# Eighteen Sound

# Tetracoil Technology

As the motor is the engine of a loudspeaker, the Eighteen Sound Tetracoil design provides benefits in magnetic, mechanical and thermal transducer performance.

*Background*

The Tetracoil technology can best be understood by reviewing the evolution of conventional loudspeaker motors. Traditional electro-dynamic loudspeakers incorporate a motor with single copper or aluminum voice-coil immersed in a static magnetic field created by a dedicated permanent magnetic circuit. Due to current flowing in the voice-coil a Lorentz force will move the coil in a direction perpendicular to the magnetic field. This conventional design is shown in Fig 1.

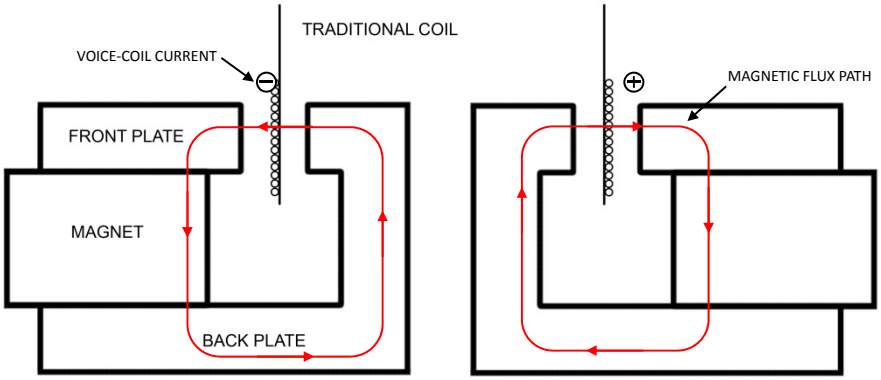


Figure 1 Traditional magnetic circuit with conventional voice coil

For many years (see fig. 2), single and multi-layer voice-coils have been wound on the outside layer of the voice-coil former. High power voice-coil formers made from polyamides or glass fiber effectively acts as a thermal insulation between the inner voice-coil layer and the motor pole piece. This thermal insulation reduces thermal radiation from the voice-coil to the steel parts.

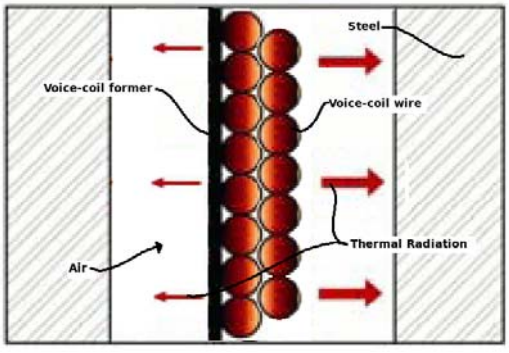


Figure 2: Traditional voice-coil wound outside of the former

To take advantage of voice-coil wire to steel intimacy, the ISV Interleaved Sandwich Voice coil technology has been used by Eighteen Sound since 1998[1]. As shown in Figure 3 and Figure 4 the ISV voice-coil divides a single multi-layer voice-coil into two separate voice-coil segments by winding coil layers on both the inside and outside of the voice-coil former.

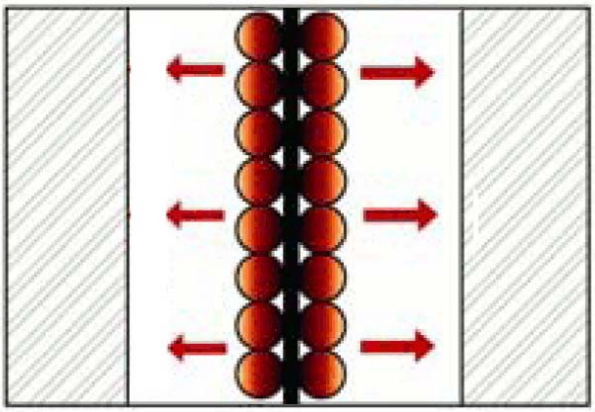

Figure 3: Interleaved Sandwich Voice-Coil

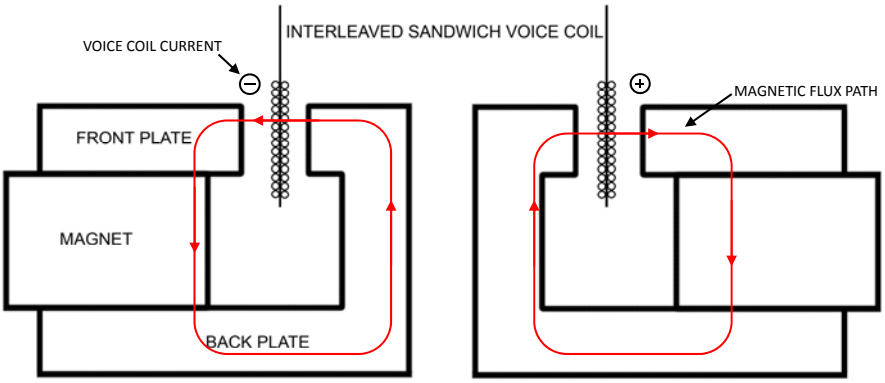


Figure 4: Traditional magnetic circuit with ISV coil

It is clear that the ISV coil doubles the direct surface area relation between voice-coil and steel plates, increasing thermal conductivity for improved transfer of heat from voice-coil to pole plate and front plate.

### *Tetracoil Technology*

The Tetracoil technology extends the ISV principle into a dual gap motor structure. With two inner and two outer coils there are in effect four voice-coils, hence the name “Tetracoil”. The two Interleaved Sandwich Voice coils are wound on a single cylindrical voice coil former, suspended evenly in the two magnetic gaps as shown in Fig 5.

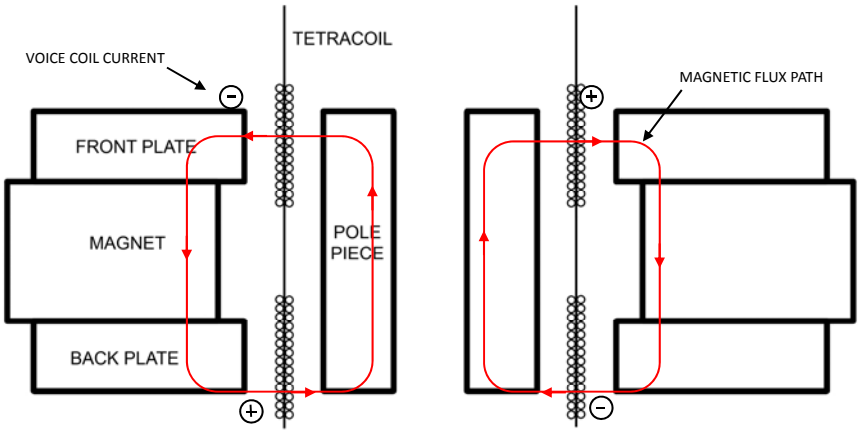


Figure 5: Tetracoil motor showing magnetic flux path flow

In the Tetracoil design the flux flowing in the upper gap has an equal flux density but with opposite direction from the flux flowing across the lower gap. The current flowing in the upper voice-coil is equal to but with opposite direction from the current flowing in the lower voice-coil. It is important to notice that the motor structure is perfectly symmetric about the horizontal axis. Consequently, this dual gap, dual voice-coil topology provides an equal Lorentz force in each voice-coil with motive force in the same direction.

*Tetracoil Benefits:*

*Increased heat transfer*

The first benefit provided by Tetracoil technology is the increase in thermal conductivity. As shown in Figure 5, each gap of the Tetracoil motor structure is equal to the gap of a traditional structure shown in Figure 4, however the area of direct thermal path is doubled, resulting in a reduction of thermal resistance. This leads to an increased power handling and lower power compression. Compared to a traditional voice-coil with single gap topology the Tetracoil provides four times the voice-coil to steel surface area contact. This is corresponding to using a 5.6” diameter voice-coil in place of a 4” diameter voice-coil. In this scenario it is easy to see that the larger diameter voice-coil has more surface area.

Fig 6 illustrates power compression comparisons between two 18 inch speakers, one with Tetracoil technology and one with ISV structure, powered with 15 minutes of pink noise filtered from 30 to 300 Hz. Measurement shows that the Tetracoil structure allows more than 1 dB less power compression.

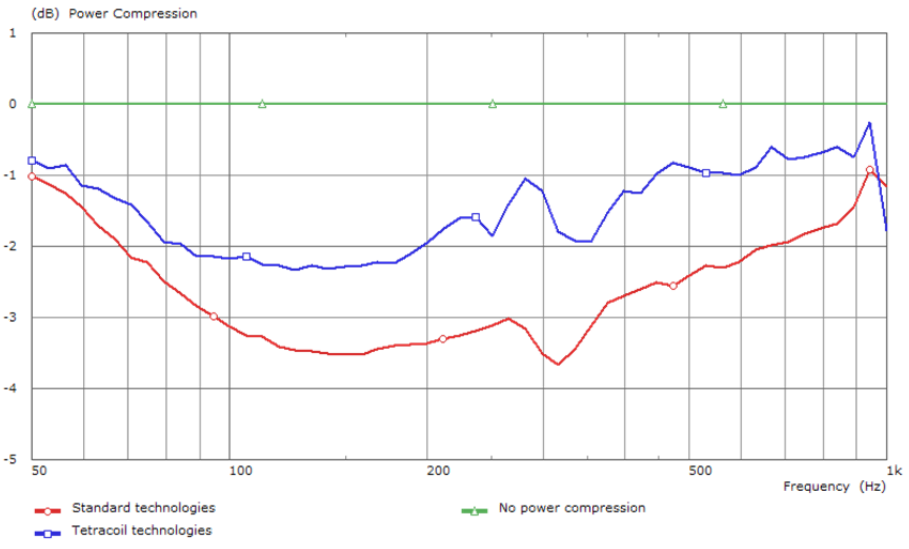


Figure 6: Power Compression Comparisons for single layer, ISV and Tetracoil technologies

*Motor Symmetry: Bl(x) symmetry*[2]

As stated before, the magnetic circuit is perfectly symmetric in the horizontal plane. This leads to a perfectly symmetric flux density shape and since the coil is symmetric, as seen in Figure 7, the Bl factor will be symmetric as well, minimizing the even distortion usually caused by Bl (x) asymmetry and the DC component effect.

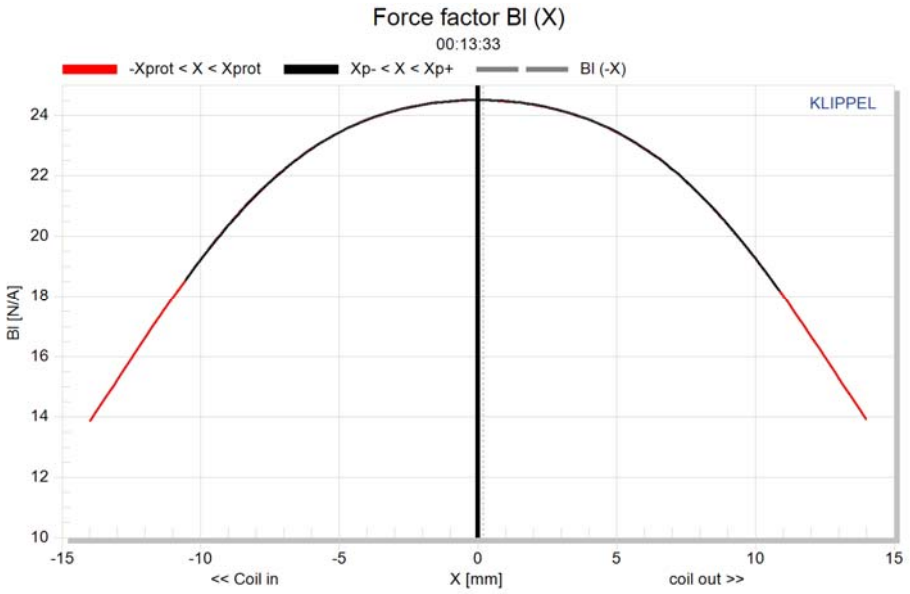


Figure 7: Tetracoil speaker Bl(x) measurement

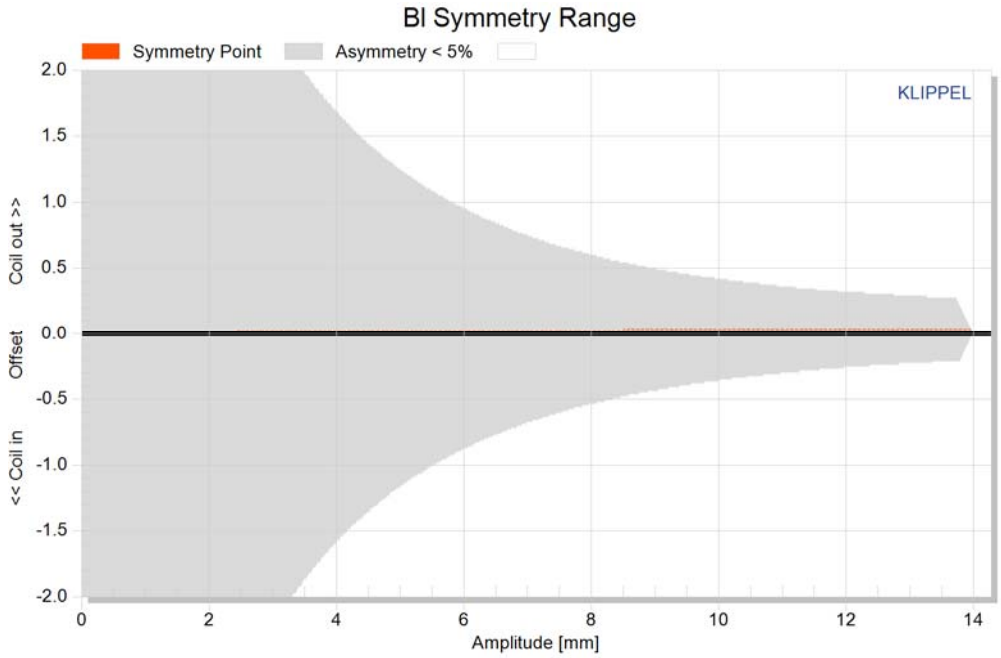


Figure 8: Bl Symmetry range measurement

*L(x) regularity*

The motor symmetry creates a very symmetric and quite flat inductance curve as plotted against voice-coil excursion in Fig 9. When the cone moves up, the lower coil goes into the gap while the upper one leaves the gap. Consequently, the magnetic path "seen" by the whole coil is quite always the same, with constant inductance curve, in contrast with the inductance of a traditional magnetic circuit, Fig.10.

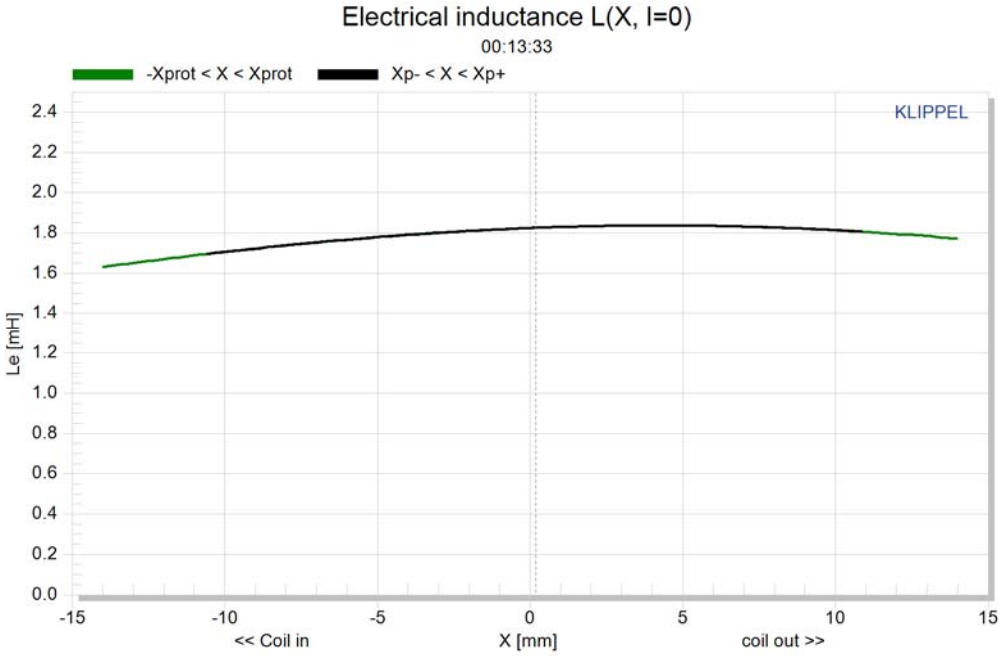


Figure 9: L(x) measurement of a Tetracoil speaker

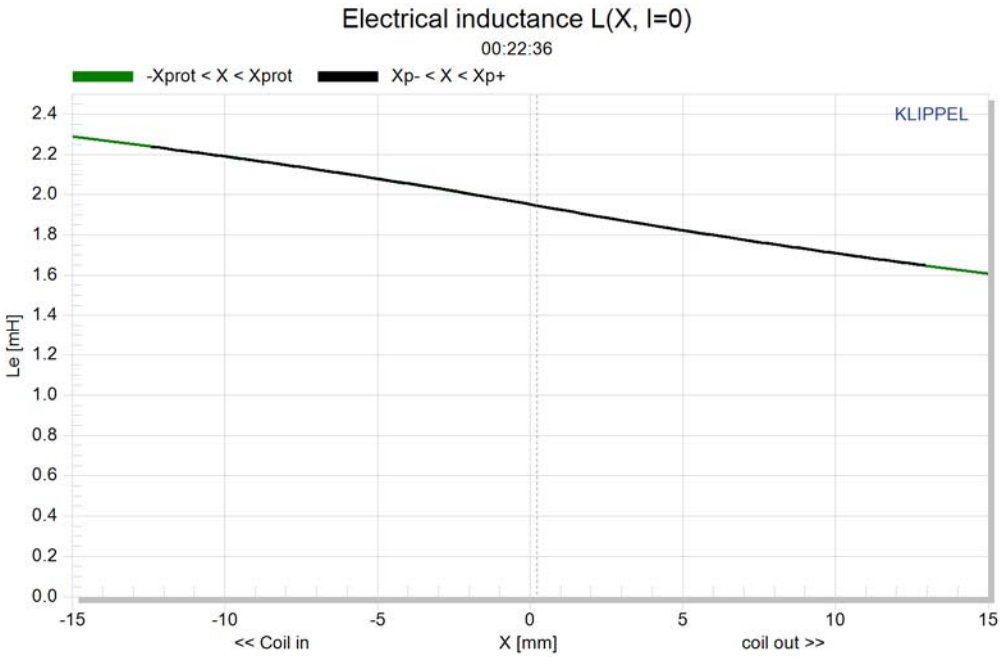


Figure 10: L(x) measurement of a traditional speaker

$$F = \frac{1}{2} I^2 \frac{dL}{dx} \quad ,$$