

Mounting a driver to a baffle

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A cone type electro-dynamic driver is primarily a generator of mechanical vibration force and heat. It sets air into motion, but the reactive force of the air has insignificant influence on its behavior. For acoustic and mechanical reasons a driver is always mounted to a baffle of some form. Thus the forces generated in the driver try to set the baffle into motion. The resulting whole body movement is usually a small fraction of the cone movement and governed by the relative masses of cone and baffle. $M_{ms} v_{cone} = M_{baffle} v_{baffle}$. Since the cone velocity v_{cone} decreases with increasing frequency for constant SPL, the whole body motion is usually only noticeable at low frequencies and causes an insignificant reduction in SPL. This is a non-resonant phenomenon and no energy is stored.

Take, for example, two woofer drivers where each has a cone of 135 g moving mass and both are mounted in a box of 60 lb total weight or 27 kg mass. The box will want to move in reaction to the cone movement by $270g / 27000g = 1 / 100$ of the cone. Thus a cone displacement of 10 mm leads to a box displacement of 0.1 mm in the opposite direction. You can feel this readily by lightly touching the box. The effective movement is 9.9 mm, and a reduction in acoustic output by 0.1 dB which is insignificant.

Fundamentally different from this is the excitation of panel vibration modes. These are always resonant, store energy and can radiate sound. Usually the baffle or box surface is larger than the cone area. Thus small modal displacements can lead to more sound being radiated directly from the baffle or box at certain frequencies than from the cone. Knocking with your knuckle on a panel can give you a rough idea of the dominant mode frequency, though it might not necessarily get excited by the driver. This test can also tell you how stiff the panel is, when the pitch is high, or how well the panel is damped because it hurts to make it respond.

It is illustrative to look at the forces generated by a midrange driver at a given Sound Pressure Level.

The above excerpt from the spreadsheet [SPL-dependent.xls](#) is based on the textbook [theory](#) that was given in [Publication \(4\)](#). Note that at 90 dB SPL the 20 g moving mass, M_{ms} , of the driver generates a g-force of 6.1 N or 1.4 lb rms between basket rim and magnet, a sinusoidal oscillating force of +/-2 lb peak. The cone undergoes a constant value acceleration of 30.9 g rms, or +/-43.6 g peak, at all frequencies. The peak cone excursion, X_{peak} , is of course strongly frequency dependent and decreases as $1/f$. The kinetic energy, $1/2 m v^2$, falls off as $1/f^2$.

This same driver mounted on an open baffle and equalized to remove the 6 dB/oct dipole cancellation will have larger excursions below [Fequal](#) than when in a closed box. Therefore the forces are larger and frequency dependent. Likewise the kinetic energy is higher, but falling off as $1/f^3$.

The [spreadsheet](#) also shows the large force and extreme acceleration experienced by a tweeter dome, though the kinetic energy is quite small due to a low moving mass.

There are several ways to reduce modal panel vibrations. Because the vibration energy from the driver decreases rapidly with increasing frequency it is advantageous to push the panel vibration modes up in frequency where the excitation energy is small. This is best accomplished by increasing the panel stiffness, but often goes together with increasing the mechanical Q of resonance.

Dampening the panel by using a constrained layer that dissipates energy will reduce Q. Panel stiffness is also obtained by extensive bracing. As my rule of thumb, no un-braced box panel area should be larger than 4 inch squared for 3/4 inch thick wood panels. That is a lot of bracing, but it pushes modes into the low kHz range.



PANEL RESONANCES

- $Q_{\text{wood}} \approx 50$
- Damped Panel: $Q \approx 10$
- Stiff panel: $< 4''$
 $f_{\text{res}} > 1.5 \text{ kHz}$

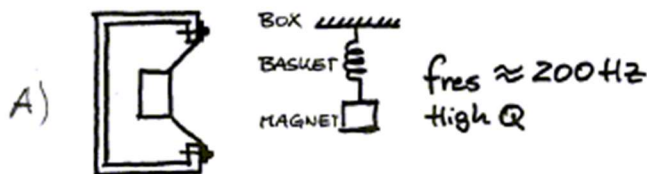
Increasing the thickness of a panel makes good sense when the resulting increase in stiffness is larger than the increase in mass. Otherwise modal resonance could occur lower in frequency than for the thin panel. Still, the increase in mass requires larger amounts of excitation energy and can therefore be beneficial.

Panel vibration modes are not only excited by structure borne vibration energy but also by air borne vibration such as the large sound pressure inside a box loudspeaker. Even if the box panels are infinitely stiff, secondary delayed sound will leak out through the thin cone material at higher frequencies where air modes can exist inside the box. A perfect [acoustic resistor](#) to absorb all sound is not available.

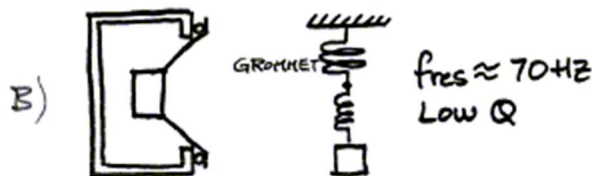
There is yet another potential problem with the driver to baffle interface, even if the baffle is perfectly inert. It is related to the mechanical construction of the driver itself and how it can become a mechanical resonator of its own.

Typically a loudspeaker driver has screw holes in its basket for mounting it to a baffle. Usually a sealing gasket is placed between the driver basket rim and the baffle. The driver becomes in effect stiffly clamped to the baffle. This method sets up a mechanically resonant structure which is formed by the compliance of the basket and the mass of the magnet as seen in figure (A).

DRIVER MOUNTING RESONANCES



A) Drivers with a stamped metal baskets are prone to exhibit a high Q resonance when tightly clamped to the baffle. The magnet moves relative to the voice coil at the resonance frequency. Energy is stored and also readily transmitted from the moving mass of the cone into the cabinet.



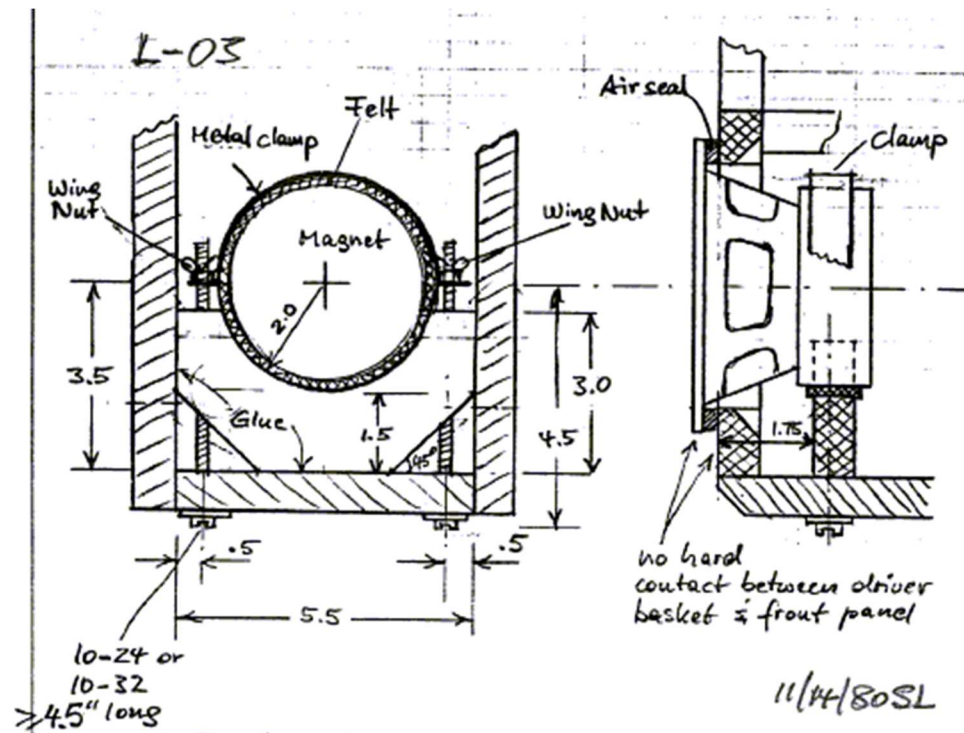
B) Soft mounting the driver basket to the baffle using rubber grommets reduces the resonance frequency. A 2nd order lowpass filter is formed that reduces the transmission of vibration energy from the moving cone to the baffle and cabinet. The resonance must occur below the operating range of the driver.



C) If the driver is mounted from the magnet and the basket rim touches the baffle only softly, then the magnet-basket resonance cannot occur and the transmission of vibration energy into the baffle is minimized.

The basket-magnet resonance can be measured with an accelerometer that is mounted to the magnet. The drive signal is optimally a shaped toneburst. Its energy is concentrated in a narrow

frequency band. When tuned to the right frequency a long decay tail becomes visible on an oscilloscope. Often the resonance can be seen as a small bump in the driver's impedance curve in the few hundred Hz range. It should not be confused with the higher frequency bump due to cone breakup.



An early example of a box loudspeaker where a KEF B110 midrange/woofer driver magnet is clamped to a support structure. The clamp can be tightened from the outside of the box. The basket rim is floating.

Often the effects due to driver mounting are deemed to be of secondary importance to the overall sound quality of a loudspeaker. They are usually costly to remedy. They cannot be ignored when the goal is to design a loudspeaker of the highest accuracy.