Building a Minimally Baffled Dipole Loudspeaker

*By Charlie Laub*

What Happens When Free Hanging Drivers Move?

The frame of a decoupled, freely hanging driver will move in opposition to its cone movement under the effect of action-reaction. When the driver is hanging freely, the counter movement of the frame is completely linear and causes a reduction in the acoustic output generated by the cone. One concern that has been voiced to me is that the level of this reduction will be significant, so I will provide a brief analysis to address the issue.

Newton’s Second Law states that acceleration depends on the force applied and the mass of the object (F=m\*a) and Newton’s Third Law states that for every action there is an equal reaction, that is F1 = ─F2. The force F being applied is generated by the motor and this force pushes the cone against the other driver parts (frame, motor, etc.). Since the driver parts are decoupled from the ground by the suspension system and are free to move, the motor force induces motion in them as well. Thus, we can write:

cone\_mass \* cone\_acceleration = ─ driver\_mass \* driver\_acceleration

Because the direction of the driver acceleration is opposite that of the cone acceleration, the negative sign can be dropped from the term on the right side and acceleration taken to mean the magnitude of the acceleration henceforth. Rearranging this we get

driver\_acceleration = cone\_mass \* cone\_acceleration / driver\_mass

In this analysis, “driver” refers to everything except the cone, voice coil former, voice coil, and air load. Because the driver is accelerated away from the cone in the opposite direction, this reduces the net acceleration of the cone compared to when the driver is immobilized by a connection to the ground via a cabinet or baffle. The net cone acceleration will then be:

net\_cone\_acceleration = cone\_acceleration - driver\_acceleration

We define the loss ratio as the ratio of the cone’s net acceleration to the acceleration without the loss from the driver acceleration:

Loss\_ratio = ( cone\_acceleration - driver\_acceleration ) / cone\_acceleration

Substituting the expression for driver\_acceleration and rearranging we get the result that:

loss\_ratio = 1 ─ ( cone\_mass / driver\_mass )

Because the sound pressure in the far field is proportional to cone acceleration, the value calculated by the loss ratio also predicts the loss in far field sound pressure.

Let’s do the calculation for a lightweight neo magnet pro driver, the Eminence Deltalite II 2515: the driver weighs 2590 grams overall and the mass of the moving parts and the air load (Mms) is 79g resulting in a mass ratio of 36:1. Plugging in this ratio, we have loss\_ratio = 1 - 1/36 = 0.972, which is approximately -0.25dB. As an example of a home-audio 6” class driver, the SB Acoustics SB17MFC weighs 1550 grams overall and Mms is 12.3g. This represents a mass ratio of 126:1, which corresponds to -0.07dB.

These examples show that for both hi-fi and pro-audio drivers this source of sound pressure loss is typically much less than 1 dB and can be considered negligible. This analysis also highlights that the frame of the driver undergoes acceleration. It is useful to decouple it as much from other parts that can move, other drivers, or even the loudspeaker cabinet for boxed speakers since the induced vibrations will lead to cabinet panel resonances. For example, should the midrange and tweeter be affixed together but otherwise free to move, the tweeter’s position will undergo motion induced by the midrange’s reaction force, which would modulate the tweeter output and could cause doppler distortion. By decoupling drivers from one another within the wireframe scaffold this source of distortion can be eliminated.