wavecor

BALANCED DRIVE

Line of speaker units designed with
optimized motor symmetry.

The Wavecor Balanced Drive Technology

Introduction

The Balanced Drive line of loudspeaker transducers is yet another example of Wavecor paying attention to every detail.

Instead of following the common way by designing loudspeaker drivers "as usual" Wavecor have spent significant research time further optimizing one of the most important parts of a loudspeaker transducer: The motor.

The motivation for the work was our continuous search for better sound and in this project we set the target to reduce the harmonic distortion generated by non-symmetrical motor structures.

This paper uses the specific results obtain for our 7" mid/woofer WF182BD01. However, all members of the BD (Balanced Drive) product line offer the same improvements and symmetrical motor structure.

The study

Looking at a traditional transducer motor structure like shown fig. 3a below it is relatively obvious that the design probably is not ideal. One thing that comes to mind is that symmetry might be improved. We have verified this assumption with a series of simulations shown on the following pages. So does this lack of symmetry lead to any negative effects when looking at the performance of the transducer? The concern here is how the poor symmetry of the magnetic flux density curve over distance will influence the symmetry of the force factor (Bxl) as the voice coil moves to different positions. Ideally the Bxl curve should be constant as a function of voice coil position or at least symmetrical for movements in/out.

As an experiment we fed a pure 100 Hz sine wave into a spectrum analyzer. With no noise or distortion present we obtained the result shown as the black 100 Hz vertical line in fig. 1. No harmonics present. Next we manipulated the 100 Hz sine wave by

compressing the positive halves of the sine wave by 50%. As shown on the following pages this is a realistic large-signal situation for a non-optimized magnet structure normally used for loudspeaker transducers. The resulting spectrum we obtained had added significant even harmonics, 2nd, 4th, etc. They are the blue lines in fig. 1. In our example the 2nd harmonic is 17dB below the fundamental corresponding to around 14% of 2nd order harmonic distortion. There is additionally noticeable levels of 4th order harmonics (2.5%). All higher order even harmonics are present as well although at lower levels.

This means we are claiming that for many existing transducers the large-signal even order harmonic distortion caused by non-symmetrical motor structures could easily reach 10-20% or even higher levels.

The conclusion of our study therefore is that creating symmetrical motor structures is a great avancement in loudspeaker transducer design.

Results

By introducing the Balanced Drive Technology Wavecor have greatly reduced the even order harmonic distortion that is present in traditional transducer motor designs.

The resulting improvements in motor symmetry are shown on the following pages. Within a wide distance interval almost perfect symmetry is obtained for the flux density curve and, more importantly, for the Force factor curve, Bxl.

We specifically used the Wavecor mid/woofer model WF182BD01/02 to generated all the curves shown below in figs. 4 to 7. Using the Balanced Drive motor technology has resulted in a Bxl curve that has non-symmetry better than +/-5% within a voice coil travel range of +/-12 mm.

The Balanced Drive design leads to one additional improvement: Due to the extension of the center pole the voice coil inductance symmetry is improved too as a function of the voice coil position.
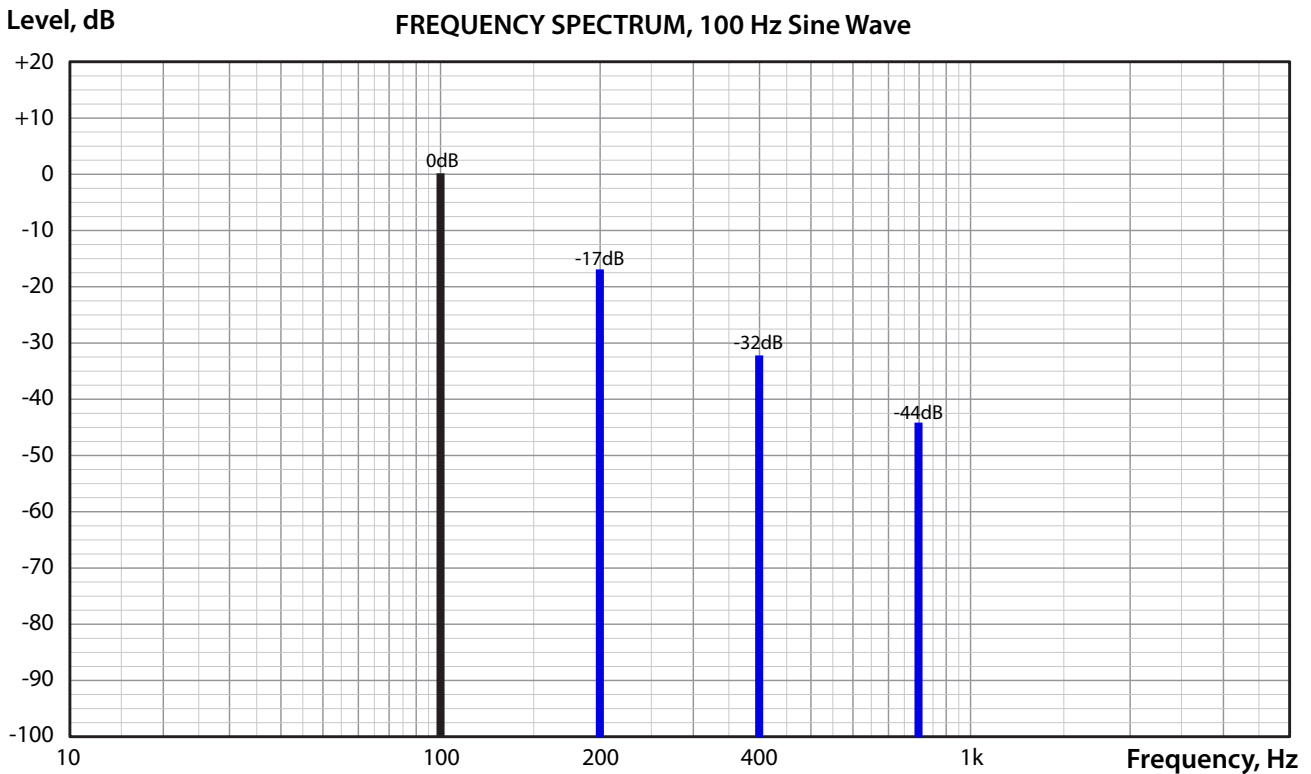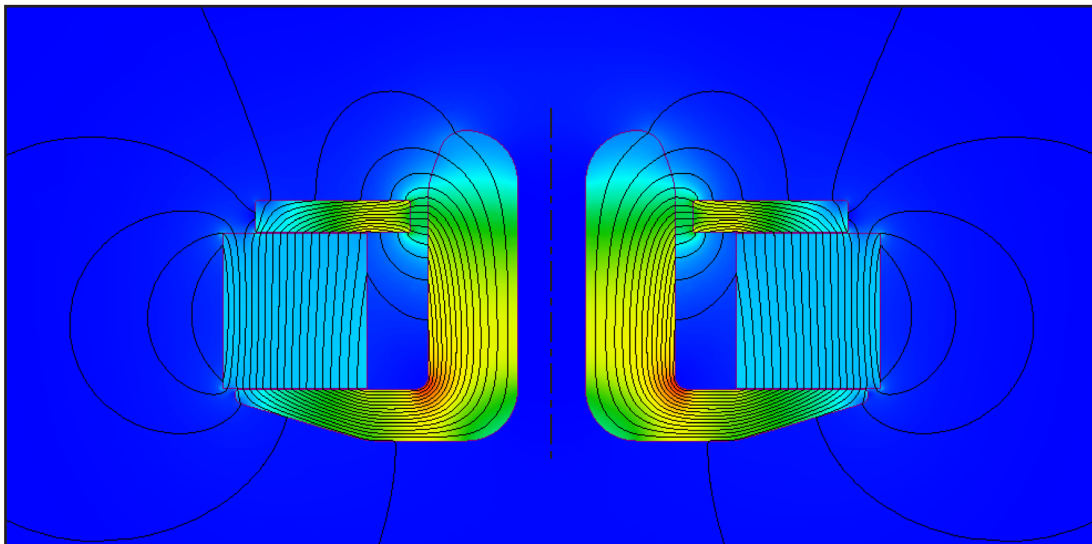
Level, dB

FREQUENCY SPECTRUM, 100 Hz Sine Wave

Frequency, Hz

Fig. 1. *Frequency spectrum for a pure 100 Hz sine wave (black vertical line) and the even order higher harmonics (blue vertical lines) created by non-symmetrical transducer motors.*

Fig. 2. *The magnetic structure of the Balanced Drive line of Wavecor transducers is optimized using advanced Finite Element Analysis software.*


1: Voice coil windings
2: Top plate
3: T-yoke (center pole & back plate)
4: Magnet
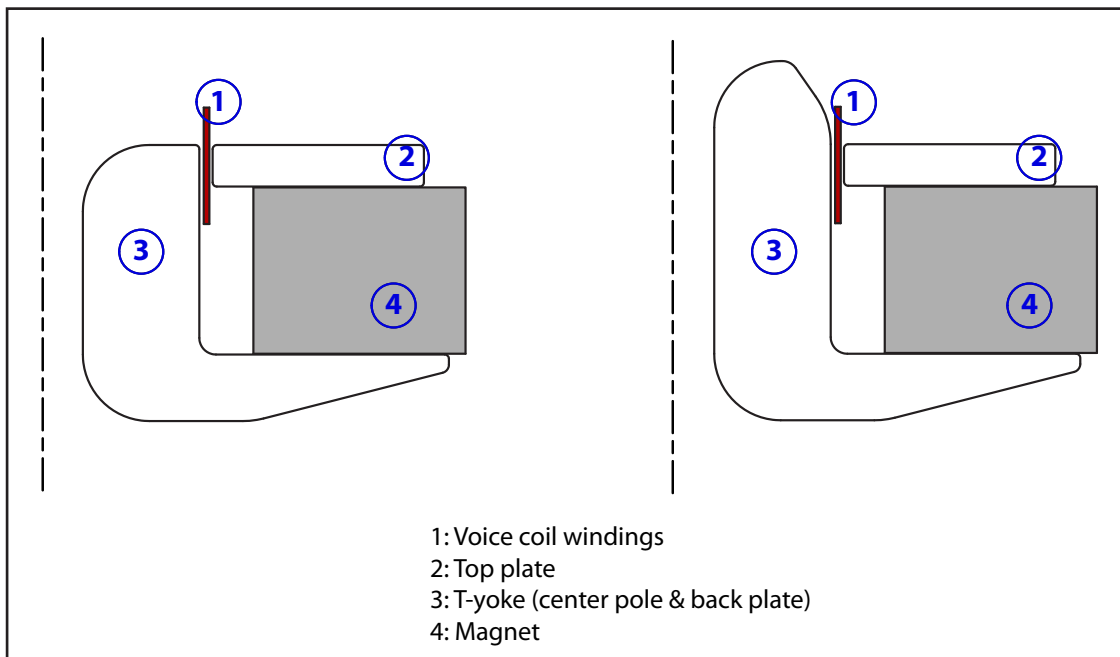
Fig. 3a (left). *Cross section of a traditional motor design.*

Fig. 3b (right). *Cross section of the Balanced Drive motor design used for woofers in the Wavecor BD line. The shown motor is the actual structure used for the Wavecor WF182BD01 mid/woofer.*

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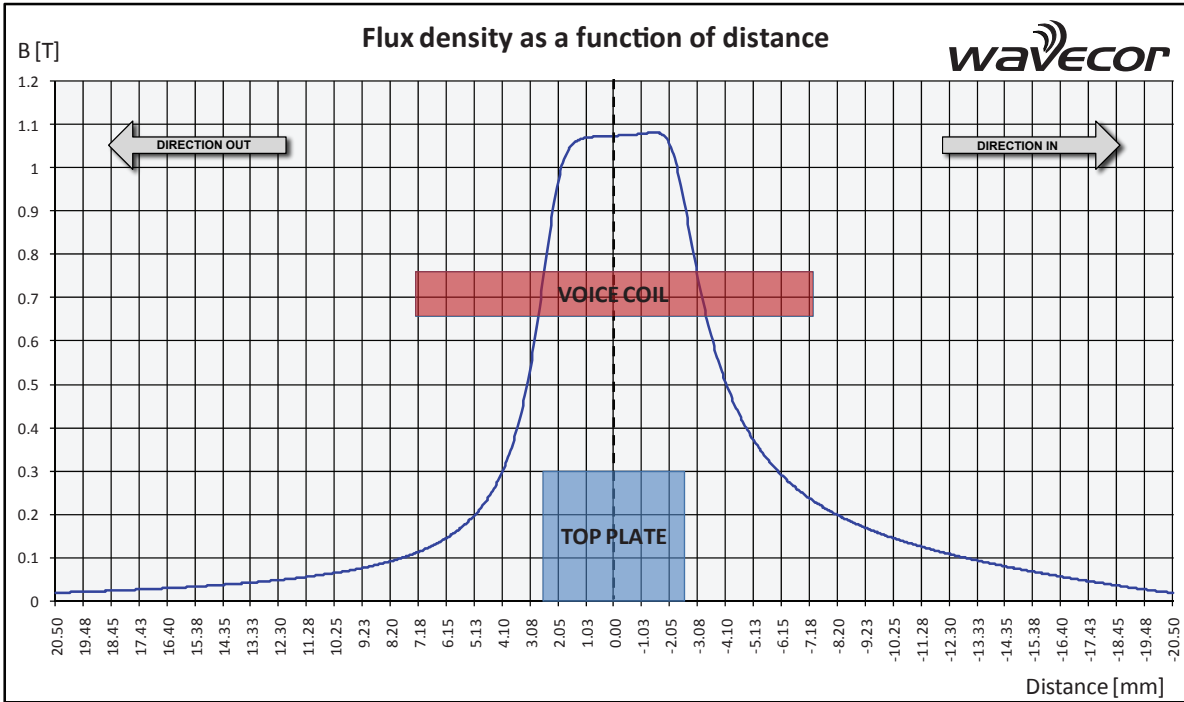
Fig. 4a. *Magnetic air gap flux density (B) distribution for a traditional magnet structure as shown fig. 3a. Notice that the curve is non-symmetrical with higher levels in the direction towards the inside of the magnet structure.*
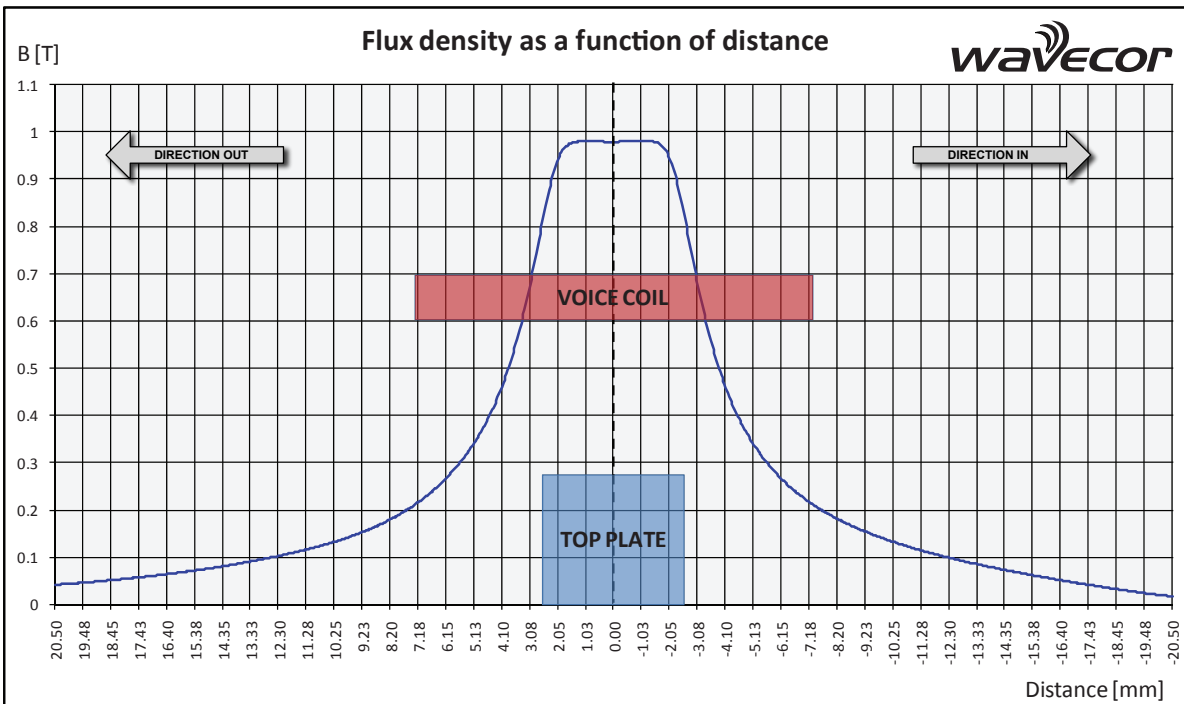
Fig. 4b. *Magnetic air gap flux density (B) distribution for the Wavecor WF182BD01 mid/woofer. The curve is almost perfectly symmetrical. The red bar shows the actual WF182BD01 voice coil and its position. The blue square illustrates the top plate, which is 5mm thick for WF182BD01.*
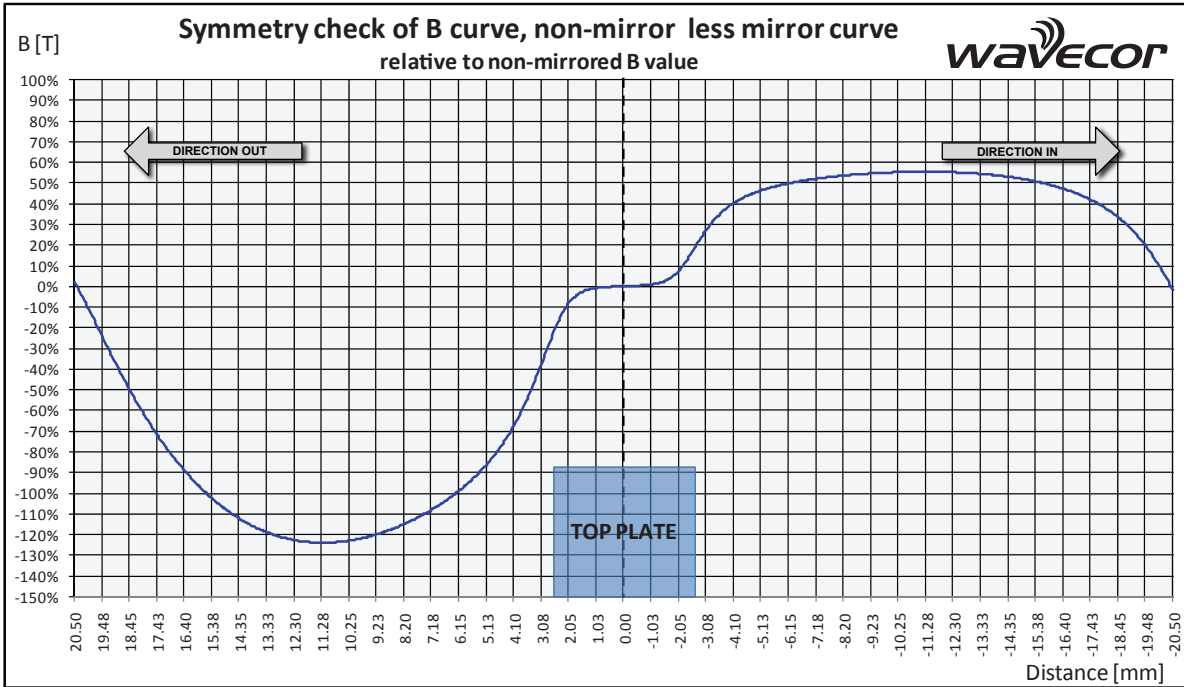
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Fig. 5a. *Magnetic flux density (B) distribution for a traditional magnet structure as shown fig. 3a. The figure shows the relative symmetry as the difference when measuring B out/in, held relative to the value outwards.*
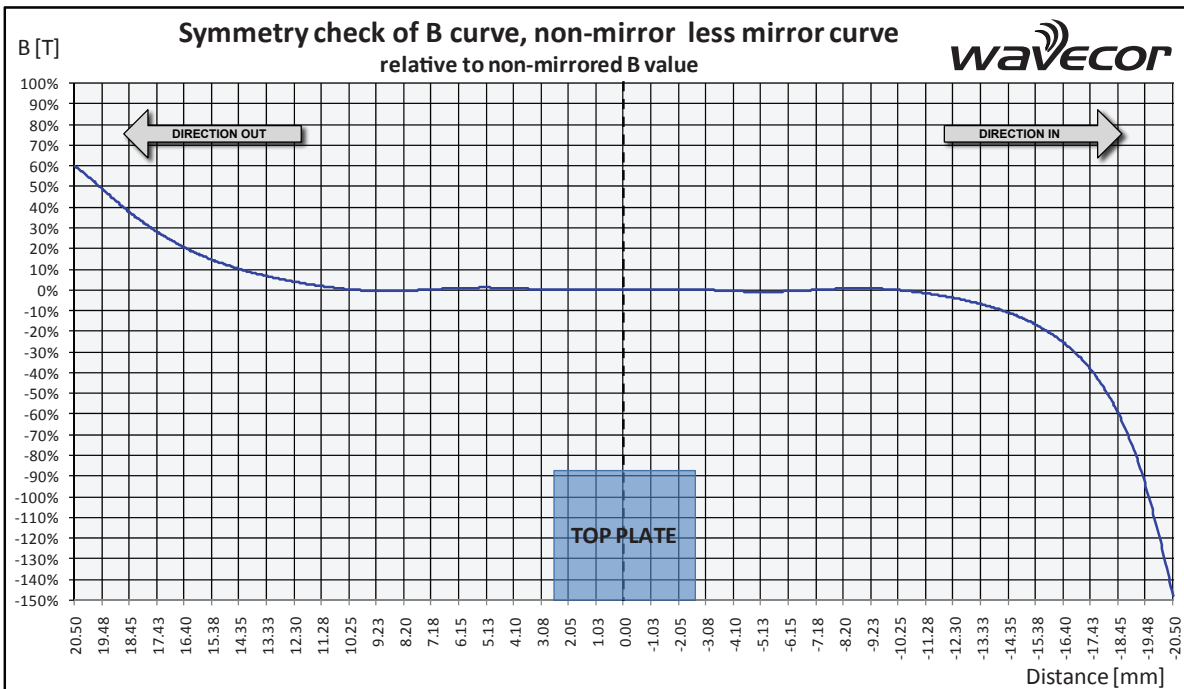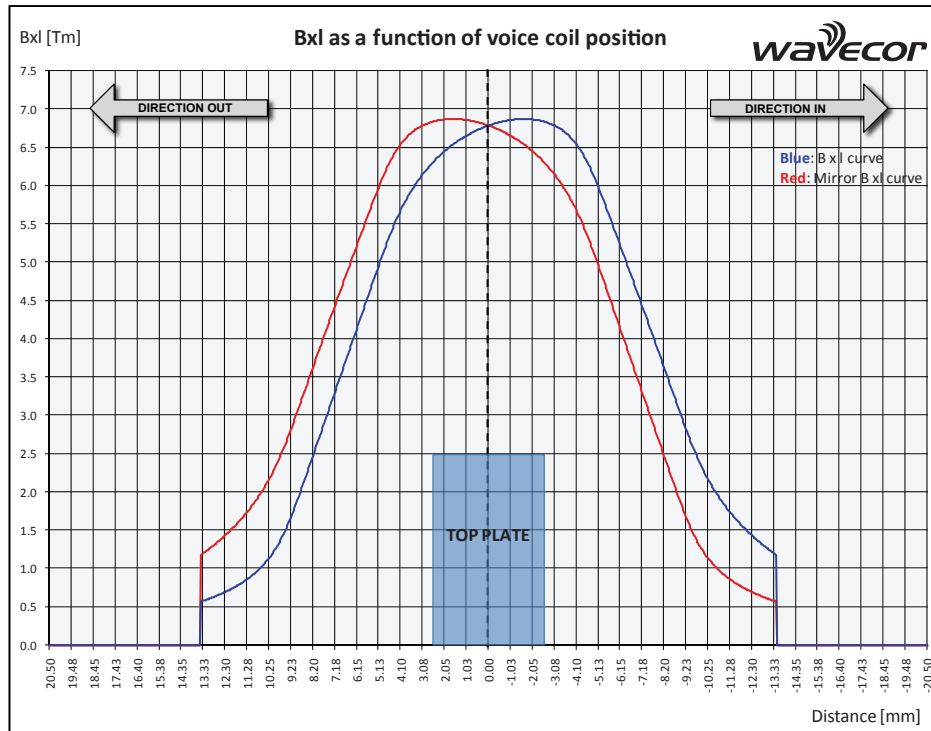

Fig. 5b. *Magnetic flux density (B) distribution for the Wavecor WF182BD01 mid/woofer. The figure shows the relative symmetry as the difference when measuring B out/in, held relative to the value outwards. Notice the very significant improvement compared to fig. 5a.*
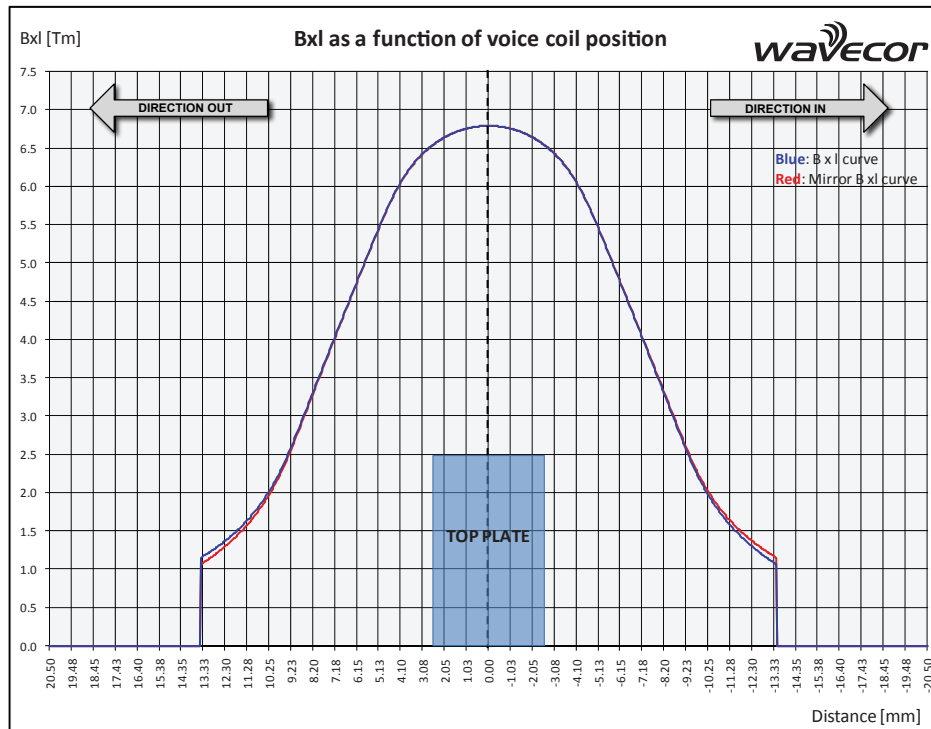
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Fig. 6a. Force factor (Bxl) as a function of voice coil position for a traditional magnet structure as shown fig. 3a. The curve is non-symmetrical and that the maximum Bxl is obtained with the voice coil positioned 1-2 mm below the center of the air gap.


Fig. 6b. Force factor (Bxl) as a function of voice coil position for the Wavecor WF182BD01 Balanced Drive mid/woofer as shown fig. 3b. Notice that the curve is almost perfect symmetrical and greatly improved compared to the results of a traditional design as shown fig. 6a.
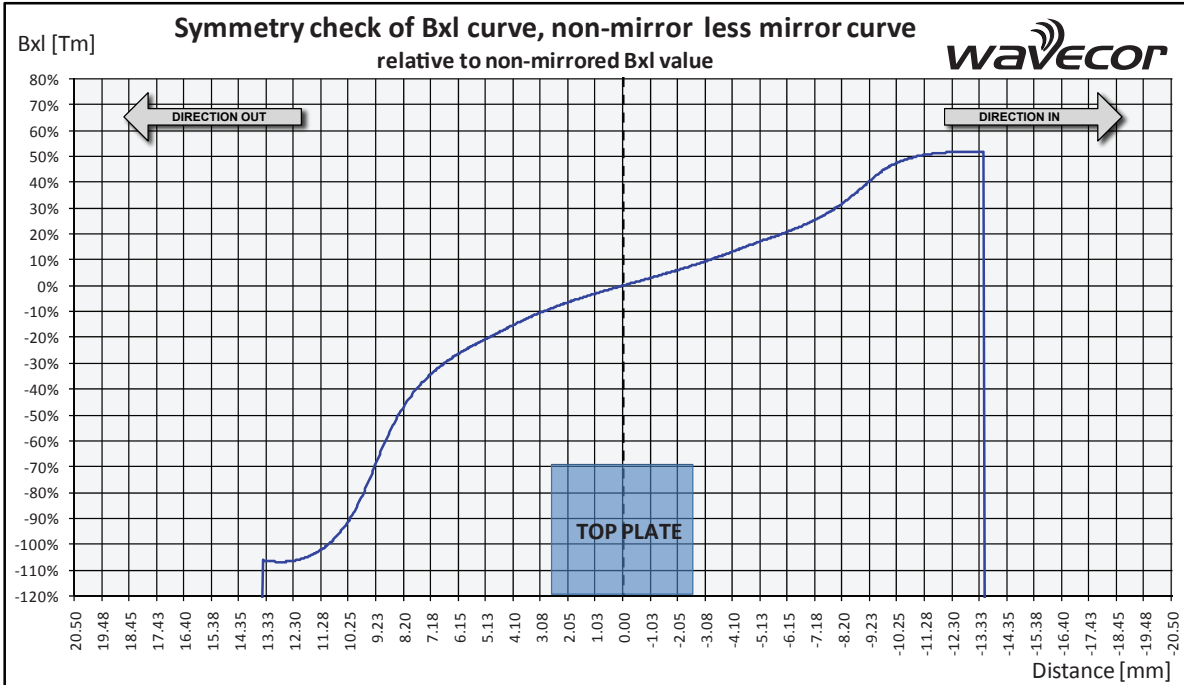
Fig. 7a. *Bxl as a function of voice coil position for a traditional magnet structure as shown fig. 3a. The figure shows the relative symmetry as the difference when measuring Bxl out/in, held relative to the value outwards.*
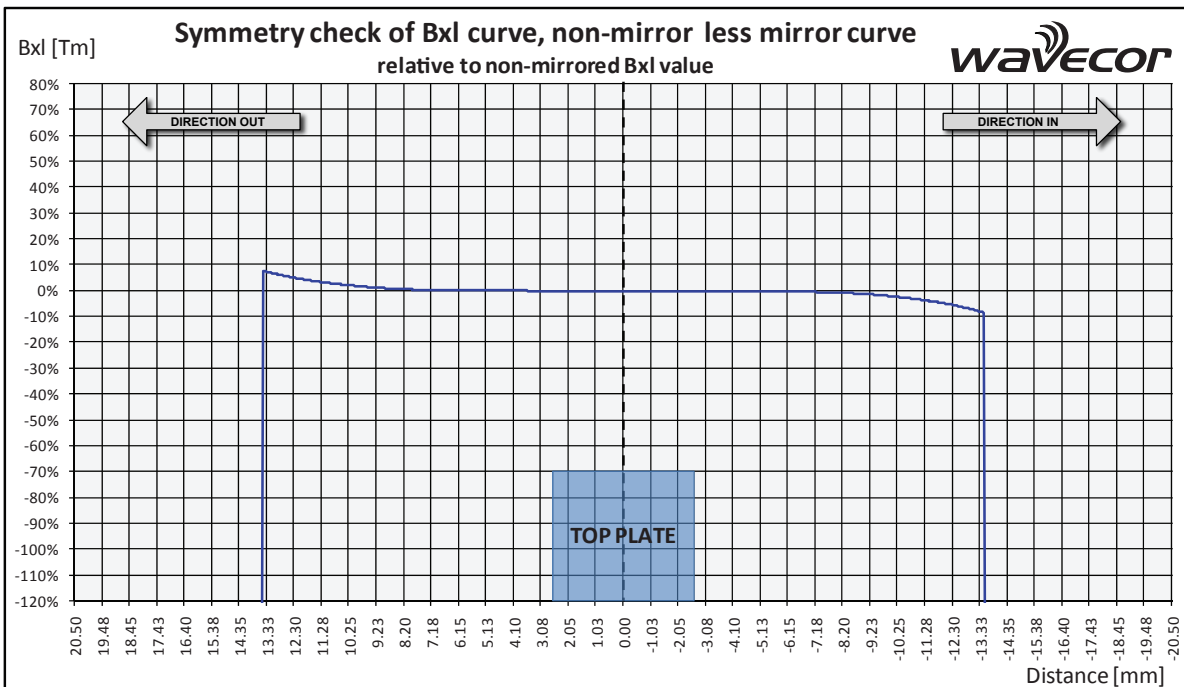
Fig. 7b. *Bxl as a function of voice coil position for the Wavecor WF182BD01 mid/woofer. The figure shows the relative symmetry as the difference when measuring Bxl out/in, held relative to the value outwards. Notice the very significant improvement compared to fig. 7a.*