMSOL and FEMM gave very accurate results for the flux density and the force factor. COMSOL has proven to be a little faster and the possibility to implement a parameterized geometry is probably better suited for a development work and automatic optimization.

- For the blocked impedance, COMSOL results were well within a 4% error across the entire excursion, thus the model is perfectly suitable for development and optimization work.

The use of a finer mesh and adding the zinc plating don’t have a major impact on the results for the motor topology showed in this paper. For topologies using neodymium discs inside the voice coil (typical for many other drive units), ignoring the nickel plating applied to protect the sintered NdFeB magnets results in a blocked impedance magnitude error of about 8%.