Baffle Vibrations in Open Baffle Dipole Loudspeakers

Abstract: Due to physical limitations of individual loudspeaker drivers, more than one unit must be used in order to cover the full frequency range from 20Hz up to 20kHz or beyond. It is quite typical to use a 3-way system: Woofer, midrange, and highs. Sometimes, even a 4-way system is being used.
In an open baffle system, at least two drivers are usually mounted on a common baffle, directly linking them mechanically. Any mechanical structure, depending on its shape and how it is restricted, is subject to mechanical vibrations, and exhibits resonant frequencies. Each driver is exerting a driving force to the structure and is creating vibrations in the structure, being at maximum when resonance frequencies of the structure are excited. In a mechanically coupled system, these vibrations will produce mechanical (usually front to back) movements of the drivers against space. Similar to intermodulation distortion in amplifiers, this will create Doppler shift, which is similar to FM modulation of electrical signals. This will create a coloring or smearing effect of the overall sound, and will negatively affect the so-called soundstage.
This defect cannot be corrected with DSP or room correction software.

The solution: Complete mechanical decoupling of individual drivers.

The test: Apply a signal to the midrange driver from typically 120Hz to 1200Hz. Apply (in a 3-way system) a 10kHz signal to the upper driver. When resonance has been found, take a spectrum analyzer measurement of the 10khz signal. One would expect FM type modulation sidebands. (i.e. if the resonance is at 400Hz, one would expect 400Hz sidebands). In a system, where the woofer is mechanically linked to the system, one could also test the excitement from the woofer to the rest of the system.

The modern design of a complete sound system requires the use of many technologies, from basic electronics, computers, loudspeaker drivers, mechanical design, room acoustics, amplifiers, DSP, room correction, baffle or cabinet design.

When some people proposed the open baffle dipole approach to loudspeakers, the argument was used that by being “out of the box” (and therefore using out of the box thinking), one would remove any coloring of the sound by eliminating the emanation of sound from resonating walls.

I believe that this is a fallacy, because even baffles have resonances. One may have reduced the effect of sound being generated from the wall (or baffle), but what most designers have overlooked so far is the effect it has on other drivers on the baffle, especially the high frequency ones. Any slight movement creates Doppler shift. We have a 1000:1 range in sound wavelengths; therefore the high end is the critical range. This effect cannot be corrected by DSP or any other means.

My own research shows, once I mechanically completely separated drivers from each other that this constituted the greatest improvement in sound quality, mostly in the stability of the soundstage.

Having a stable soundstage makes listening so much more enjoyable. Many of my recordings suddenly have a new life, even if played back in the mp3 format.

Even if one has mechanically separated the different drivers, there is also an issue for each individual driver.

The usual method of mounting is to rigidly connect the driver to a support structure. Unfortunately such a structure must counteract the force being created by the moving mass of the driver, usually the voice coil and the diaphragm, according to the physical principle of F = m x a (Force equal mass times acceleration).
In order to avoid the excitation of any vibration, this structure has to be very rigid and any resonances have to be above the frequency range of the driver and also have to have a low Q. Unfortunately again, such structures are very difficult to design since mechanical structures have a tendency toward very high Q resonances.

These resonances also create coloring for each individual driver, effecting the soundstage and timbre.

While designing high-speed centrifuges for medical applications, I learned another method called flexible shaft. The flexible shaft and the rotor have a resonance at a fairly low speed, well below any operating speed. Dampers are used during start-up and are released once this speed has been passed. The shaft deflects slightly so that the rotor will rotate around its center of gravity rather than its geometric center, which would cause enormous imbalance induced vibrations.

My first solution has been to use the principle of the pendulum. Hanging the driver on strings.

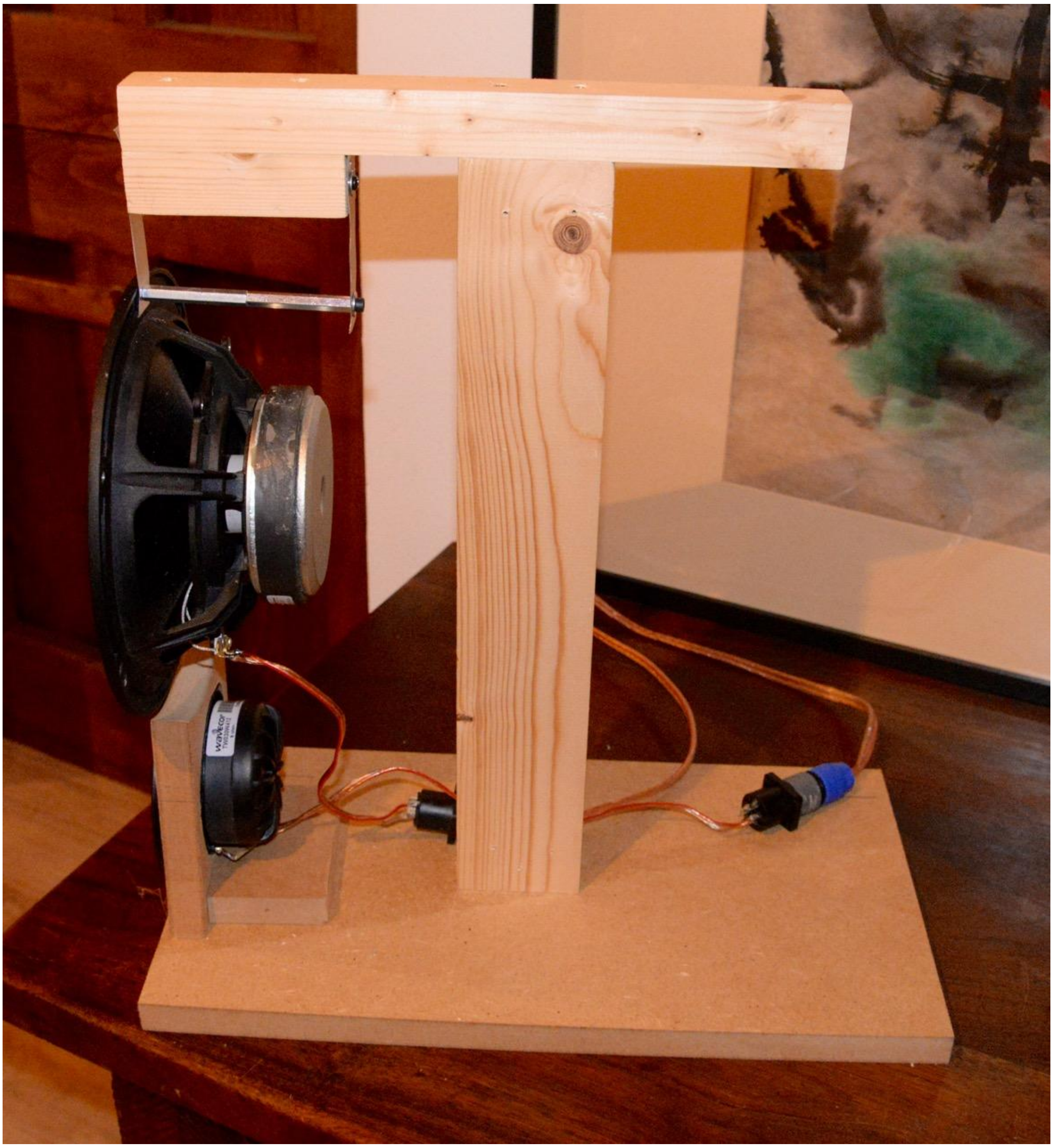
If one wants to eliminate the frame, the driver can also be hung directly from the ceiling.

You can barely see the strings in this picture, on the left a little better than on the right.

This does indeed solve the problem.

I have now also discovered a more appealing solution, easier to integrate into open baffle systems, when baffles are indeed being used: **Leaf Spring**

This is flexible aluminum, which is much wider than thick, making the spring very rigid in the side direction and very flexible in the forward direction. In comparison to the string approach, there is only movement in the forward direction in line with the movement of the diaphragm. The first resonance is very low, well below the operating range of the driver.



side view

Close-up of the suspension system

The final flat spring should be made of steel, about 10mm wide, .5mm thick and about 70mm long with 4mm holes at both ends for easy mounting.

Some tests are necessary to find the optimum solution, both in terms of material being used and actual dimensions.

There could also be rubber stops with clearance in between in order to limit front to back movement during transport or positioning.

In summary: The amount of movement of the chassis is reduced by the ratio of the moving mass to the overall mass of the chassis.

During my test I can barely feel movement of the chassis, but absolutely no movement of the frame.

This method reduces the driving force to the support structure dramatically.

It also eliminates any coloring, which is the case if one uses a rigid support structure.

The very slight opposite movement (about 1/200) of the chassis reduces the absolute movement of the diaphragm against space, but it does not create any artifacts.

June 27th, 2016

Sellaño, Ponga, Asturias, Spain

Rüdiger Franz Rauskolb