Presented at the COMSOL Conference 2009 Milan

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Accuracy of Fully Coupled Loudspeaker Simulation Using COMSOL

Michael J.D. Hedges [1] and Yiu Lam[2]

[1] Monitor Audio Ltd, [2] Salford University

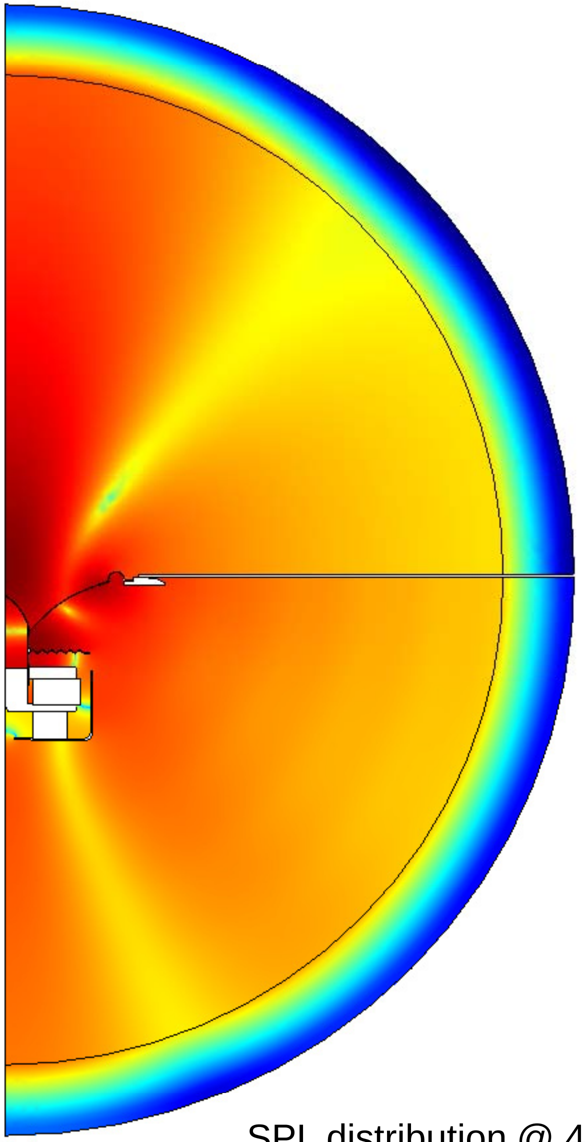
*Corresponding author: Michael J.D. Hedges, 24 Brook Road, Rayleigh, Essex, SS6 7XL, michael.hedges@monitoraudio.co.uk

AIMS

- Use Comsol to develop a model of a 'real' loudspeaker building on the industrial tutorial model found in the acoustics module of Comsol 3.5a.

- Show the results of the model against measured results from a standard drive unit selected from a batch and averaged data where applicable.

- Show the accuracy of the Comsol model and how it can be used to improve design and prototyping efficiency.



SPL distribution @ 4kHz

BRIEF OVERVIEW OF MODELING TECHNIQUE

Static Magnetics

- Azimuth Induction Current, Vector Potential (emqa)
- Analysis Type: Static
- Outputs force factor Bl

AC Electromagnetics

- Azimuth Induction Current, Vector Potential (emqa2)
- Analysis Type: Time-Harmonic
- Outputs Blocked Coil Impedance

Structural Mechanics

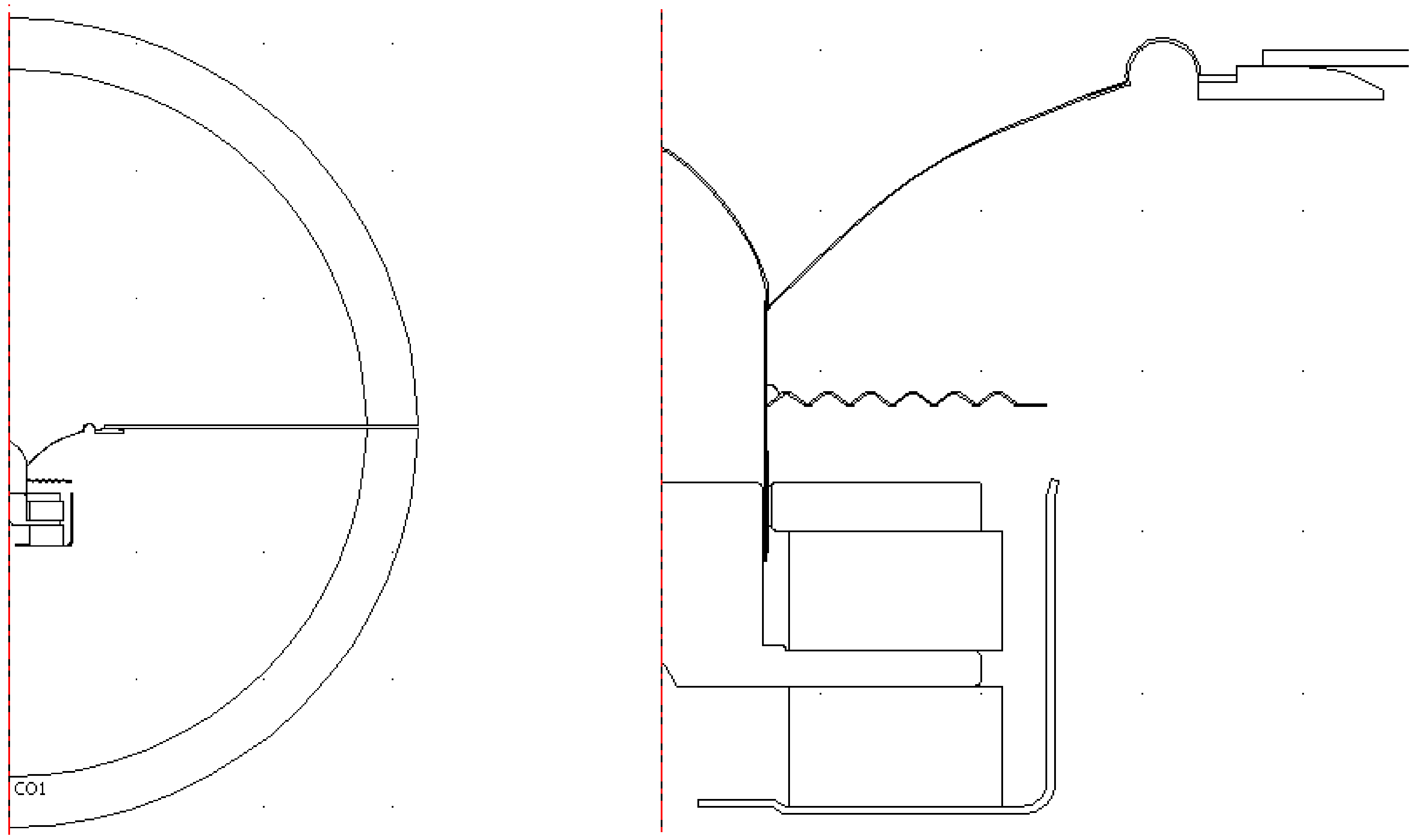
- Axial Symmetry, Stress-Strain (acaxi)
- Analysis Type: Frequency Response
- Blocked Coil Impedance, Force Factor Bl and voice coil velocity used to describe Force applied to voice coil.
- Coupled along diaphragm with acoustic pressure.

Acoustics

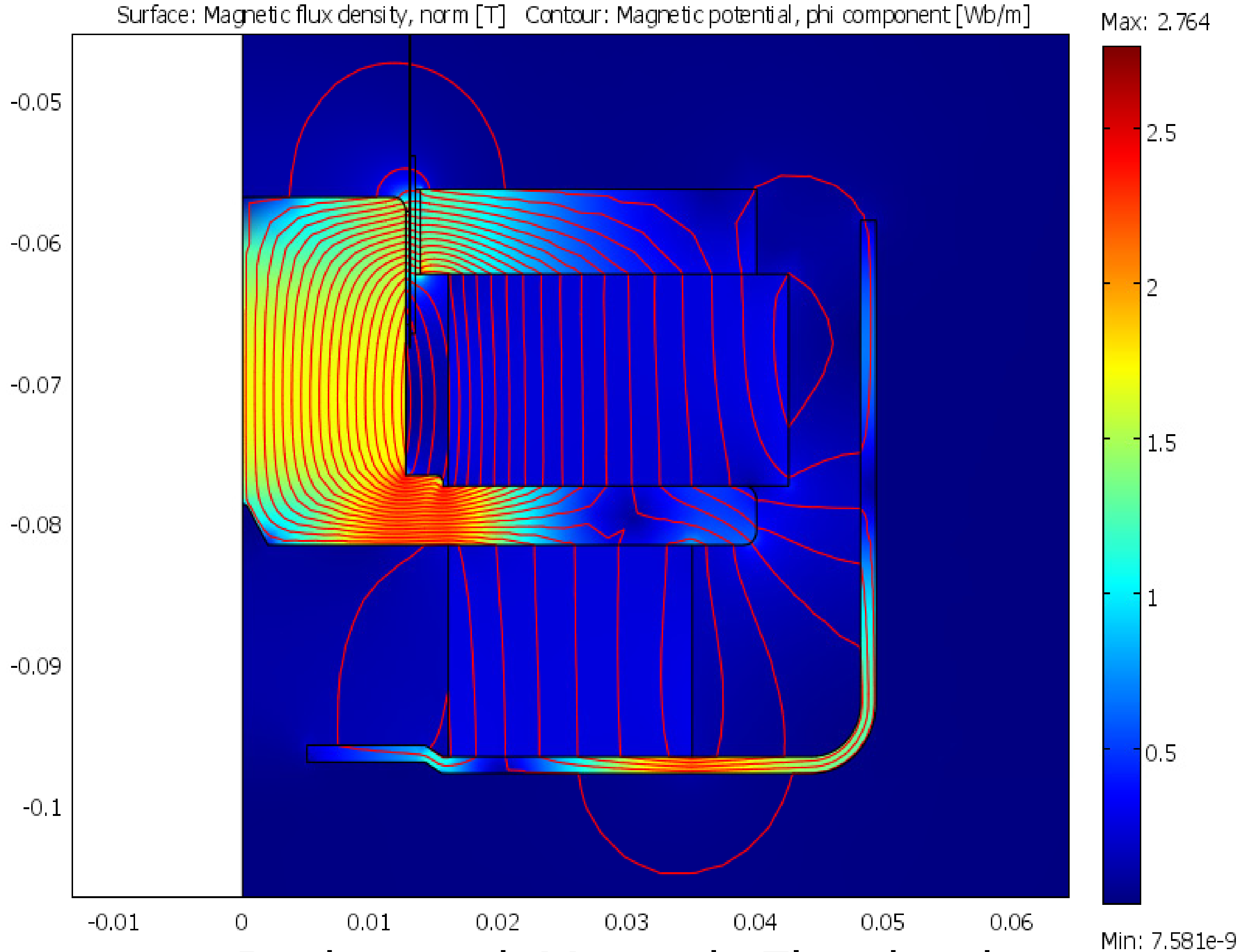
- Pressure Acoustics (acpr)
- Analysis Type: Time-Harmonic
- Coupled along diaphragm with structural acceleration.

Main Assumptions: Axial Symmetric Geometry, Small Signals

GEOMETRY BRS28-6P



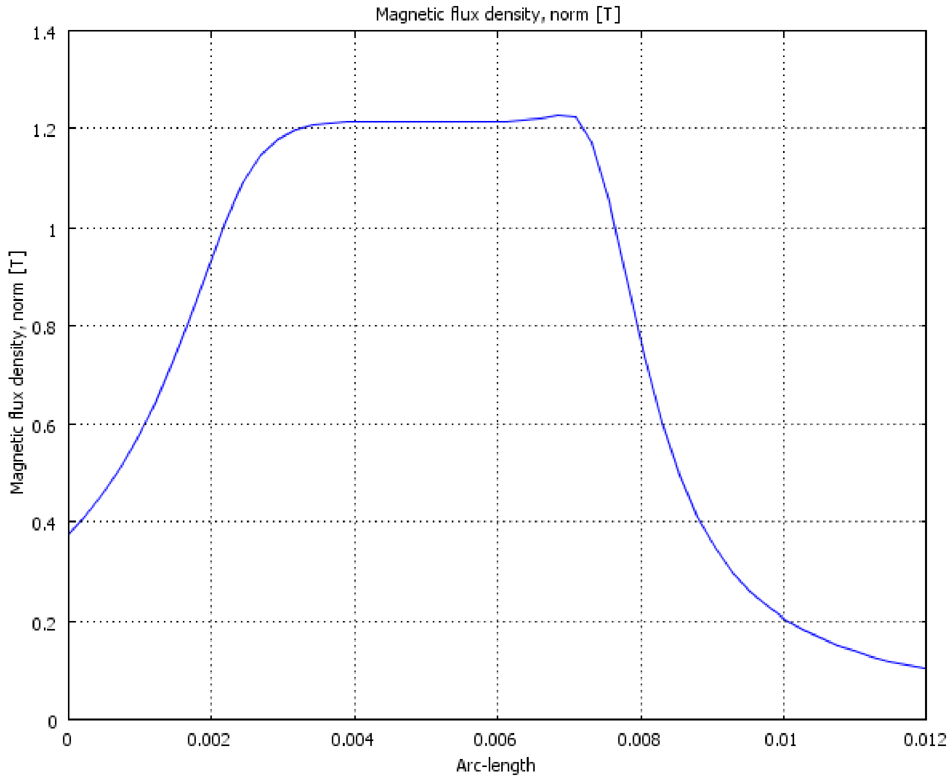
GEOMETRY BRS28-6P

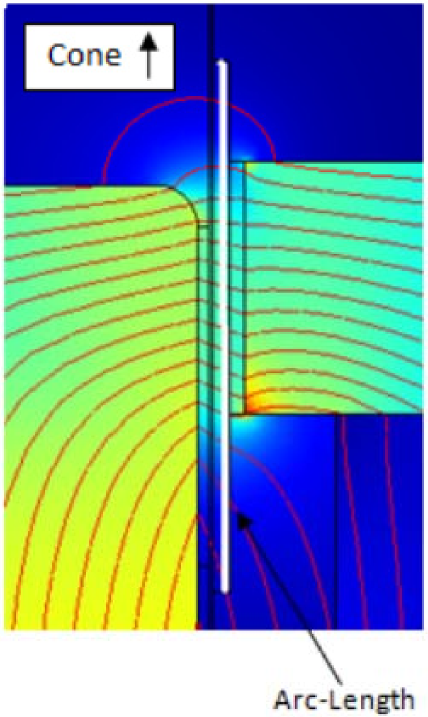


Background: Magnetic Flux density

Lines: Magnetic Field lines

RESULTS Static Magnetic

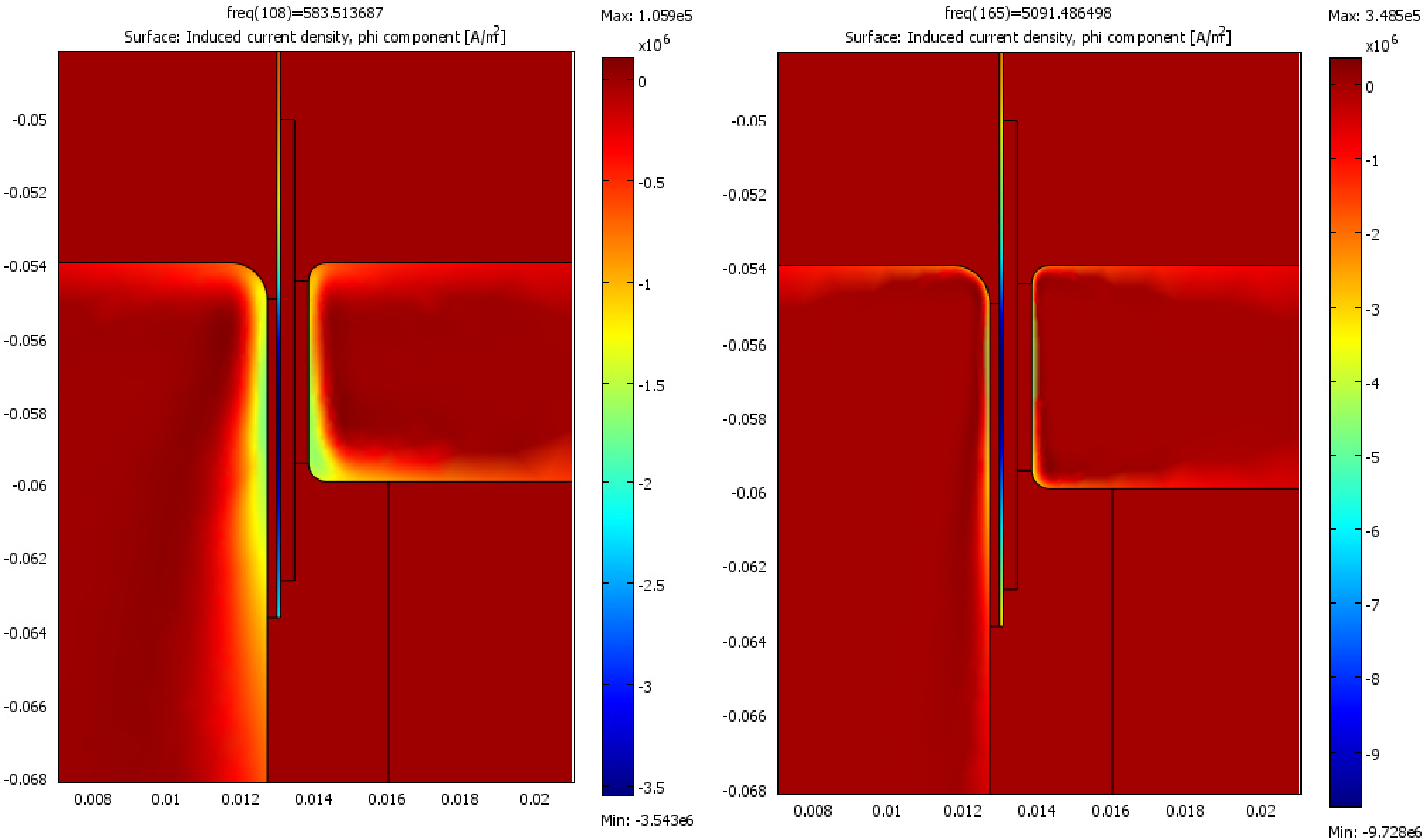




Measured peak magnetic flux density: 1.19 T
Average Magnetic Flux over Voice Coil: 0.676 T
Length of voice coil wire: 9.992m

Modelled Force Factor, Bl: 6.75 Tm
Measured Force Factor, Bl: 6.85 Tm

RESULTS Induced Current Density



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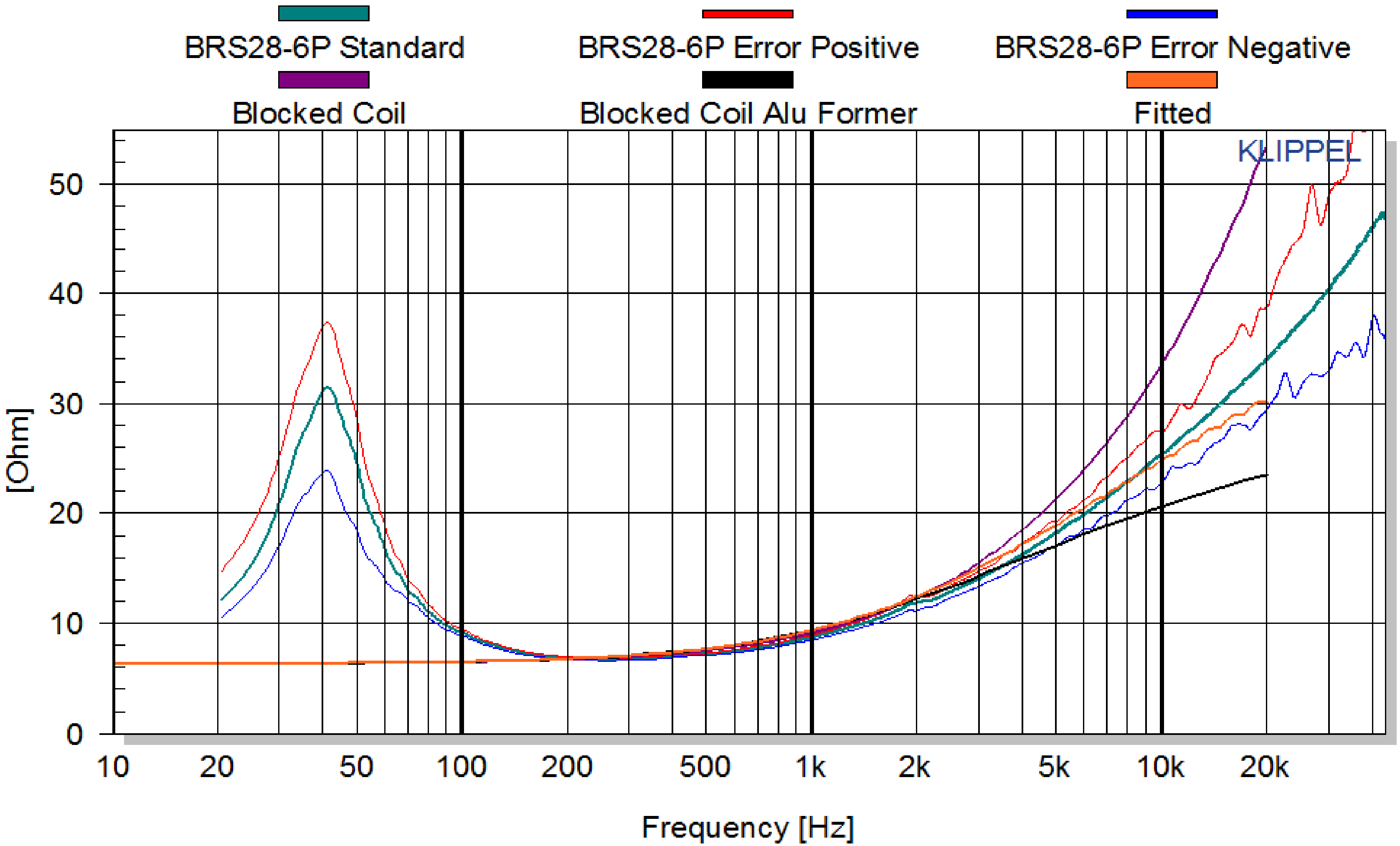
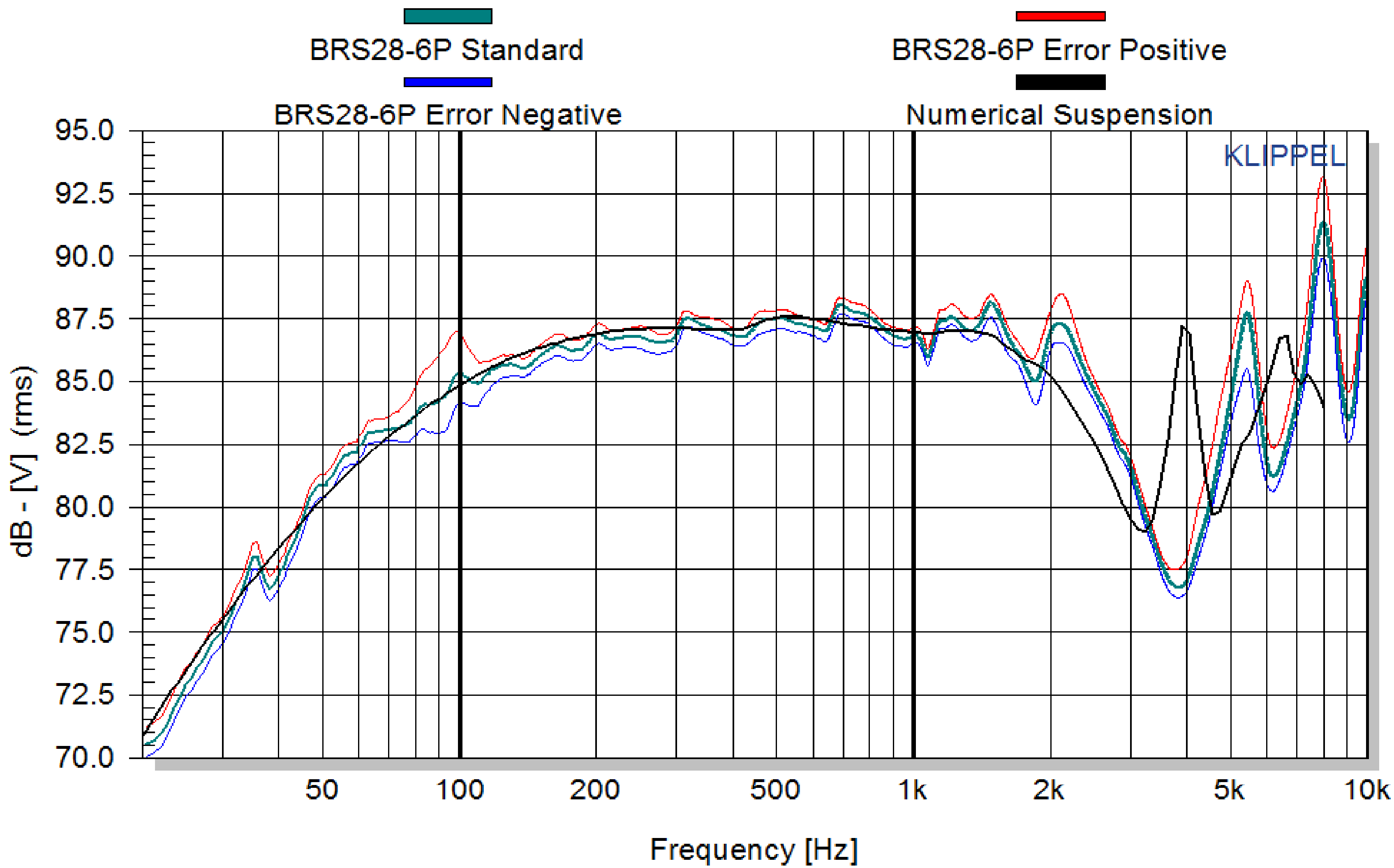
RESULTS Blocked Coil Impedance



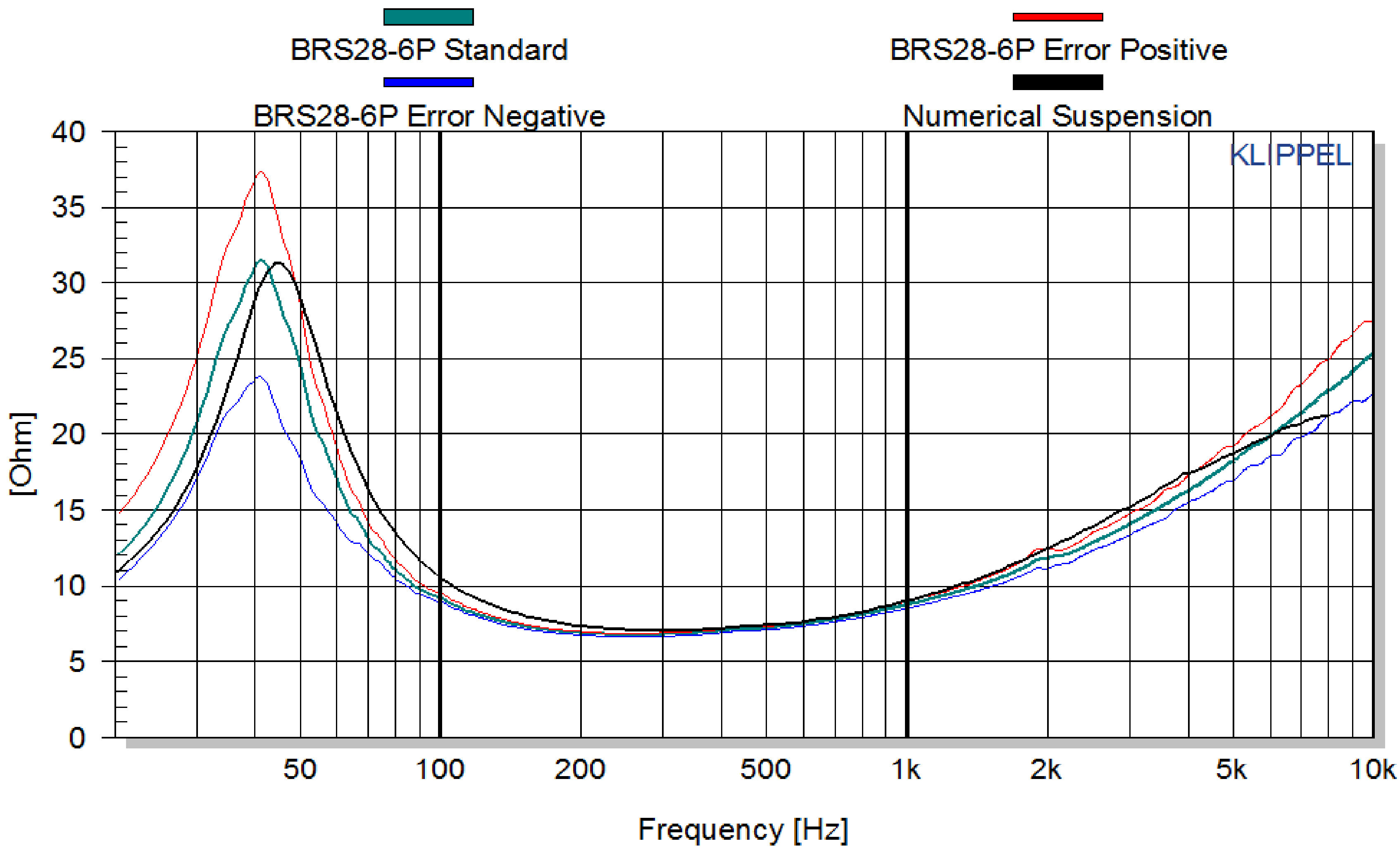
MONITOR AUDIO

Design for sound.

RESULTS Frequency Response with numerical model suspension



RESULTS Impedance Response with numerical model suspension



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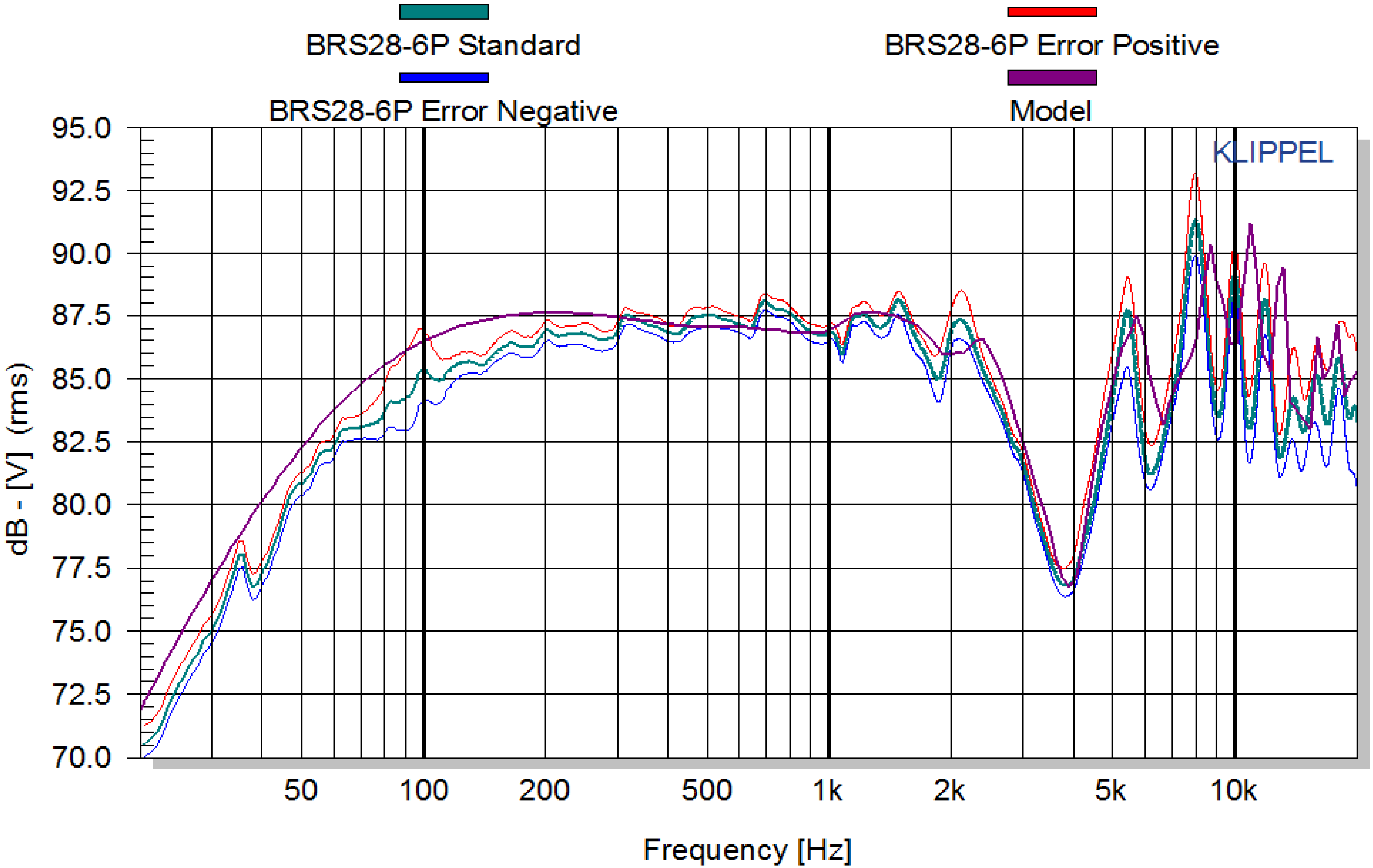
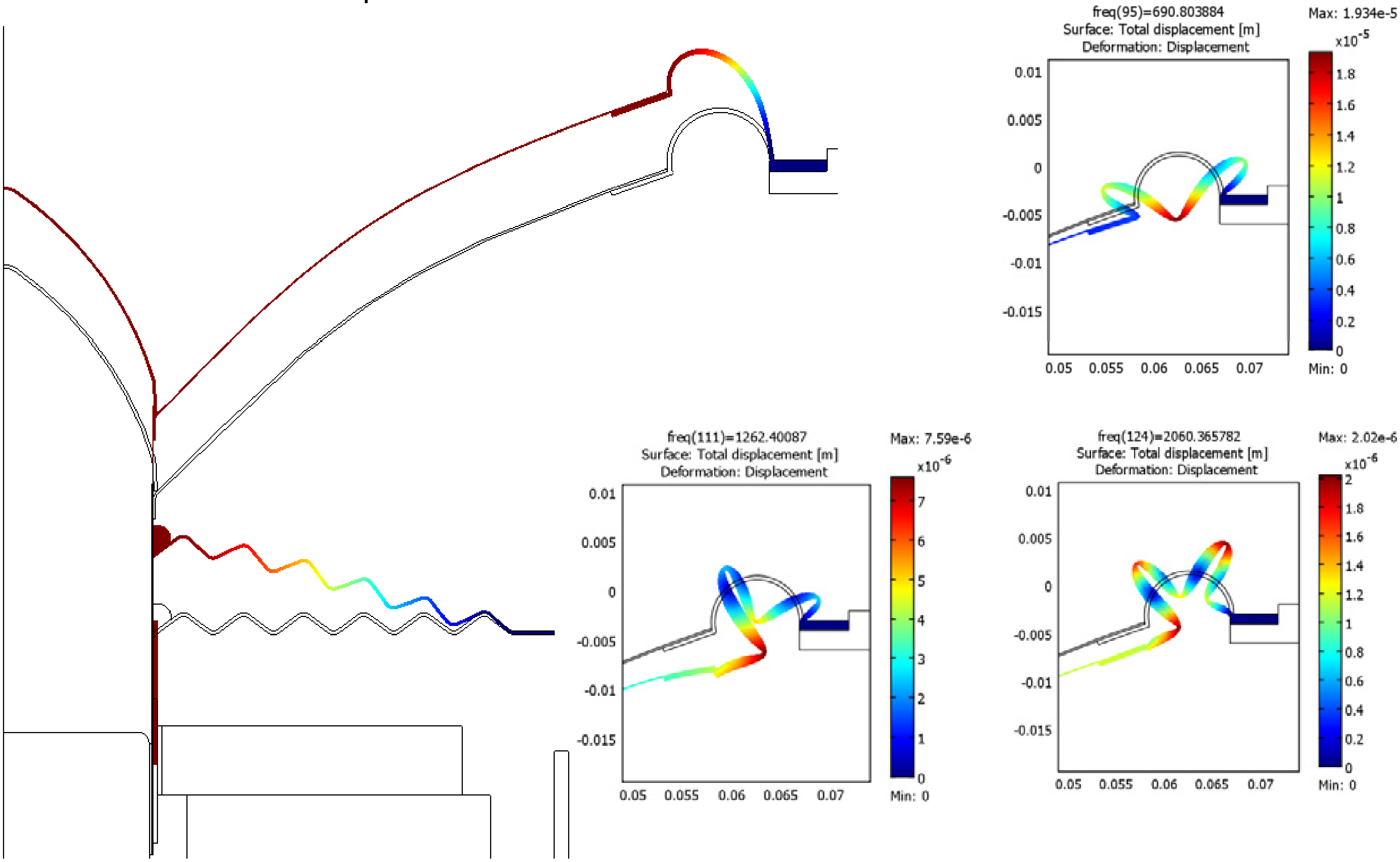
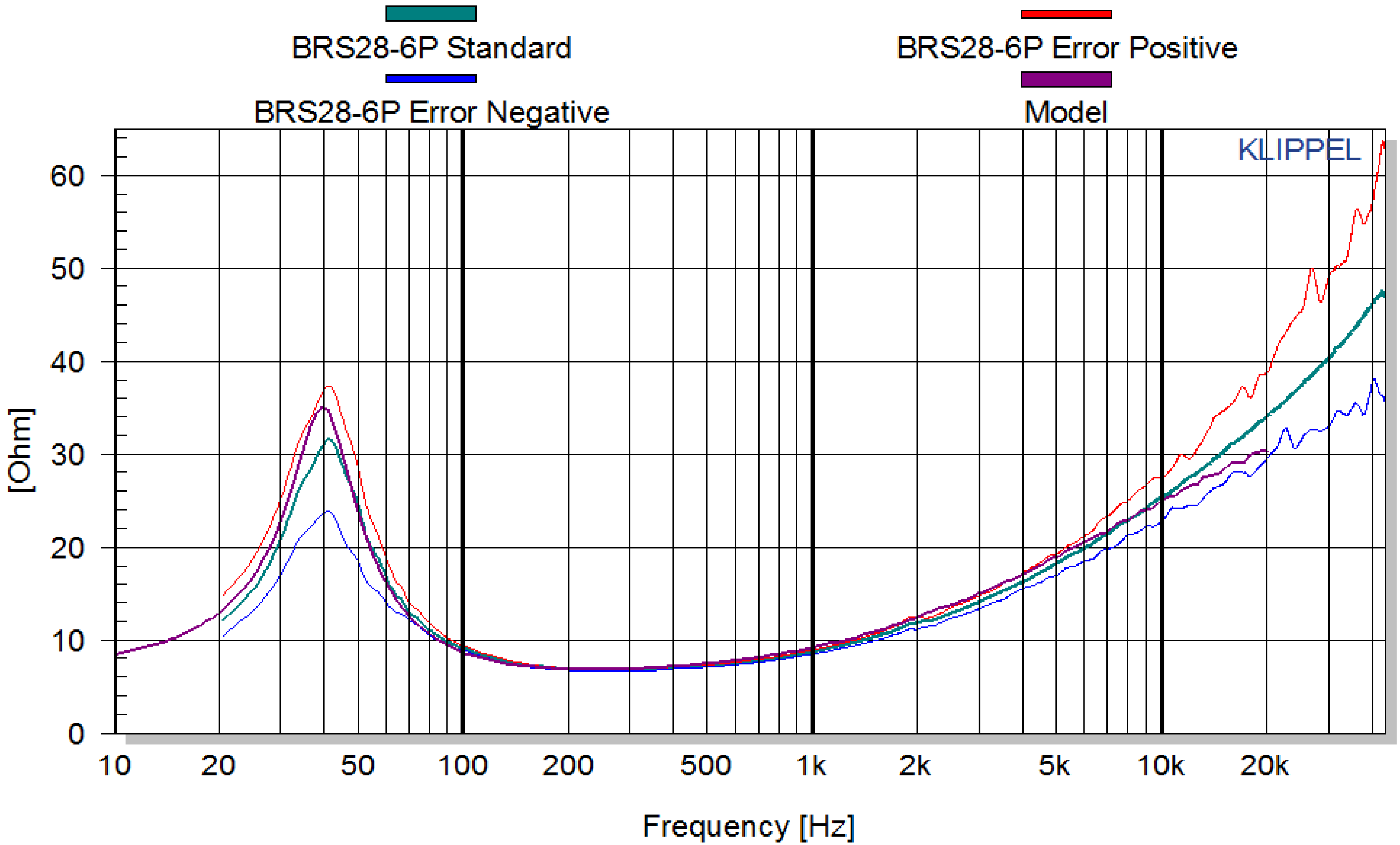
RESULTS Fully Coupled Frequency Response



RESULTS Cone Displacement



RESULTS Fully Coupled Impedance Response



MORE RESULTS

- Suspension compliance with respect to displacement Kms(x) can be calculated using a simple nonlinear structural model. This show excellent correlation with measured results from Klippel's LSI module measurement results.
- Magnetic Force Factor with respect to displcaement Bl(x) can be calculated using results from the static magnetic model. These results show good correclation with Klippel's LSI module measurement results.
- Allows advanced structural analysis of diaphragm performance.

CONCLUSION

Static Magnetics

- Magnetic Field within voice coil gap shows good correlation with measured results
- Force Factor Bl is predicted more accurately than batch variation when the material parameters are known.

Blocked Coil Impedance

- Results show the largest error, due to drive unit not being axis symmetric
- A good estimation can be found by modelling the former as aluminium and as air. Giving maximum and minimum.

Numerical Suspension Model

- Shows good correlation below 800Hz for both the frequency response and the impedance response.

Fully Coupled Model

- Shows good modelling of the higher modes of the cone and surround.
- The frequency response clearly shows the major modes of the cone and surround.
- The number and frequency of the main cone breakup modes are very close to the measured results.