Vibrational Decoupling of Low Frequency Loudspeaker Enclosures From High Frequency Driver Elements

White Paper

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The Problem

Monitor loudspeaker systems can be designed today that are capable of producing extended low frequency output at high amplitudes. Raw low frequency drivers are being manufactured with greater linear cone excursion capability along with low distortion.These drivers also possess Theile/Small parameters which allow their implementation into smaller near-field size monitor enclosures. The problem that starts to arise is that the greater the amplitude of this extended frequency range becomes, the greater the potential for the driver's enclosure to react to the physical vibrational forces created. In the physical world, every action has an equal and opposite reaction and unless the enclosure is of sufficient mass to oppose the forces created by the low frequency driver's piston motion, it is inevitable that some energy from the driver will transfer to the enclosure structure ... especially if it is a smaller near field sized enclosure. This transferred energy will be at frequencies corresponding the the driver's output. ..... one solution could be for the enclosure to be made out of concrete and coupled to bedrock .... however, this is an impractical solution for near-field systems.

The primary problem created by such vibrational energy existing in an enclosure's structure is that the high frequency drivers [midrange & tweeter (3-way) or just tweeter (2-way)] are also physically attached to the enclosure. Consequently, these drivers will now physically vibrate with the same amplitude and at the same frequency observed from the enclosure. This low frequency energy will modulate the high frequency driver's output and create a form of doppler distortion where the high frequencies will have their waves extended slightly when the enclosure's vibrational motion is moving in a direction away from the high frequency driver's plane and conversely, the high frequencies will have their waves slightly shortened when the enclosure's vibrational motion is moving in a positive forward direction to the high frequency driver's plane. This imposing of the low frequency vibrational wave onto the high frequency output of the system creates nonlinear components in that driver's output thus effecting the ultimate linear accuracy of the system.

Proof that the Problem Exists

It can be made quite evident that these low frequency physical vibrations exist in speaker enclosures by simply placing ones fingertips on the top of a monitor loudspeaker that is producing wide band material at reasonable levels. One can feel these vibrations in the fingertips and surmise that the high frequency drivers that are also attached to this enclosure are also receiving this energy and will exhibit the same low frequency vibrational characteristics. The logical conclusion would be that the high frequency driver cones or diaphragms are also being modulated by this imposed low frequency energy creating nonlinear distortion in the driver's output. Graphical proof may also be seen through tests using an accelerometer to measure the vibrational characteristics of both the low frequency enclosure and the coupled higher frequency drivers' mounting plate.

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Additional Problems

Extended low frequency output of monitor loudspeakers and subwoofers along with the observed increased vibrational energy transferred to their enclosures has created several other problems. As the low frequency driver's energy is transferred to the enclosure, so is the enclosure's energy transferred to the room structure on which it rests. Once this energy is in the room's structure, usually the floor, it travels unimpeded through the rest of the building by means of structural coupling. The only way to abate this problem and isolate the sound from traveling to neighboring spaces is to decouple the whole room from the rest of the building. Some manufacturers have recently introduced decoupling pads that are placed under the speakers. While these decoupling pads may suppress some of the energy between the speaker and the room structure, they have the potential of creating more nonlinear distortion in the speaker's output by a phenomenon called recoil. These products do nothing to abate the distortion created in the high frequency drivers through vibrational coupling as noted above and they potentially exacerbate the problem by potentially creating higher amplitude vibrations in the enclosure as a whole.

In explanation, the ideal situation for maximum output and linearity from a low frequency driver in an enclosure, as noted above, would be to have the enclosure made of concrete or of sufficient mass to resist the vibrational forces that are a result of the piston motion of the low frequency driver. If one wants to obtain zero vibrational forces than this enclosure would have to be attached to bedrock. If the enclosure is resting on a material that is compliant or springy such as a decoupling pad, the enclosure itself will have no mass opposing it's vibrational motion that were transferred from the driver. The vibrational forces would actually increase aided by the spring underneath. The result would be less driver output and smeared transient response because the recoil of the enclosure would actually cause the enclosure to move more and opposite to the driver's piston motion and deprive it of maximum air compression and rarifaction capability.

The Basic Solution

The basic solution to the problem of vibrational energy reaching the higher frequency drivers in a loudspeaker monitor system would be to mechanically decouple the low frequency driver's enclosure from the surface used to mount the higher frequency drivers.The higher frequency drivers will when operate from a motionless surface unaffected by low frequency vibrations thus eliminating the introduction of nonlinear distortion in their acoustical output.

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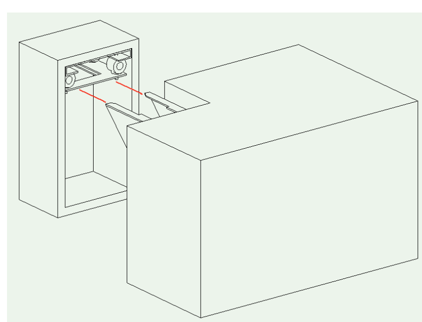
The Guzauski-Swist Solution

Guazauki-Swist Audio Systems has introduced a patented mechanical isolation system in their GS-3a monitor system. Utilizing the basic principles used in studio isolation design scaled to the smaller masses involved with loudspeaker system design, this mechanical decoupler provides a maximum reduction of approximately 80-85% of the vibrationally energy above 26Hz with attenuation actually beginning at approximately 10 Hz. This is achieved through the use of elastomer (rubber) spring components which are selected to provide a critically damped resonance of 6 Hz when loaded with a mass that achieves the specified static deflection to reach this spring's resonant frequency. Loading these springs with the correct mass creates a condition that effects what is called the spring's transmissibility. The mass required to load these springs is achieved by constructing a separate enclosure for the midrange and high frequency driver units. The combined weight of drivers, enclosure and mounting system determines the total mass loading the elastomer springs. The result of this mechanical decoupling system is a highly stable mounting system for the high frequency drivers devoid of low frequency vibrational energy which allows greater linear accuracy of their outputs. The subjective results of listening tests utilizing this system revealed greatly increased detail heard from the high frequency elements which contributes to the overall system accuracy. A-B comparisons between mechanically decoupled systems and non-decoupled systems showed a profound improvement in the monitor system's detail and accuracy.

Mounting System Diagram:



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