ANTI-RATTLE SYSTEM LOUDSPEAKER DEVICE

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ABSTRACT

On the basis of loudspeaker cabinets and panels vibration problems, this study deals with a new dynamic loudspeaker device capable to reduce mechanical vibrations transmitted to the panel where it is fixed. Virtual 3D prototype is designed and optimized by simulations. Simulations were carried out using analytical and finite element methods. A working prototype was realized, measured and then tested on a panel, in order to evaluate vibrations reduction.

1. STANDARD LOUDSPEAKER MODEL SETUP

Firstly, a standard woofer was implemented, using a ferrite magnetic assembly, steel basket, rubber surround and a paper cone.

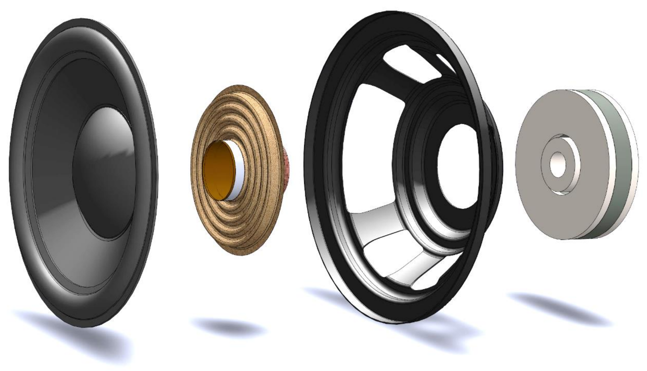


Figure 1. Standard loudspeaker parts.

Loudspeaker 3D design was imported in COMSOL, solved for the magnetic field and structural mechanics physics.

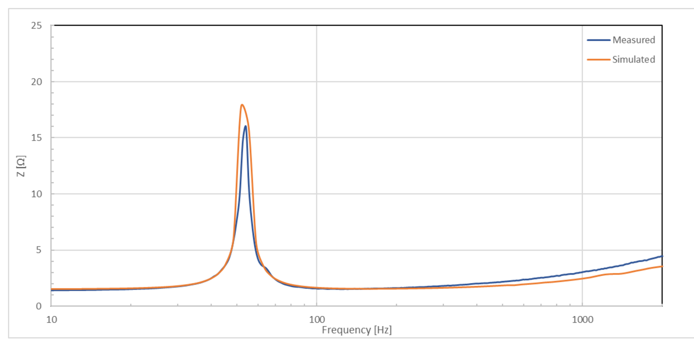


Figure 2. Loudspeaker electric impedance, measurement vs simulation plot comparison.

Real loudspeaker prototype moving parts were measured using a laser on membrane center along its axis movement.

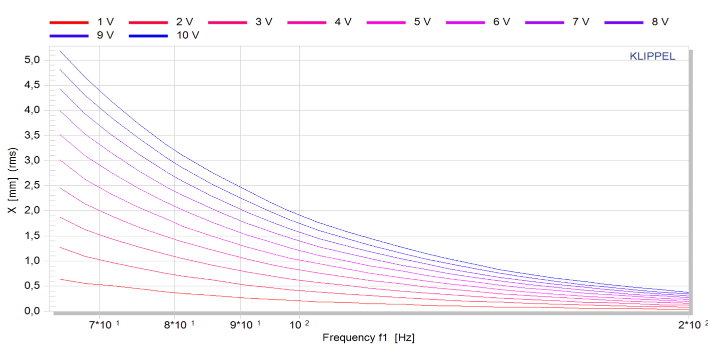


Figure 3. RMS displacement vs frequency and amplitude.

Displacement @5V is used to compare measured and simulated amplitude.

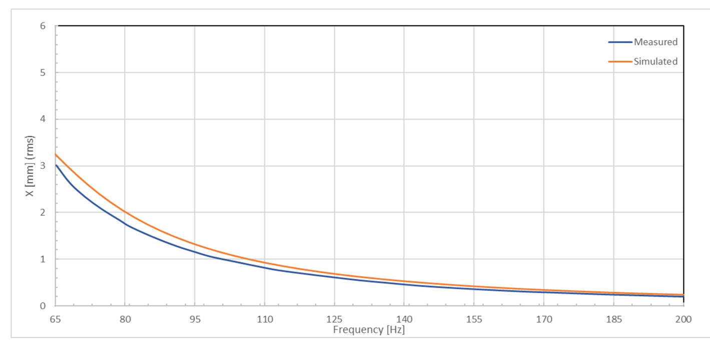


Figure 4. RMS displacement vs frequency @5V amplitude. Measurement vs simulation plot comparison.

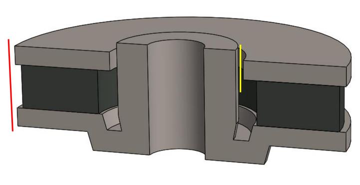


Figure 5. Transducer magnetic assembly and cut lines displayed for flux density analysis.

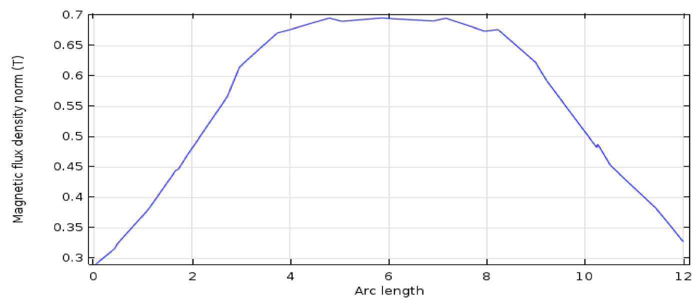


Figure 6. Simulated magnetic flux density plotted on the cut line inside transducer gap.

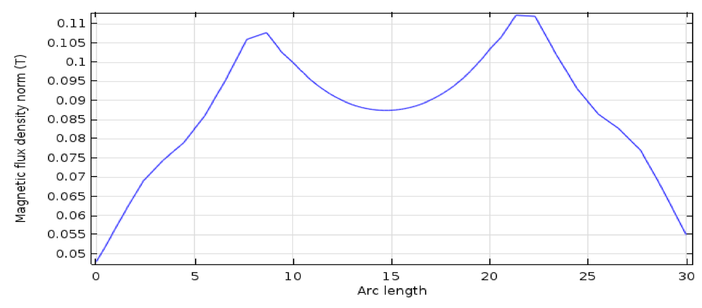


Figure 7. Simulated magnetic flux density plotted on the cut line on the magnetic assembly external side.

2. ANTI-RATTLE LOUDSPEAKER SYSTEM DESIGN

A loudspeaker with Anti-Rattle structure in a mechanical system can be identified as a TMD (Tuned Mass Damper) with 2-DOF (2 degree of freedom).

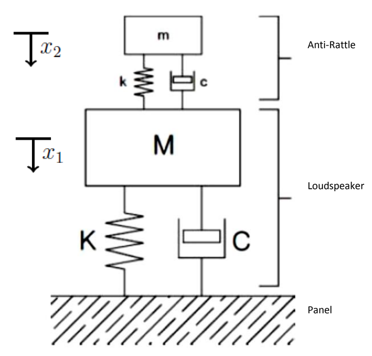


Figure 8. 2DOF TMD.

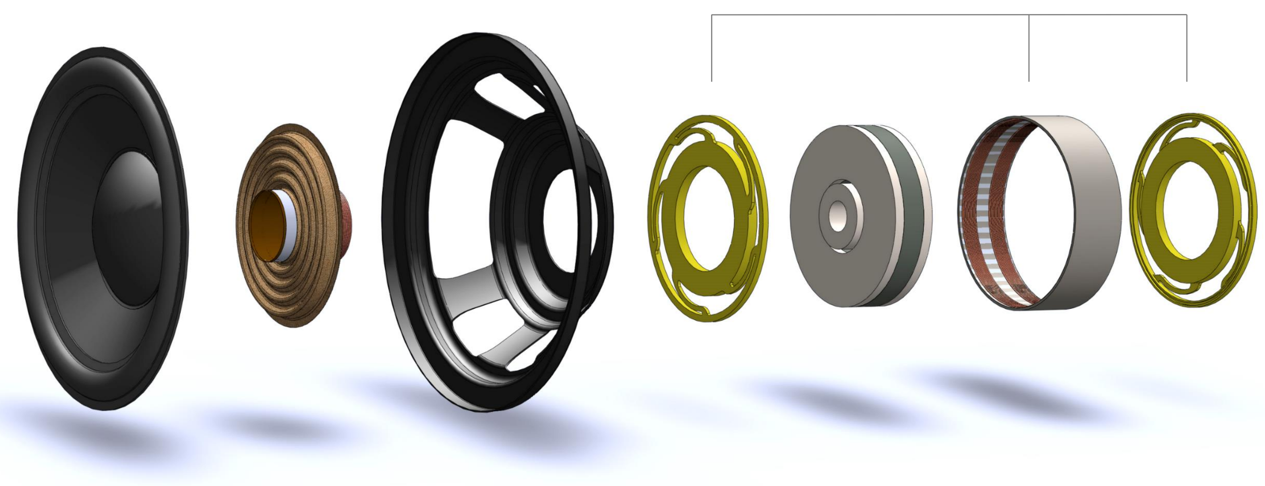


Figure 9. Loudspeaker with the Anti-Rattle system.

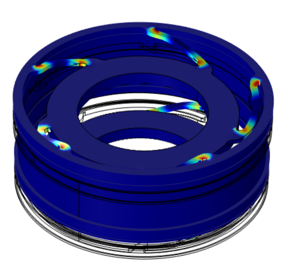


Figure 10. Simulated Von Mises Stress on Anti-Rattle springs.

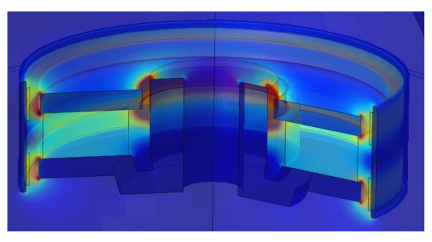


Figure 12. Simulated magnetic flux density.

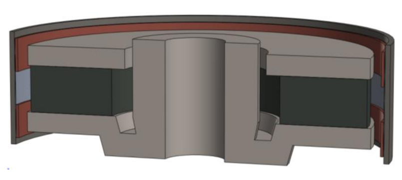


Figure 13. The new magnetic assembly will create a double magnetic gap, in which the double winding Anti-Rattle voice coil will move.

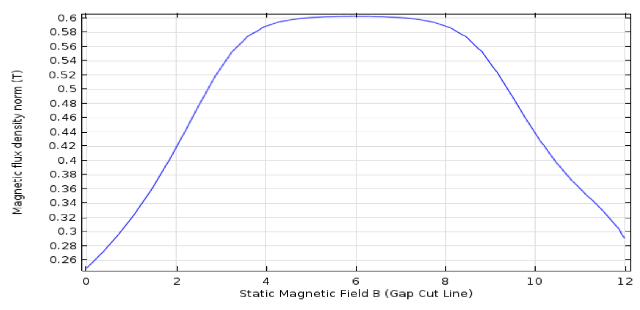


Figure 14. Simulated magnetic flux density inside transducer gap.

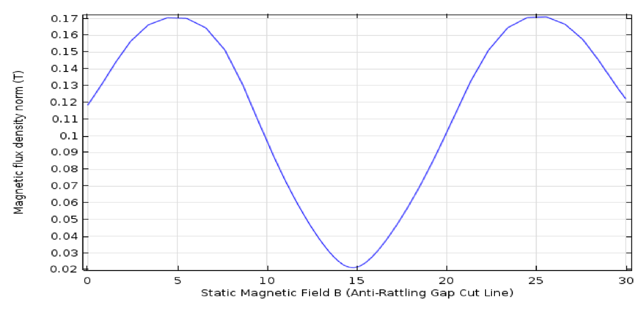


Figure 15. Simulated magnetic flux density inside the Anti-Rattle gaps.

3. ANTI-RATTLE LOUDSPEAKER SYSTEM RESULTS

The closed box has high mass panels that for a 4W measurement it's possible to consider the transducer mounted on an infinitely rigid panel.

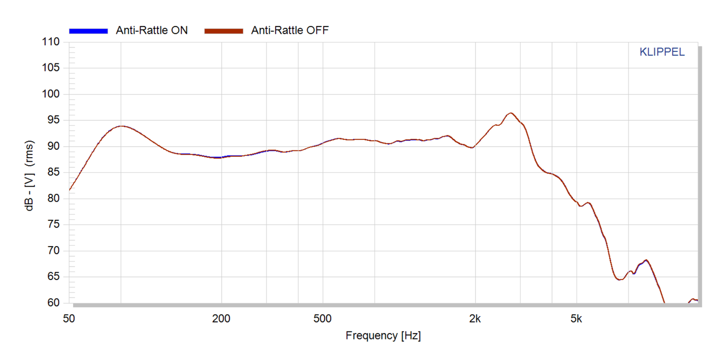


Figure 16. Frequency response comparison of the Anti-Rattle system on/off @4W.

Turning on Anti-Rattle system the THD measurement shows a different behavior in the frequency range 100÷500 Hz.

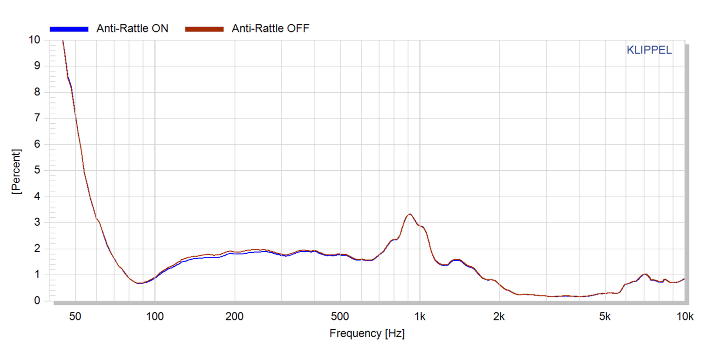


Figure 17. THD comparison of the Anti-Rattle system on/off @4W.

Changing Anti-Rattle phase the THD measurement shows a complementary behavior in the same frequency range.

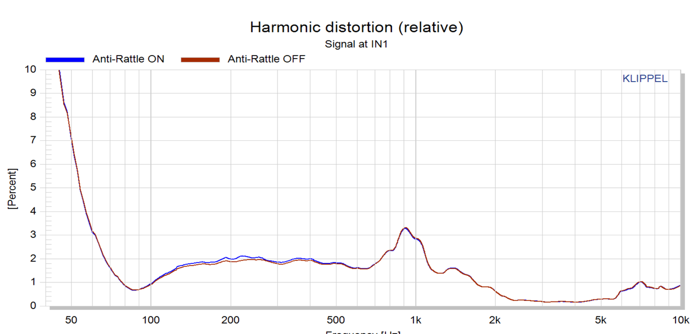


Figure 18. THD comparison of the Anti-Rattle system on/off @4W.

Eigenfrequencies structure simulation shows the first 4 modes in the range 246÷446 Hz.

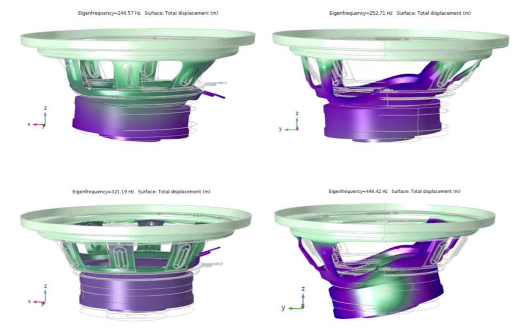
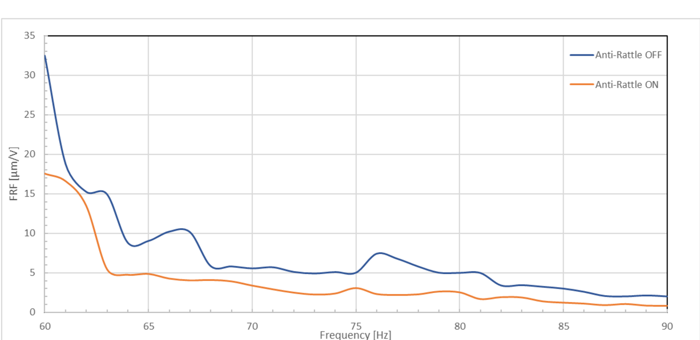


Figure 19. Eigenfrequencies. Fixed constraints on transducer basket screws.



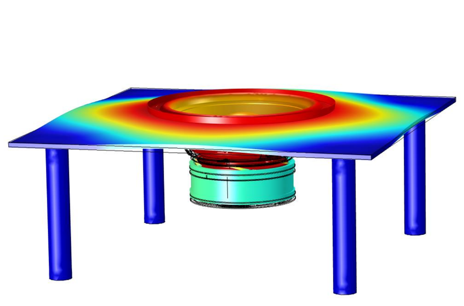


Figure 20, 21. Using a laser scanner vibrometer a structural Frequency Response Function (FRF) comparison of the Anti-Rattle system on/off has been done. Transducer mounted on a wooden panel and excited by a filtered Gaussian Noise.

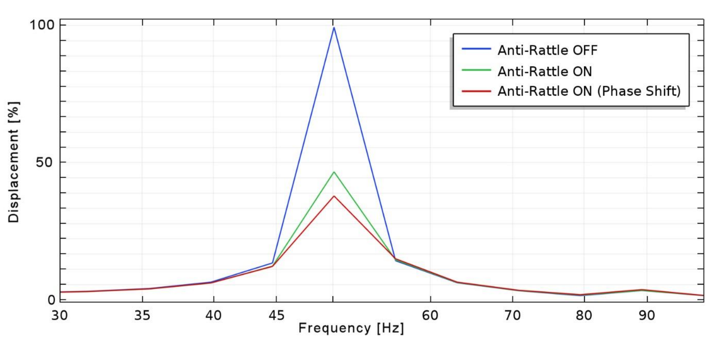


Figure 22. Simulated panel displacement focused on resonance frequency of the loudspeaker excited by a sine sweep. Improved behavior of the Anti-Rattle system given by a phase shift.

CONCLUSIONS

Anti-Rattle system doesn't represent a loss factor for loudspeaker acoustic performances. On the contrary it helps transducer eliminating structure self-vibrations. The first developed prototype reveals about 50% of panel vibrations reduction. But the latest simulations show the way to improve these results.

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Used tools: *Comsol Multiphysics* for FEM simulations, *Solidworks* for 3D design, *SpeakerLAB VVC* for voice coils calculations, *Klippel System* for anechoic measurement, *Laser Scanner Vibrometer* developed by ASK.

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