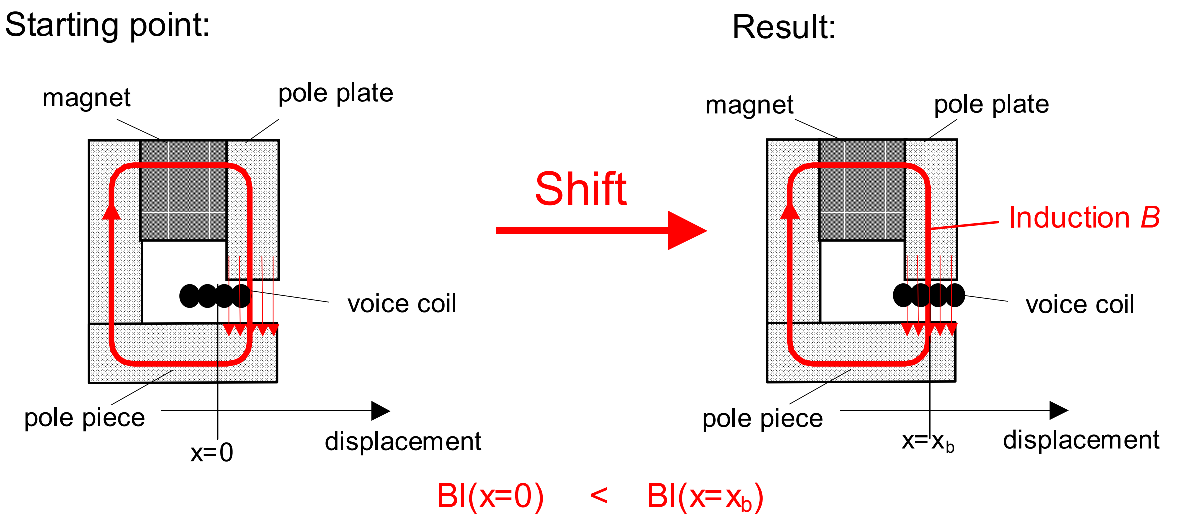
Optimal Voice Coil Rest Position **AN 1**

Application Note to the KLIPPEL ANALYZER SYSTEM

The rest position of the voice coil is a very critical parameter of dynamical transducers (speaker, shaker, headphone, ...). An offset may produce additional signal distortion and a DC-displacement derogating the stability of the driver (moving the coil outside the gap). On the other side an offset from the perfect symmetrical position in the gap geometry may partly compensate an asymmetry of the magnetic field. The optimal rest position may be found by measuring the force factor Bl versus displacement. The large signal identification module (LSI) determines this parameter dynamically by operating the driver under normal working conditions. Additional tools are provided to assess the asymmetry of the Bl-curve and to find the optimal voice coil shift.



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Measurement of the Large Signal Parameters

Requirements	To measure the nonlinear Bl(x)-characteristic the following equipment is required: • Hardware platform Distortion Analyzer 1 (DA1) • Software module LSI installed within dB-Lab on the PC • Power amplifier + speaker and amplifier cables
Procedure	Connect the SPEAKER 1 output of the DA1 to the terminals of the driver operated in free air. A driver stand is recommended if a laser displacement meter is used. Start the Large Signal Identification (LSI) on the hardware platform or from PC. Use the default setup parameters. If no laser displacement sensor is connected to DA1, the force factor value Bl at the rest position x=0 or the moving mass M_{MS} has to be imported (from LPM or other measurements) to calibrate the displacement axis. Ensure that the driver produces a positive displacement (moving out, away from the back-plate) during the *Re Mode 2(7).* If not, change polarity of the cables at the terminals. Finish the measurement and store the results after the *Nonlinear Mode 5(7).* Open the results windows **Bl(x)** and **Coil Shift.** Print the results or save them as a html-file using the report generator.

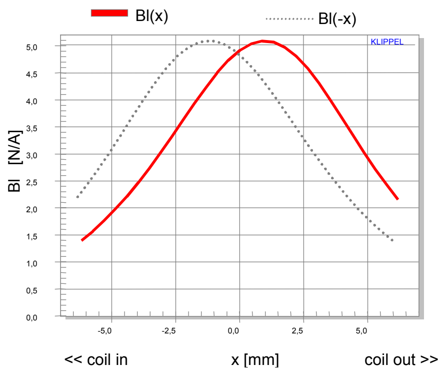
Interpretation of the Results

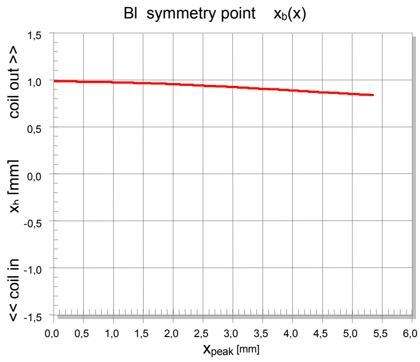
Bl(x)	The force factor is not constant as assumed in linear modeling but varies with the voice coil displacement. Clearly this value decreases when the coil moves out of the gap. There are symmetrical and asymmetrical variations. The asymmetrical variations may be caused by an offset in the rest position of the coil or by an asymmetric geometry of the magnetic field. In some cases the field asymmetry can be compensated by a coil offset. Finding the optimal voice coil shift in mm is tricky. Please note that the optimal voice coil shift is not identical with the maximum of the Bl-curve. A coil shift may help at smaller amplitudes but will make the things worse at larger displacement. Use the additional result window **Coil Shift** to assess the asymmetry quantitatively and to find a optimal shift value.
Coil Shift	The the symmetry point x_B in the nonlinear *Bl*-curve will produce the same force factor $Bl(x_B + x) = Bl(x_B - x) \qquad x_B = x_B(x_{peak}).$ For a negative and positive displacement x. If the shift $x_B(x_{peak})$ is independent on the displacement amplitude *x* then the force factor asymmetry is caused by an offset of the voice coil position and can be simply compensated by a voice coil shift of x_B. NOTE: If the optimal shift $x_B(x)$ varies with the displacement amplitude *x* then the force factor asymmetry is caused by an asymmetrical geometry of the magnetic field and can not be compensated by coil shifting completely.

Examples

Equal Length Configuration

An equal-length configuration is very sensitive to an offset in the rest position of the coil. Field asymmetries play as secondary role and can be compensated by a voice coil shift.





The overlay of the original Bl(x) curve (red solid line) with the Bl(-x) curve (grey dotted line) mirrored at x=0 reveals the asymmetry of Bl-characteristic.

The asymmetry of the Bl of the driver above is caused by an offset in the coil rest position.

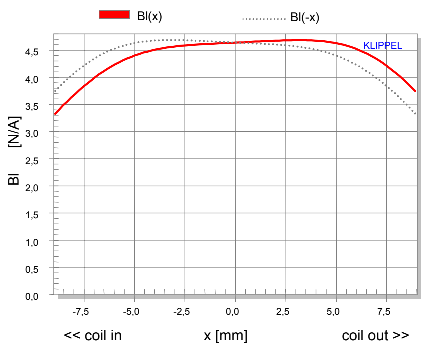
There is a distinct maximum of the coil 1 mm outside the gap.

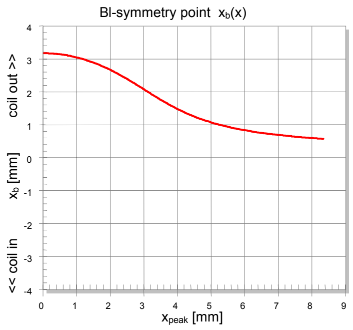
The parameter Bl-symmetry x_B varies from 1mm at small amplitudes to 0.75 mm at peak displacement X_{peak} = 6 mm.

A coil shift of X_B= 1mm to positive direction (coil out) will improve the stability of the driver, and reduce the generation of a DC-displacement and distortion.

Overhang Configuration

A large overhang of the voice coil gives more robustness against an offset of the voice coil rest position but is more sensitive to asymmetries of the magnetic field as an equal-length configuration.





The overlay of the original Bl(x) curve (red solid line) with the Bl(-x) curve (grey dotted line) mirrored at x=0 reveals the asymmetry of Bl-characteristic.

The asymmetry of the Bl-curve is caused by the stray field of the magnet accumulated by the overhang of the lower voice coil part.

The maximum of the Bl-curve at x =+3 mm gives a Bl-value which is only few percent higher than at the rest position.

The Shift Parameter x_B varies with peak displacement substantially. For very small displacement X_{peak} < 1 mm a shift of 3mm would be required to have a symmetrical curve. But this value would degrade the performance at maximal peak displacement X_{peak} = 8 mm where a smaller shift of 0.5 mm would give a better compensation of the field asymmetry.

The field asymmetry can only partly be compensated by a voice coil shift of 0.5 mm.

An FEM analysis of the magnetic field gives further information about the causes of the field asymmetry.

More Information

Papers	W. Klippel, "Diagnosis and Remedy of Nonlinearities in Electrodynamical Transducers," presented at the 109^{th} Convention of the Audio Engineering Society, Los Angeles, September 22-25, 2000, preprint 5261.

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