Interactive design of an electrostatic headphone speaker using COMSOL Server

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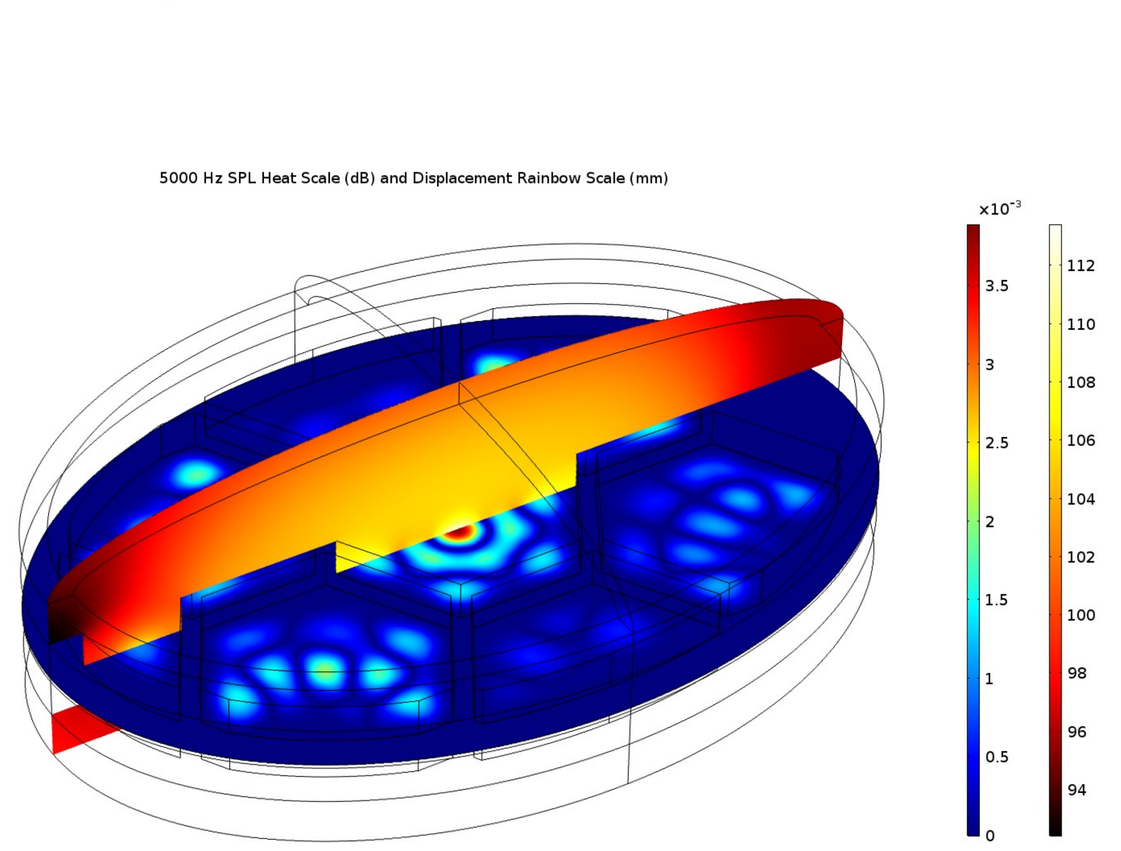
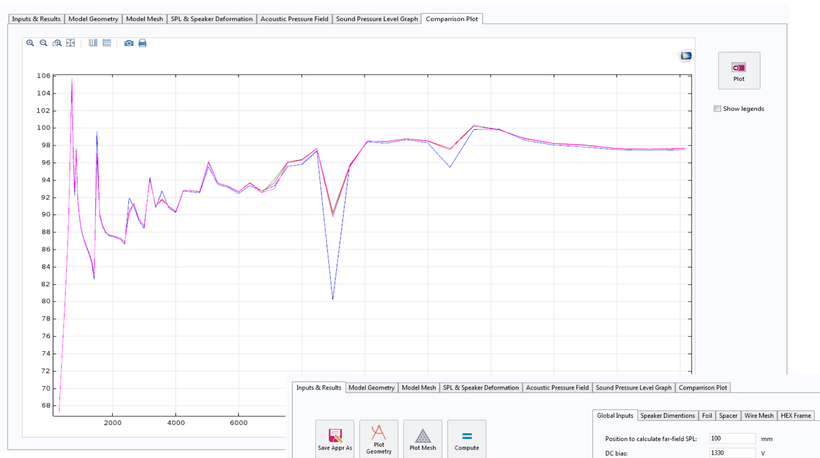
Introduction

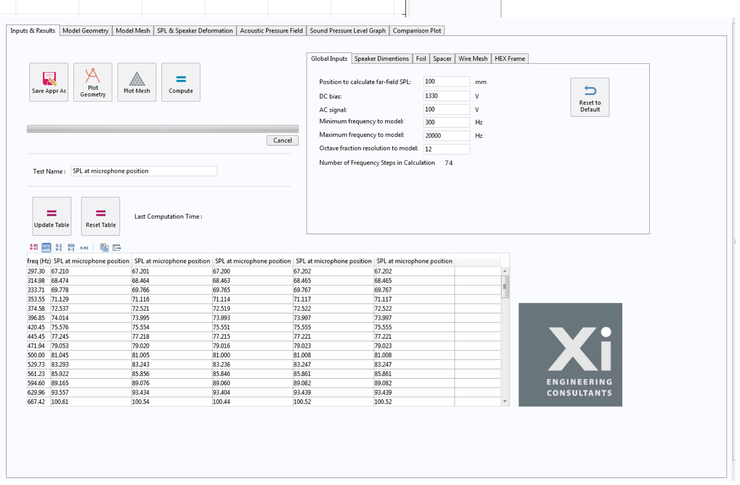
- Electrostatic headphones include many interrelated design elements that affect the frequency response of the headphone and the users listening experience.
- Small changes to design elements like material properties, membrane tension, speaker size and AC and DC signal levels can have a large effect of the speakers acoustic output.
- Xi developed a model to help understand the dynamics of the speaker. The model was used to reduce low-end roll-off, reduce distortion and increase sound pressure level for a given input level.
- A graphic user interface (GUI) was built using COMSOL Server.
- The GUI allowed Warwick Audio Technologies to optimise their speaker using virtual tools and thereby reduce expensive and time consuming prototyping.

Speaker models and challenges

- Warwick Audio Technologies produce a novel one-sided electrostatic speaker for the high-end consume market. Audiophiles demand extremely high quality performance from their speakers.
- The dynamics of the one-sided speaker presents some unique challenges not experiences in more conventional two-sided balanced-drive speakers.
- The dynamics are dependent on the extremely complex interplay between foil tension, AC-signal level, geometry of the speaker, elastic and electromagnetic properties of all materials, thermo-acoustic losses and added-mass effects of the air.
- The correct modelling of the dynamic relationship between the force asymmetry of the one-sided system and the strongly non-linear of the electrostatic force was extremely challenging.
- Xi used a fully-coupled acoustic-structure-MEMS model in COMSOL Multiphysics to model the frequency response of the speaker.
- The model was validated against Warwick Audio Technologies experimental date.







The GUI

- For rapid virtual prototype a GUI was run with COMSOL server and hosted on an Amazon Server.

Global Input
- DC bias
- AC signal level
- Frequency range and resolution

Material properties
- Membrane properties
- Spacer elastic and permittivity
- Wire mesh elastic properties
- Wire mesh aperture size and thickness

Geometric changes
- Speaker size
- Cell size
- Cell shape
- Rim and cell wall thickness
- Spacer thickness
- Hex frame size and thickness

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