TETRACOIL

Eighteen Sound introduced the Tetracoil technology in 2013, and focused first on subwoofer applications, starting with 18″ and 15″ ferrite drivers and then successfully extending the use to neodymium 18″ and 21″ models. However, the advantages of the Dual Gap design which is at the core of Tetracoil technology are not limited to very low frequencies, and while gaining experience in the use of the technology, Eighteen Sound investigated how to bring those advantages into transducers dedicated to a wider range of applications, developing an entire family of Dual Gap based products ranging from 21″ down to 6″ format.

This document shows the basics of the Tetracoil architecture, composed of two design techniques (Dual Gap motor structure and Interleaved Sandwich Voice coil), and illustrates the main benefits in magnetic, mechanical and thermal transducer performance.

Introduction

The structure of the Tetracoil technology can best be understood as an 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 the 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.

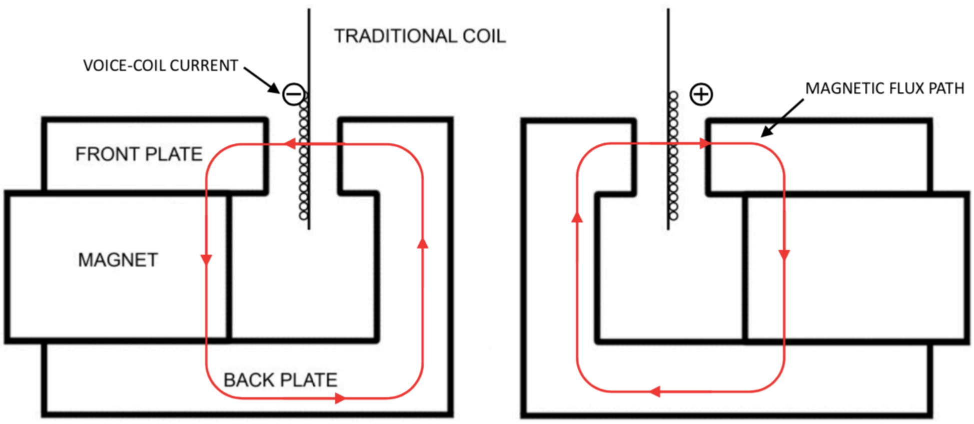

Fig. 1 - Traditional magnetic circuit with conventional voice coil

Dual Gap

In the **Dual Gap** magnetic circuit used in Tetracoil (Fig.2) there are two air gaps and in each one is present one voice-coil. The magnetic flux in the upper gap has an equal flux density but with opposite direction from the one across the lower gap, and the current flowing in the upper voice-coil is equal to but with opposite direction from the current flowing in the lower voice-coil.

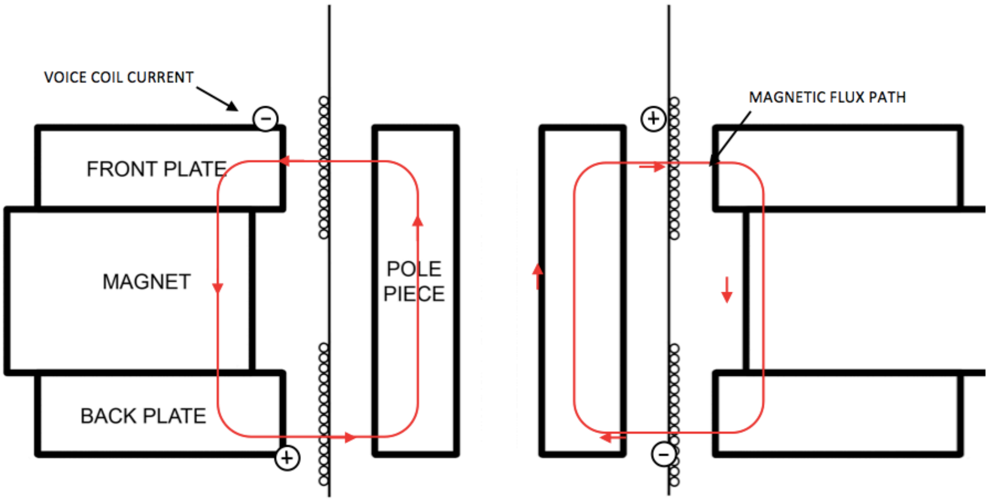

Fig. 2 - Dual Gap motor showing magnetic flux path flow

It is important to notice that the motor structure is **perfectly symmetric** on the horizontal axis. Consequently, this Dual Gap, dual voice-coil topology provides an equal Lorentz force in each voice-coil with a resulting motive force in the same direction.

ISV

The **ISV - Interleaved Sandwich Voice coil** is a quite common technique taking advantage of voice-coil wire to steel intimacy and has been used by Eighteen Sound since its very beginning in 1998.

As shown in Figure 3 and Figure 4, the ISV 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.

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.

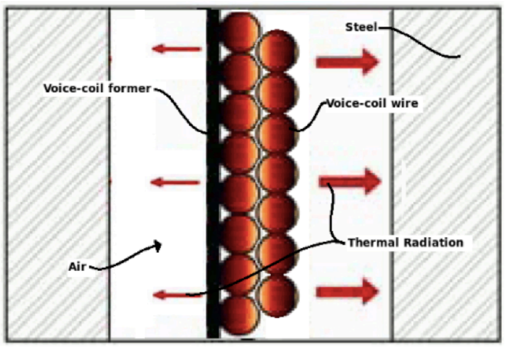

Fig. 3 - Traditional voice-coil

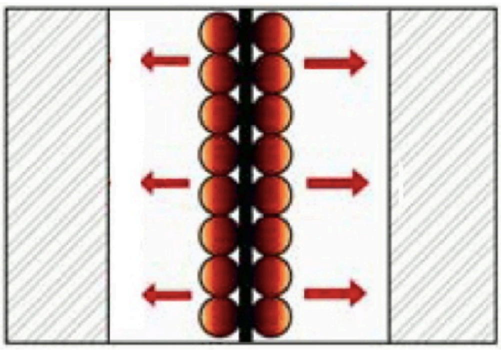

Fig. 4 - Interleaved Sandwich Voice-Coil

Tetracoil = Dual Gap + Interleaved Sandwich Voice Coil

The Tetracoil technology combines the ISV technique with 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

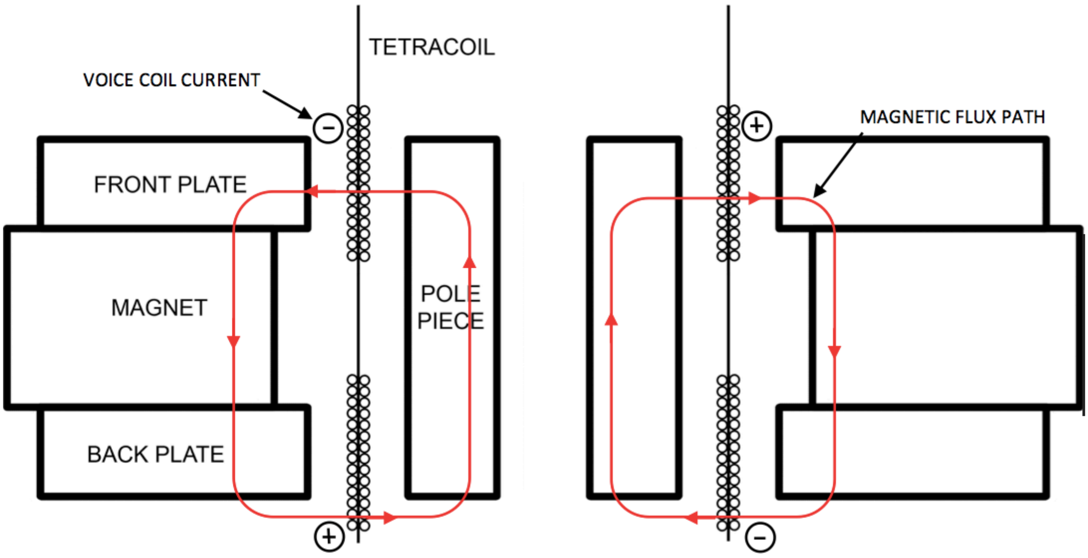

Fig. 5 - Tetracoil motor showing magnetic flux path flow

Benefits

Increased heat transfer

The first benefit provided by Tetracoil technology is the increase in thermal conductivity. As shown in Fig. 5, each gap of the Tetracoil motor structure is equal to the gap of a traditional structure shown in Fig. 2, however the area of direct thermal path is doubled, resulting in a reduction of thermal resistance, and consequently in 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: for example, a Dual Gap motor using a 4″ diameter voice-coil could be considered equivalent to using a 5.6″ diameter voice-coil.

Fig. 6 illustrates power compression comparisons between two 18″ 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.

Fig. 6 - Power Compression Comparisons for single layer, ISV and Tetracoil technologies

Motor Symmetry: Bl(x) symmetry

As stated above, the magnetic circuit in a Dual Gap design is inherently symmetric in the horizontal plane. This leads to a perfectly symmetric flux density shape (Fig.7 and 8) as well as a wider and more constant Bl(x) factor (Fig.9), which results in a **minimization of the even distortion** usually caused by Bl (x) asymmetry **and of the DC component effect**.

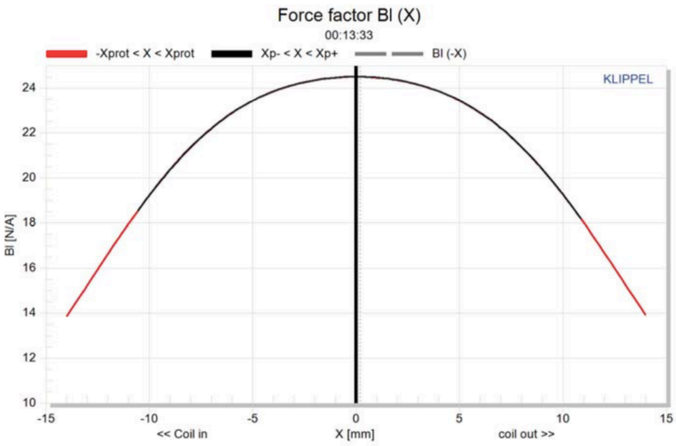

Fig. 7 - Tetracoil speaker Bl(x) measurement

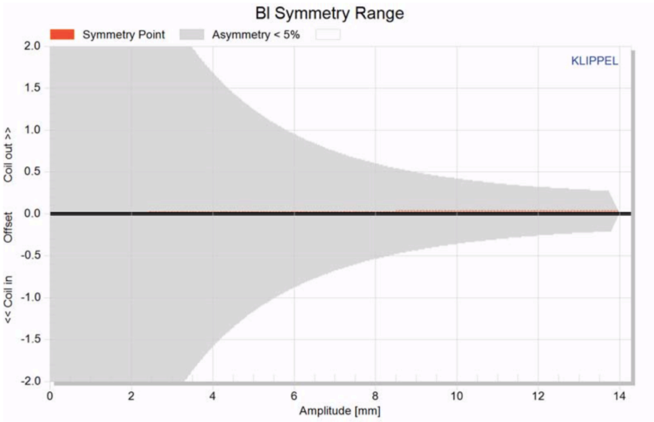

Fig. 8 - Bl Symmetry range measurement

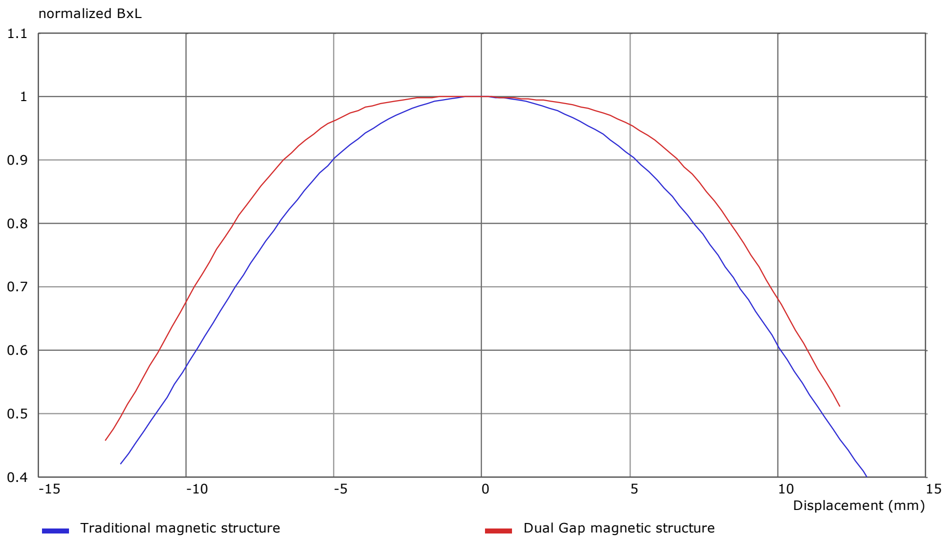

Fig. 9 - BL comparison (same VC height)

L(x) regularity

The Dual Gap design has multiple beneficial effects on the inductance of the driver, again due to the symmetry of the structure: in fact, when the cone moves up, the lower coil goes into the gap while the upper one leaves the gap, and consequently the magnetic path "seen" by the whole coil is quite always the same leading to a much more constant inductance curve than as seen in a traditional magneti circuit, as shown in Fig.10 and Fig.11

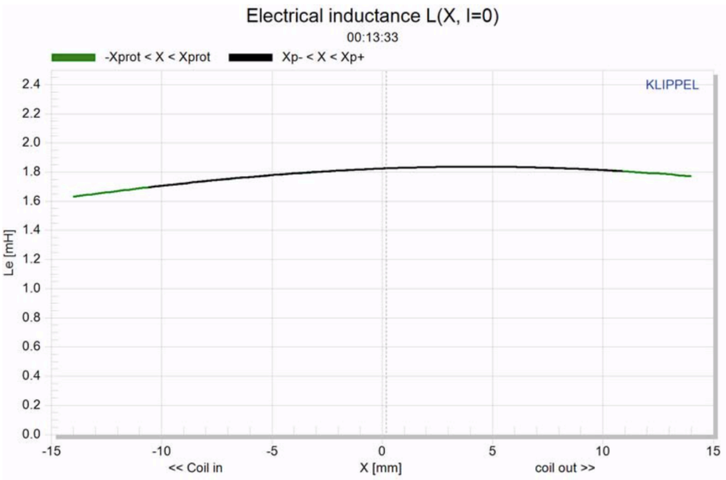

Fig. 10 - L(x) measurement of a Tetracoil speaker

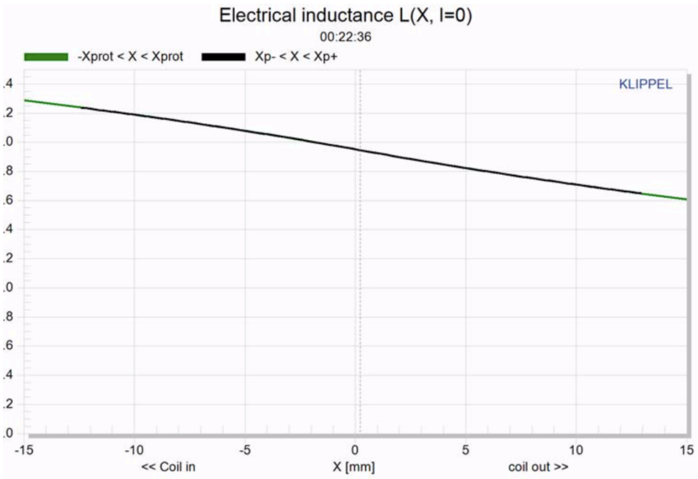

Fig. 11 - L(x) measurement of a traditional speaker

The much more **regular** and **symmetric** behaviour are even more evident when the Dual Gap structure is used in designs where the additional internal voice coil used in Tetracoil is not required, and the lower mass also allows for a strong **reduction** of the inductance, as shown in Fig.12 and Fig.13, resulting in an **extremely low distortion at higher frequencies**, which becomes especially important in full range applications where the low frequency driver can extend its operation well into the vocal range up to 1000 Hz.

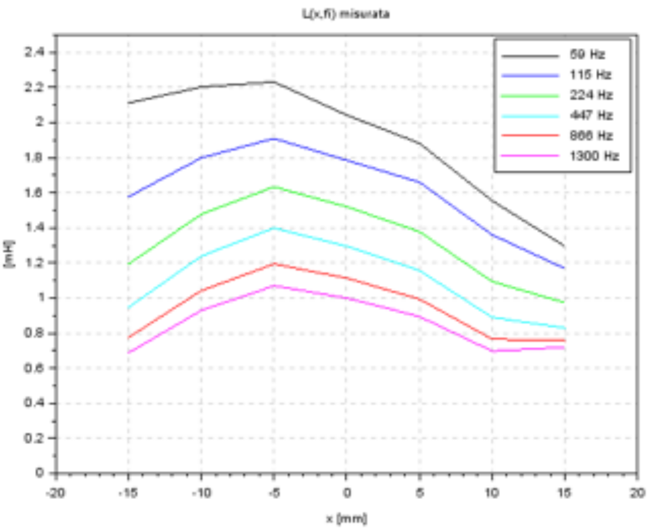

Fig. 12 - L(x) in a traditional magnetic structure.

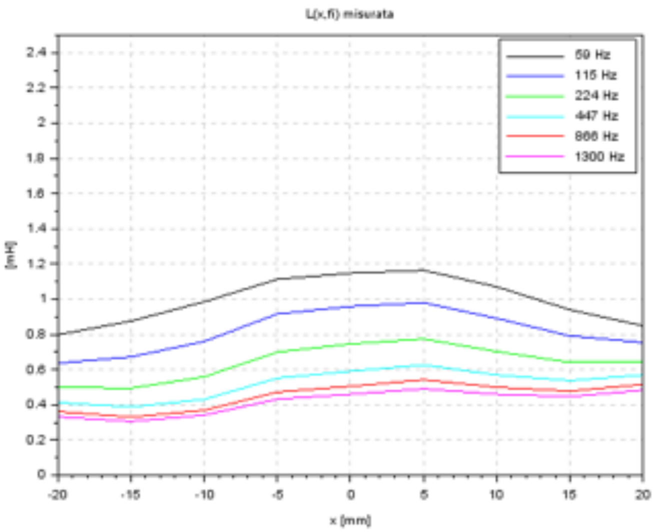

Fig. 13 - L(x) in Dual Gap magnetic structure

Conclusions

As seen, the Dual Gap and Tetracoil technologies are able to convey a number of advantages that can benefit different sizes and classes of woofers in relation to the required performance and intended use.

Showing a **noticeable improvement of the power handling** and **reduction of power compression** while **balancing motor symmetry,** they proved to **reduce the intrinsic distortions** and DC component offsets caused by Bl(x) and L(x) asymmetries for extreme linear excursion with maximum low frequency SPL, and the capability to reduce and linearize L(x) leads to a **tangible distortion reduction even in the midrange**.