A Whitepaper: The Audibility Of Cabinet Panel Resonances and Pat. Pend. Method Of Reduction Of Audible Coloration

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Editor’s Note: Dagogo is honored to be chosen as the platform for the first publishing of a new Whitepaper by Albert Von Schweikert.

Lately, several high profile speaker companies have launched advertising campaigns using their cabinet construction methods as the topic of discussion.

One manufacturer claims that stacked plywood slices using an aluminum baffle is a ‘magic’ cabinet design, yet another claims that pure aluminum cabinets are ‘The Best In The World’ when compared to any wood-based cabinet. A third manufacturer, using resin impregnated MDF, claims that their ‘proprietary ABC mystery material’ is the best choice. Since all of these claims seem to have scientific facts behind them, and since it is well known that inexpensive thin-wall speaker cabinets can contribute a high degree of coloration due to panel resonance, VSA Corp. has undertaken a two-year scientific study of panel resonances, their audibility, and methods of reduction. As we wanted to conduct the highest level of analysis, we used a reputable university’s laboratory, which is well stocked with laser interferometer, Finite Element Analysis software, and Fast Fourier Transform-equipped computer programs.

This paper seeks to inform the reader of a new Pat. Pend. design now utilized on all Von Schweikert Audio speaker systems, using a triple-layer of constrained damping materials with opposing Q factors. See Photo #2 below.

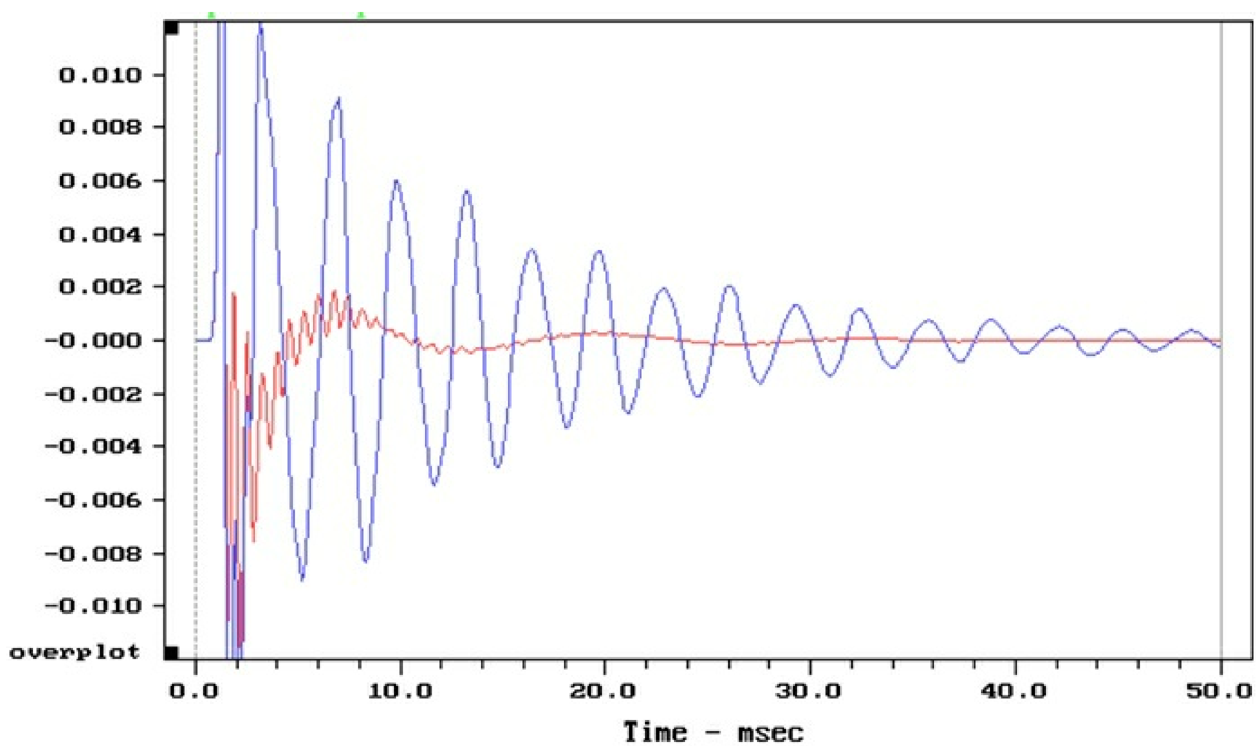
In essence, our cabinet design utilizes a multiple laminate of three different materials, since there is no perfect single material with ‘magic’ properties. In addition, our design goes one step further – decoupling of the drive units from the baffle, and in the UniField Series, the baffle is further decoupled from the cabinet proper. This is accomplished by our proprietary use of a visco-elastic gasket that provides a mechanical barrier to vibration transmission. (See pages 4 & 5 to review this isolation technology).

THE AUDIBILITY OF CABINET WALL RESONANCES

Readers will instinctively realize that in order to reproduce a musical note faithfully, an accurately designed loudspeaker should not add or subtract anything from the original signal. Speaker systems that claimed to be “tuned to the orchestra” by the use of resonant cabinet designs are nonsense. An accurate speaker should have no sound of its own, including cabinet panel resonances. After all, speaker systems are not ‘generators’ of music, they are ‘reproducers’ of music, which is self explanatory.

Below is a graph showing a 6” bass-midrange driver mounted on a ‘traditional’ speaker cabinet with a ‘damped’ baffle design versus an ‘undamped’ baffle. An accurate loudspeaker must trace the signal as quickly as possible, and any ‘time smear’ emanating from a ringing baffle or resonant cabinet wall will be highly audible if the amplitude of the vibration is sufficient. In addition, if the cabinet wall resonance falls into a frequency range that is excited constantly by music or the human voice, i.e., 100-400Hz, the resonances will be even more audible.

Finally, due to the nature of high Q versus low Q effects, the type of damping utilized will have a large impact on the success of the method. A narrow, high Q resonance found at 1kHz may not be as audible as a low Q resonance found at 150Hz, so the type of damping and its effect on the resonance is highly frequency dependent. For that reason, a wide bandwidth resonance reduction method necessitates the use of several different types of materials, and their individual Q factors need to interact with each other in order to be effective at all offending frequencies. Successful implementation will result in greater clarity.



#1. Comparison of Damped Vs. Undamped Baffles
(Graph courtesy of A. Jones, TAD laboratory)

Notes to Illustration #1, Above
In illustration #1 above, the Red line is the accelerometer-measured response of a mid-woofer mounted on a baffle using a compliant decoupling method. Note how quickly the impulse excitation is damped. The 6” mid-woofer frame has been mounted onto the baffle using a synthetic clay absorptive gasket, effectively isolating its vibration from the front baffle. In turn, the baffle is decoupled from the cabinet itself, using the same compliant gasket method, thereby reducing the mechanical vibration transfer from the mid-woofer to the rest of the cabinet.

The Blue line is the response of the same driver, hard-mounted on the same baffle, without compliant decoupling. Note how the driver and baffle are still ringing up to 50 milliseconds after the impulse. Since the mid-woofer is mechanically attached to the baffle, and the baffle is mechanically attached to the cabinet, there is a high degree of unwanted transfer of vibration into the cabinet, effectively adding “smear” (a lack of clarity due to the constant ringing of the cabinet walls). This results in poor sound.

Since the surface area of a speaker cabinet can be up to 30 or 40 times the area of the cones, very little motion of the cabinet walls is necessary to become audible. The implication is that the cabinet vibration might have as much energy as the output of the driver itself, and this unwanted energy must be cancelled if true clarity is desired.

TRIPLE- WALL LAMINATE CONSTRUCTION

Below is a photo of VSA’s Pat. Pend. wall construction, as used in every Von Schweikert speaker system offered today. This wall construction was pioneered for use in our UniField Model 3 speaker system in 2007 and has been so successful that we are utilizing this method in all VSA models in production today.

The idea is to use mass loading combined with ‘over-kill’ wall damping to reduce vibration. In addition, we’ve discovered a clever method of ‘Q interaction’ in the layers of laminations to further boost the damping effect.

The VSA Triple-Wall Laminate Construction uses three different materials that have an inherent difference in their ‘Q’ factors, Q being a ‘qualitative’ factor. The choice of these three different materials was based on how their Q factors interact with each other, with a dense inner high Q layer and soft low-Q barrier layers. The three layers are bonded together using a rubberized adhesive (in itself a barrier to mechanical vibration transmission). The three layers consist of the following materials:

1. Outer shell: MDF (medium density fiberboard) is a ‘medium’ Q material, with a high degree of sound transmission. By itself, MDF (even with a high quantity of resin impregnation), is not a one-step solution. The colorations of MDF tend to be ‘woody but musical’ in timbre, almost like the sound of a cello, but this coloration is not desirable from the standpoint of utter neutrality. MDF is used by most fabricators due to ease of machining and low cost. Resin impregnation adds mass and stiffness, which serves to raise the frequency of resonances to an area above the critical range. Our Unifield Series of speakers use a molded outer layer of resin with fiberboard powder composition. All other VSA speakers use compressed MDF with resin impregnation as outer walls, using #2 and #3.

2. Inner liner: Bonded to the inner side of the MDF outer shell is a layer of synthetic stone, fabricated from crushed gravel, minerals, and resin binder. This layer exhibits a very high Q, with a tremendous mass and stiffness quotient compared to MDF – in fact, it is more comparable to solid aluminum and is far denser than any type of plywood laminations of comparable thickness. The synthetic stone inner layer is formed of small blocks that are bonded to the MDF with an industrial anti-vibrational rubber-based adhesive. The adhesive layer is extremely thick (5mm) and provides an additional mechanical barrier in addition to ‘shearing’ of energy, turning mechanical motion into heat for dissipation.

3. On the surface of the synthetic stone layer is a final layer of hard felt, with an extremely low Q factor. This layer provides absorption of the acoustic energy generated by the transducers on the inside of the cabinet. Once again, the felt layer is bonded with the same rubber-based adhesive.

4. Since the transmission of energy requires an efficient medium that will conduct vibration readily, the use of these three different layers effectively absorbs the energy before it can reach the level of audibility. These three layers have been designed to be the most efficient combination of vibration absorption for their given thickness, weight, and cost– far surpassing any other method of cabinet wall construction and guaranteeing genuine transparency of sound.

Shown below is a side-view photograph of the UniField Model 3 cabinet wall. The outer layer of resin impregnated MDF is to the right of the photo, with the white synthetic stone layer in the middle and the hard felt inner layer shown in dark gray. The black material shown in between laminate layers is the rubber adhesive layer used for bonding and vibration damping. The white fluffy material to the left of the felt layer is Acoustic Dacron polyester fiberfill, used to damp the internal cavity resonance created by the hollow cabinet. We apply the Dacron in three different thicknesses, which we term ‘Gradient Density DampingTM.’ The Dacron is packed extremely tight closest to the cabinet walls, and is gradually packed with less density approaching the rear of the driver. This technique provides absorption without reflection back into the cone.

Triple Wall Lamination photo by A.V.S.

On various VSA models, the wall thickness can approach 4” (100mm) but on the UniField Series, shown above, the total wall thickness is 2.5” (63mm).

VIBRATION CONTROL THROUGH ISOLATION

It is known that the cabinet walls are set into resonance by two different means: A) the physical vibration of the driver, transmitted to the front baffle, in addition to: B) the acoustic energy transfer from the rear of the driver into the cabinet cavity. In order to reduce this unwanted transfer of energy, we have devised a method to isolate the driver from the front baffle, in addition to isolating the front baffle from the cabinet proper in the UniField Series of speakers.

A) In order to effectively ‘isolate’ the vibration of the driver from the cabinet, we have employed the use of a 6mm thick, visco-elastic polymer clay gasket material, originally designed to damp the hull of nuclear submarines. The damping property of this proprietary gasket is extraordinary and serves to nearly eliminate the transfer of energy from the driver frame to the front baffle. In essence, our drivers are 'floating' on the surface of the baffle and hence cannot transfer vibration into the rest of the enclosure. This technique alone drops the resonances down by more than 12dB compared to conventional driver mounting methods used by our competitors. This is a tremendous reduction of distortion!

B) The drive units radiate energy acoustically into the interior of the cabinet, which can result in a highly audible cavity resonance. These reflections from the internal walls of the cabinet create a pressure wave on the rear of the cone, resulting in dips and peaks in the frequency response related to the wave lengths involved with the dimensions of the internal cavity. Our use of the hard felt inner damping layers, combined with our proprietary Gradient Density Damping, reduces the internal cavity resonances below audibility. By contrast, the examination of our competitor's cabinets will reveal that they use hollow cavity design to 'enhance' resonances to achieve their desired 'voicing.'

BRACING TECHNOLOGY

Although our cabinet wall damping technique is 'state of the art,' we also employ 'over-kill' internal shelf bracing, which also forms the chambers for our hybrid reflex transmission line bass loading. In addition, the UniField Series also use curved side walls to reduce internal reflections that cause standing waves and non-linear frequency response, while our VR Series use slanted front baffles and massive cabinet construction techniques found in products that cost several times our price.

TRANSPARENCY FACTOR

In 1976, while developing acoustic theory at California Institute of Technology, I coined the term 'Transparency Factor' to describe a recipe of engineering requirements to elevate a moving coil loudspeaker to the clarity levels of electrostatic speakers, which do not use cabinets. More than three decades later, I still believe that our goal of achieving better sound through scientific research has paid dividends in enhanced clarity, image focus, and transparency through the reduction of distortion and colorations inherent in cabinet design. Our latest development of the Triple Layer cabinet wall design fulfills this goal in a novel and quantifiable way.

Direct side-by-side A/B comparison tests with the most expensive and most hyped speakers in the world have proven the effectiveness of our cabinet wall resonance damping technology – our speakers sound more transparent than competitors costing up to 5 times our price due to the reduction of coloration and distortion inherent in low-tech cabinet designs.