Acoustic optimisation of hi-fi racks using resonator technology

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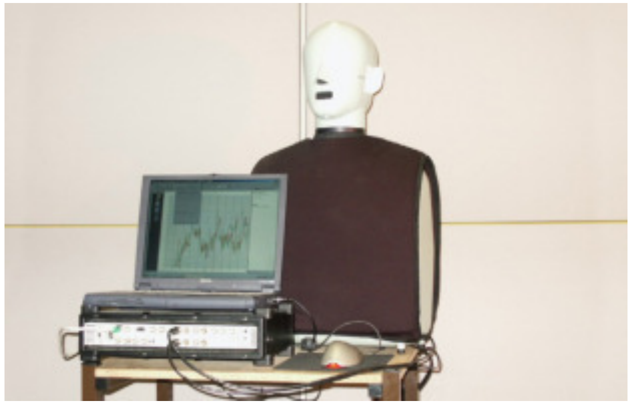
MADE IN GERMANY

With kind assistance of
and in cooperation with
Fachhochschule
Dortmund
University of Applied Sciences
Dortmund

Reduction of oscillation and noise in technical systems with resonators



Acoustic dummy with PULSE system to measure airborne sound pressure

In research cooperation with the Dortmund University of Applied Sciences finite elemente developed a sound optimisation of the pagode° Master Reference and Edition racks by using resonators, relatively small, rod-shaped add-on components that are installed in the rack und handle triggered resonance oscillations instead of the large surface of the component shelves, inaudible due to their small noise radiation surface area.

This patent pending process is based on mechanical energy principles for the mathematical determination of resonator geometry. Resonance oscillations of the rack are avoided in that the noise-neutral resonators, which are naturally easier to excite, dissipate the annoying oscillation energy, converting it into thermal energy.
If a component shelf of the rack is triggered by environmental or loudspeaker noise, then this will cause sound-distorting oscillations in this system component.
Resonators installed in the component shelf level take over the incoming oscillation energy and are set in motion in place of the component shelf level.

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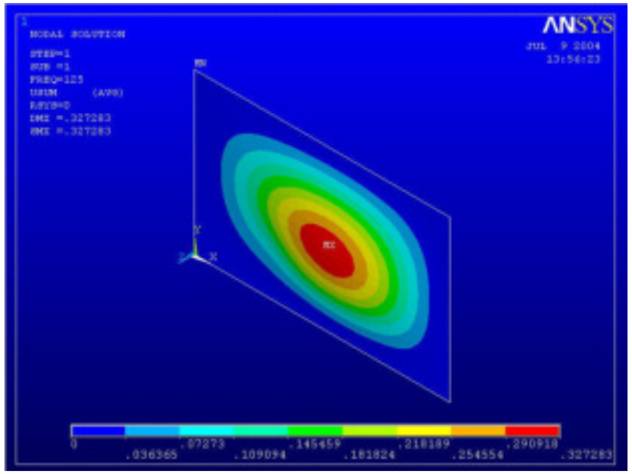
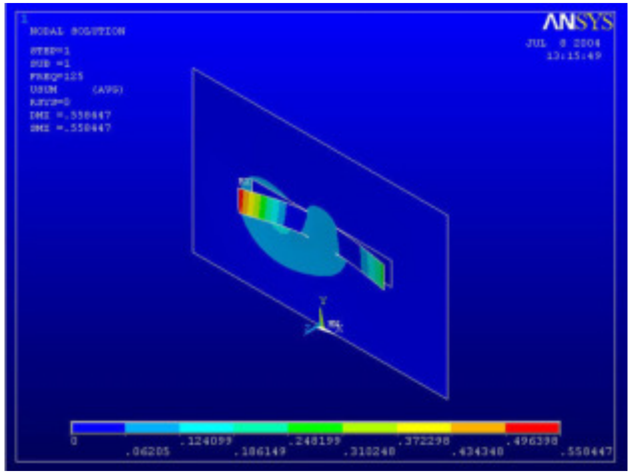
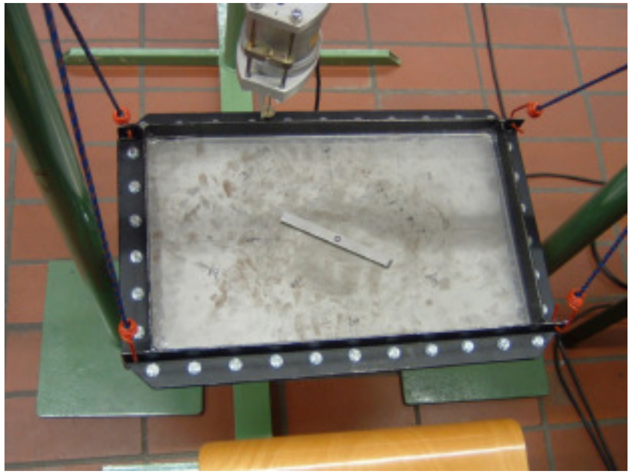






RED = maximal oscillation BLUE = no oscillation

Modal analysis <u>without</u> resonator

- Natural resonance: 125 Hz
- Surface oscillations with strong amplitude
- 80% strong oscillation
  20% oscillation-free

Result: extreme loss in sound quality by resonance disturbance

Modal analysis <u>with</u> resonator

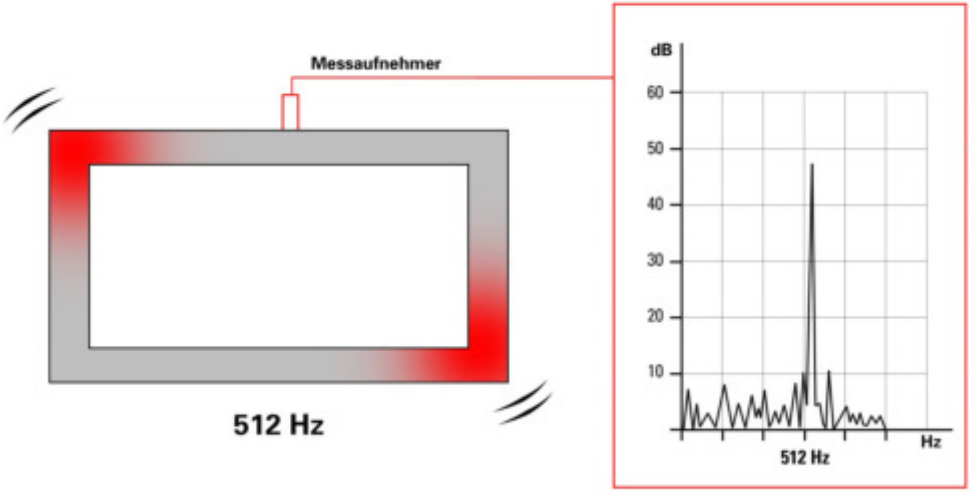
- Twin resonator determined to 125 Hz, with fixation in the middle
- Minimally oscillating surface
- Resonator oscillates in place of the surface
- 90% oscillation-free
  10% reduced oscillation

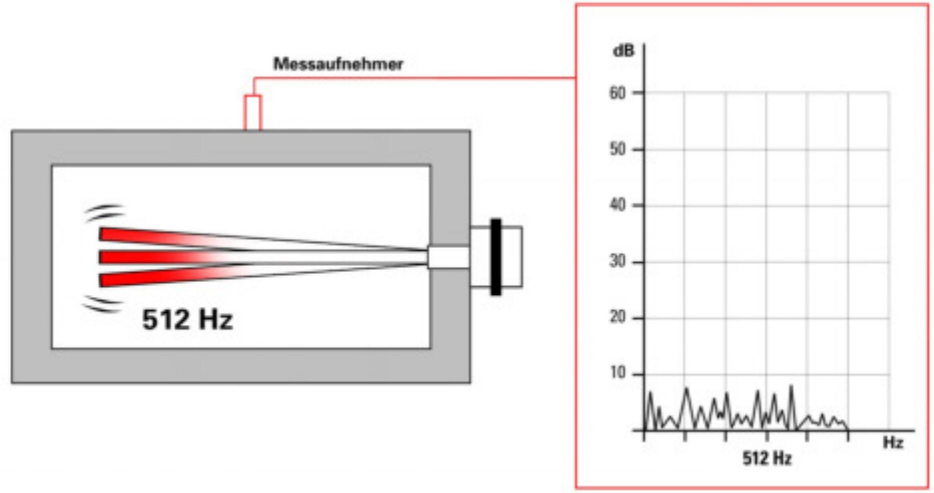
Result: significant sound improvement through minimized natural resonances

Research installation with resonator

- Twin resonator determined to 125 Hz on all-round tensioned metal plate

Functional principle of the resonator in a Pagode rack





Oscillation amplitudes within technical systems that are excited by airborne or solid borne noise can be clearly reduced by integrating or adapting resonators. Resonators are rod-shaped metal components where their first natural frequency is matched to the excitation frequency or the system's natural frequency. Large amounts of the kinetic energy – with natural excitation up to 90%, with forced excitation up to 70% - are inaudibly converted by the resonators into heat. The example shows the amplitude behaviour with and without resonator at 512 Hz.

Design:

- Metal rod tensioned on one side in stainless steel cylinder
- Resonator geometry exactly determined to 512 Hz
- Stainless steel cylinder bolted with surface contact to the system to be attenuated

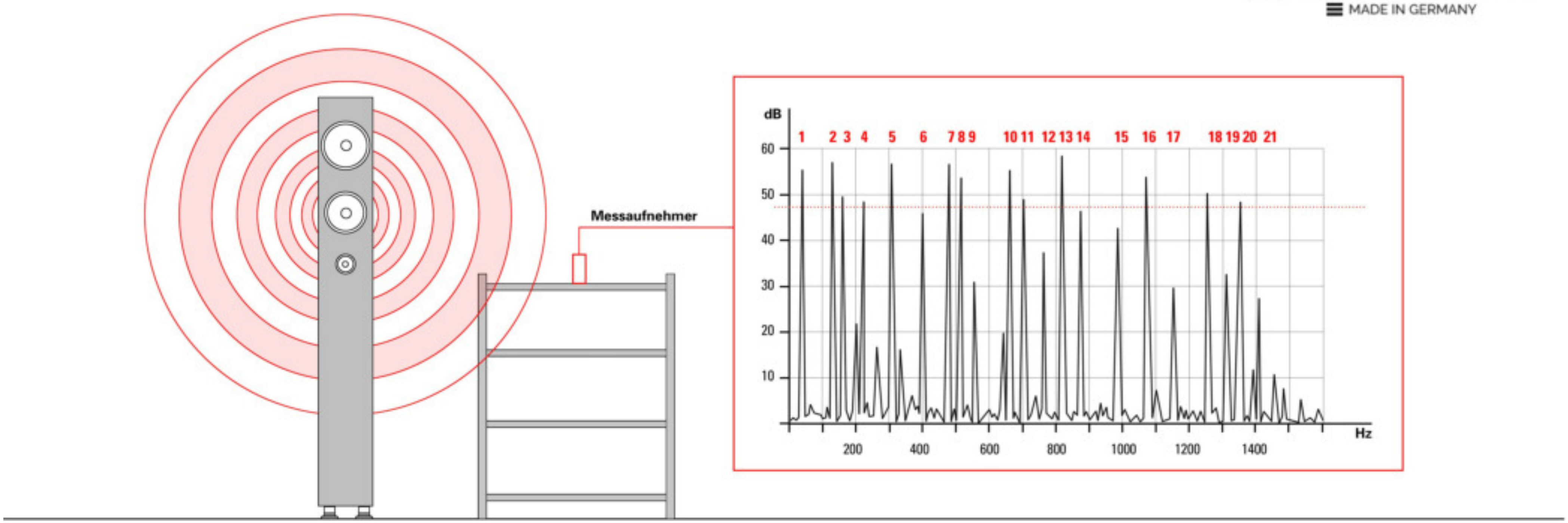
Measured results <u>without</u> resonator:

- Very high amplitude at 512 Hz
- Adjacent areas above and below 512 Hz with increased amplitudes

Measured results <u>with</u> resonator:

- Amplitude at 512 Hz reduced by factor 6
- Bandwith effect of the resonator (+/- 10%) reduces also amplitudes above and below 512 Hz

Conventional hi-fi rack



Design:

- Conventional construction
- Tubular steel welded or bolted
- Component shelves in solid MDF
- Alternatively in a different wood type filled with sand and/or lead grain
- Insufficient attenuation and dissipation

Measured results:

- Uncontrolled oscillation behaviour
- High number of sound-distorting resonances
- Too numerous high amplitudes
- High sound pressure values = clearly audible in music playback

Effect:

- Compressed and contour-less sound
- Lack of transparency
- Limited three-dimensionality
- Tonal displacements
- Insufficient detail resolution
- Limited dynamic scope

Pagode Master-Reference/Edition MKII – design concept

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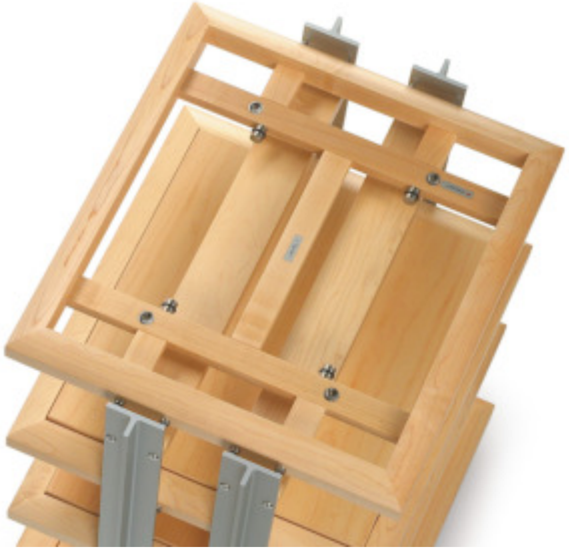
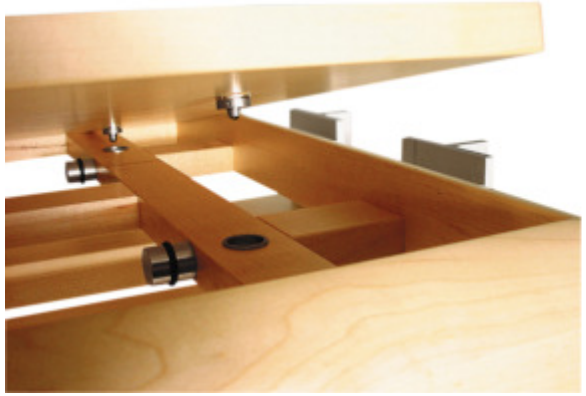
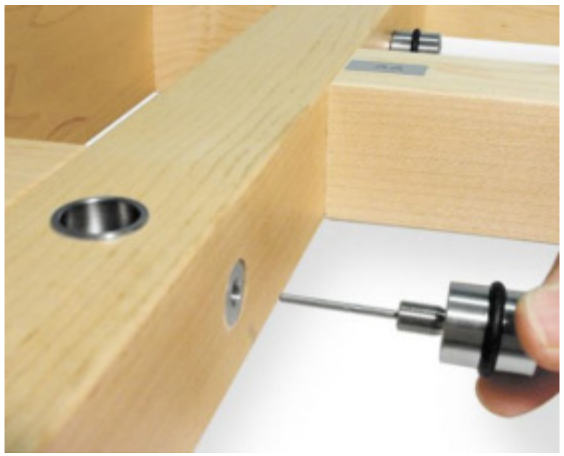
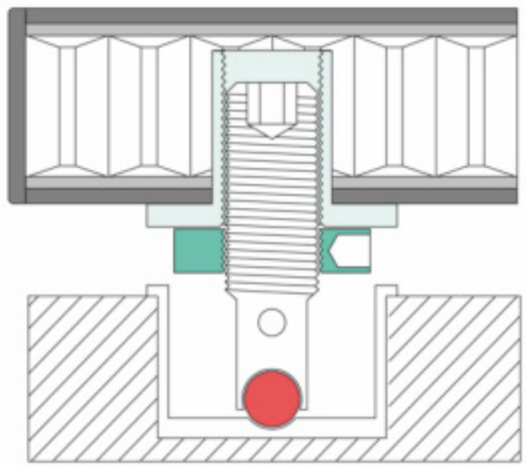




Design:

- Acoustically optimized lightweight design
- Lateral T-shaped profiles in solid aluminum
- Component level frames in solid Canadian maple
- By means of ceramic ball bolts defined coupled component shelves with ultra-light honeycomb core
- Horizontal tensioning of component level frames by means of lateral stainless steel spikes for mutual damping
- Well-balanced damping and dissipation



Honeycomb core shelf with ceramic ball coupling



Pagode Master-Reference/Edition MKII without resonators

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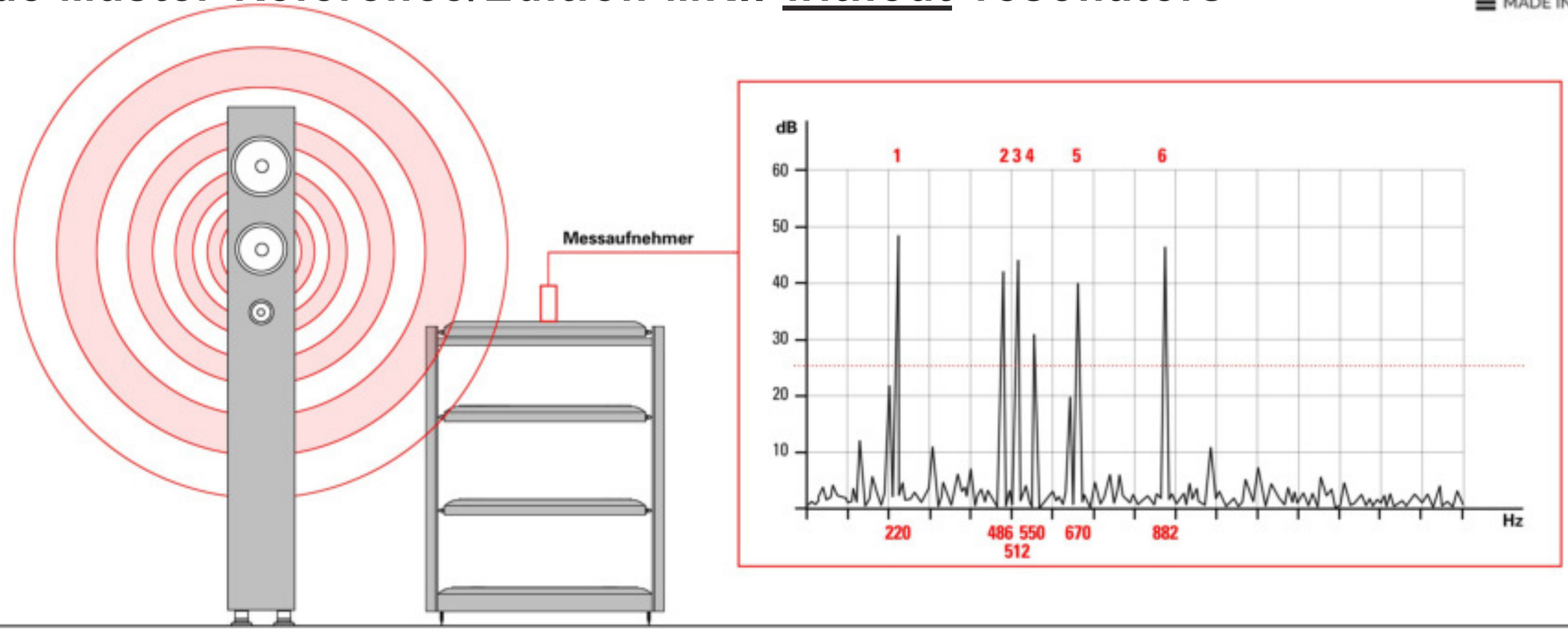


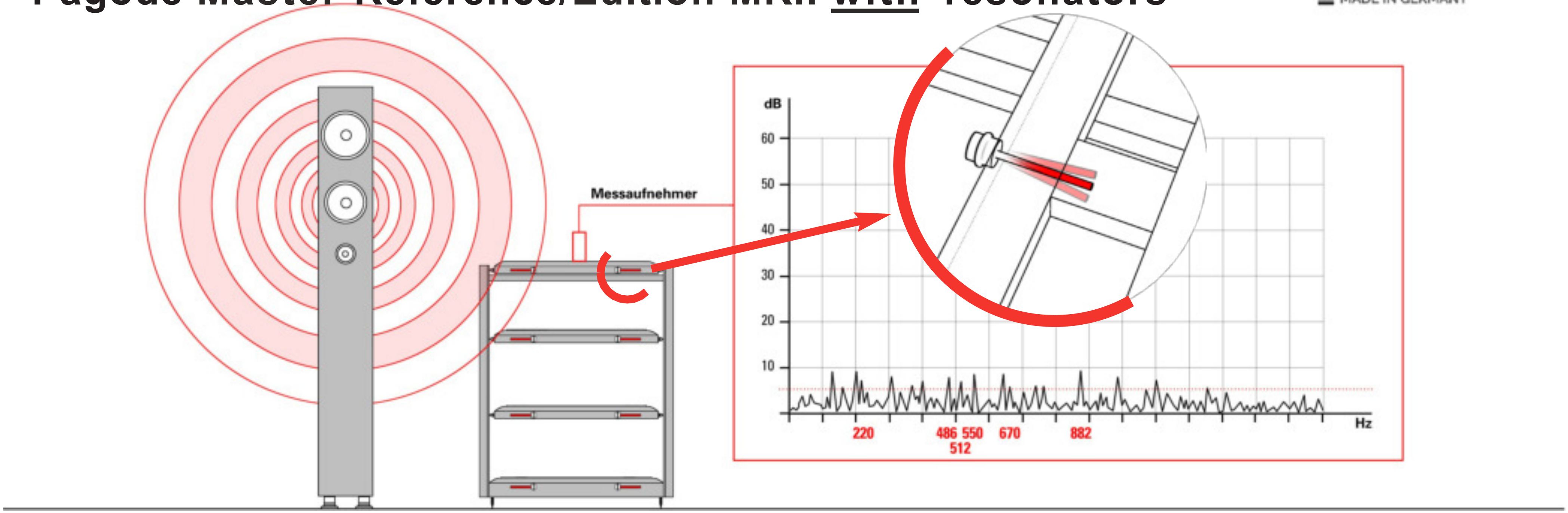
Measured results:

- Optimized resonance behaviour
- Only six natural resonances left: 220 Hz, 486 Hz, 512 Hz, 550 Hz, 670 Hz, 882 Hz
- Reduction of highest amplitudes
- Significantly reduced sound pressure values = barely audible during music playback

Effect:

- Open and contoured sound
- High transparency
- Extended three-dimensionality
- Correct tonality
- Very good detail resolution
- Large dynamic scope

Pagode Master Reference/Edition MKII <u>with</u> resonators



Design:

- Construction as Pagode Master Reference/Edition
- Controlled resonance attenuation by means of resonators
- Four resonators per level, exactly determined to the six natural resonances of the sample rack:

  220 Hz, 486 Hz, 512 Hz, 550 Hz, 670 Hz, 882 Hz

Measured results:

- Perfectly controlled oscillation behaviour
- No sound-impairing natural resonances
- Drastically minimized sound pressure values = not audible during music playback

Effect:

- Outstanding open and contoured music reproduction
- Excellent transparency
- Holographic three-dimensionality
- Perfect tonality
- Excellent detail accuracy
- Outstanding fine and coarse dynamics
- Extremely coherent acoustic image

Modal analysis of a conventional hi-fi rack

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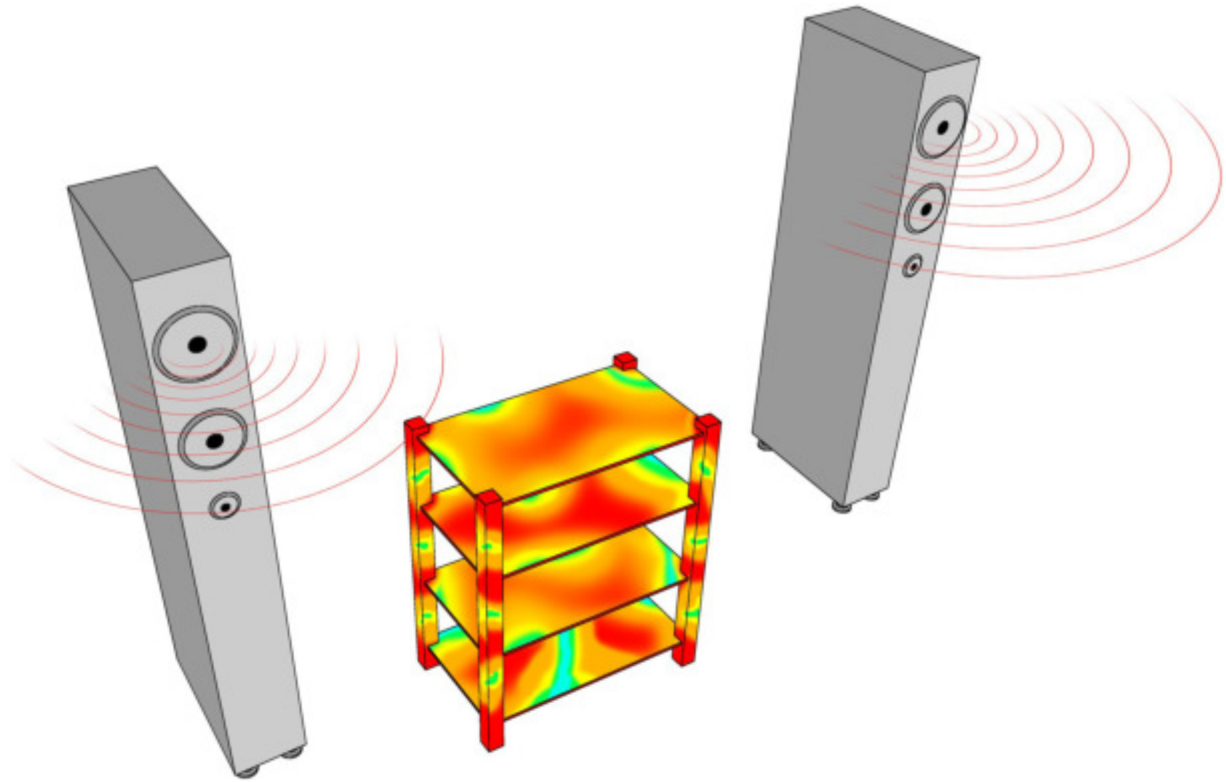

Key:

- No oscillation
- Minimal oscillation
- Low oscillation
- Medium oscillation
- Strong oscillation
- Maximal oscillation

Measured results:

- Uncontrolled oscillation behaviour
- High number of sound-distorting resonances
- Too numerous high amplitudes
- High sound pressures values = clearly audible during music playback

Effect:

- Compressed and contour-less sound
- Lack of transparency
- Limited three-dimensionality
- Tonal displacements
- Insufficient detail resolution
- Limited dynamic scope

Modal analysis of a
Pagode Master Reference/Edition MKII

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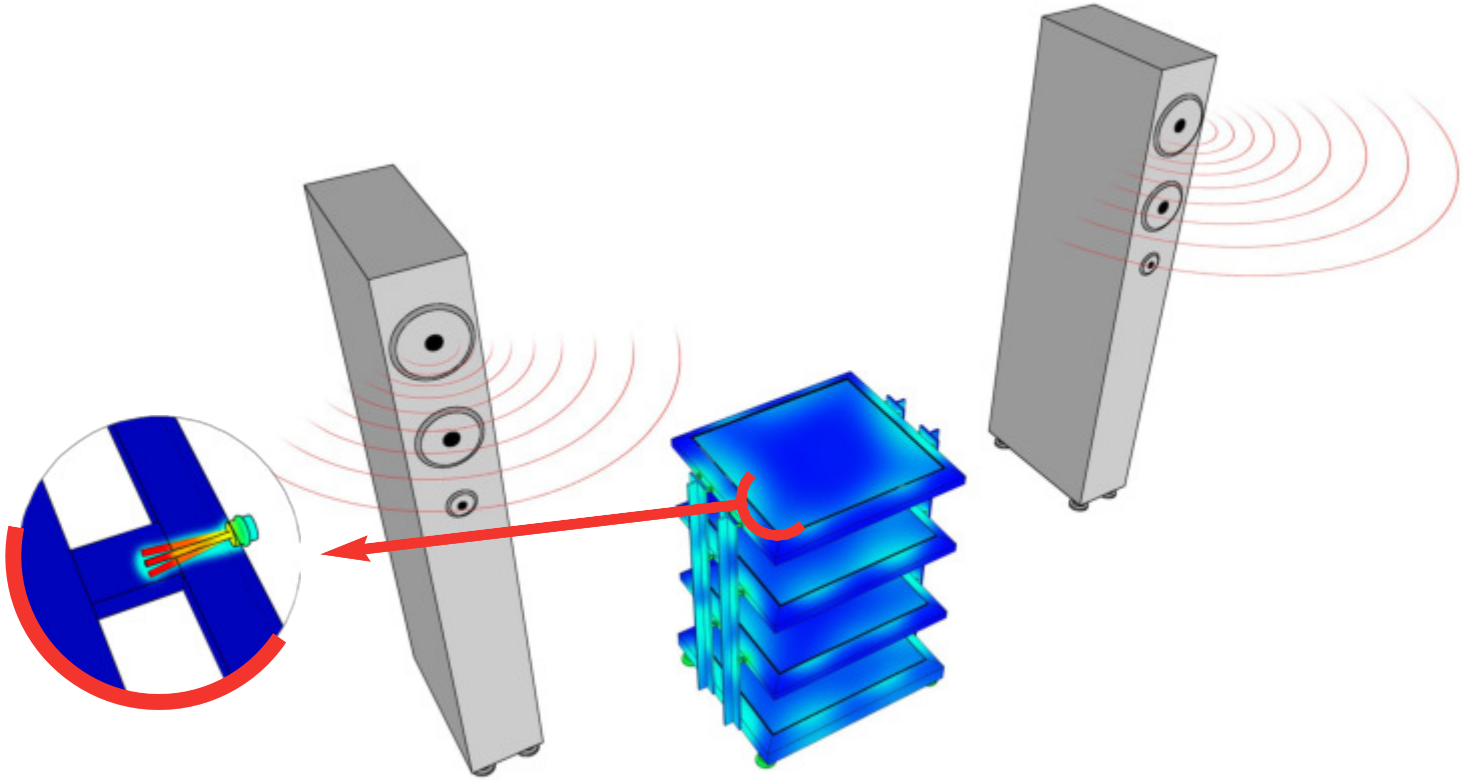

Key:

- No oscillation
- Minimal oscillation
- Low oscillation
- Medium oscillation
- Strong oscillation
- Maximal oscillation

Measured results:

- Perfectly controlled oscillation behaviour
- No sound-impairing natural resonances
- Drastically minimized amplitudes and sound pressure values

  = no longer audible during music playback

Effect:

- Outstanding open and contoured sound
- Excellent transparency
- Holographic three-dimensionality
- Perfect tonality
- Outstanding detail accuracy
- Exceptional scope in fine and coarse dynamics
- Extremely coherent acoustic image

Optimized set-up of components by means of coupling CERA° component feet

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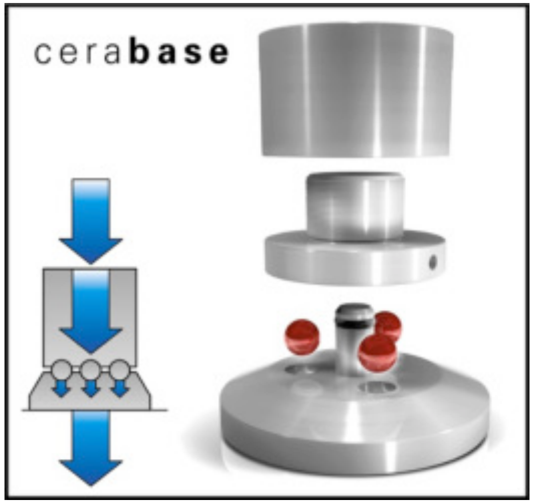

„The improvement in low-level resolution was dramatic, with increased focus, transparency and separation. Highly recommended."

(HIFI plus, England)

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Am Heimekesberg 11
33106 Paderborn
Deutschland

Fon (05254) 64557
Mail info@finite-elemente.eu
Web www.finite-elemente.eu

Fachhochschule
Dortmund
University of Applied Sciences
Dortmund

Labor für Schwingungstechnik und Akustik
Prof. Dr.-Ing. Thomas Borchert
Sonnenstraße 96 - 100
D-44139 Dortmund

Tel. ++49-(0) 231-9112-292
Fax ++49-(0) 231-9112-334

thomas.borchert@fh-dortmund.de
www.fh-dortmund.de