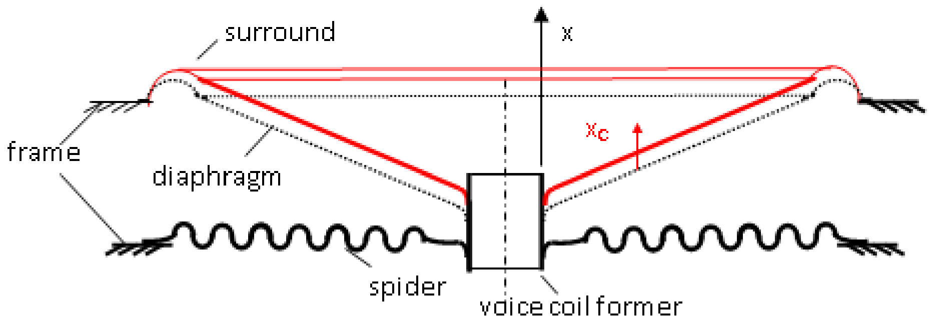
Adjusting the Mechanical Suspension AN 3

Software of the KLIPPEL R&D and QC SYSTEM (Document Revision 1.0)

DRESCRIPTION

The suspension system used in most transducers is comprised of two parts: a surround and a spider. Both parts contribute to the total compliance and they also determine the rest position of the coil. Comparing the driver's nonlinear parameters, measured with and without the surround attached, will reveal the nonlinear $C_{ms}(x)$ characteristic of each part (see Application Note 2: Separating Spider and Surround). The designer can use this information to pinpoint the contribution from each part towards the suspension's mechanical limiting. This information can also help determine the changes required to balance the asymmetry between each part. Balancing the asymmetries will help achieve the design goal of a suspension system with a symmetrical $C_{ms}(x)$. A symmetrical $C_{ms}(x)$ prevents the dynamic generation of a DC displacement, which shifts the coil from the optimal rest position leading to possible instabilities in the driver. In addition, a driver with a symmetrical $C_{ms}(x)$ will exhibit lower distortion and have better resilience to excessive stretching of the materials promoting a longer lifespan of the suspension.



CONTENTS:

1 Measurement of the Nonlinear Suspension

Requirements	To measure the nonlinear characteristics of the suspension, the following hardware and software are required: • Hardware platform Distortion Analyzer (DA) • Software module LSI installed within dB-Lab on the PC • A driver stand or similar clamping (recommended)
Procedure  	1) Operate the driver in free air. 2) Create a new object Driver and add a new LSI operation based on the Default template. Adjust the measurement set up parameters according to the requirements of your selected DUT. Use caution not to overload the DUT. To calibrate the displacement axis to the highest precision, import the force factor at the rest position Bl(x=0) or the moving mass MMS from a previous LPM or other measurement. 3) Ensure that the DUT polarity is correct. 4) Start the measurement. 5) Open the result windows $K_{MS}(x)$ 6) Open the result window Nonlinearities

2 Post processing and Interpretation

K_{MS}(x) = $1/C_{MS}(x)$	The most important parameter of the suspension is the stiffness $K_{MS}(x)$ which is the inverse of the compliance $C_{MS}(x)$. Both parameters are not constant as assumed in linear modeling but vary with voice coil displacement. Clearly, for large positive and negative displacements the suspension becomes much stiffer. Transducers without a minimum stiffness at the rest position *x=0* will have an asymmetry in their stiffness characteristic. To diagnose suspension asymmetries, the spider and surround stiffness characteristic can be measured individually and redesigned or replaced as required. This approach is time consuming but will eventually lead to the desired behavior. In the later stages of the development, when the parts can no longer be altered, they can be re-oriented or re-positioned to balance the asymmetries against each other. In most cases, flipping the surround or spider is not possible. However, the position of the diaphragm on the voice coil former may be changed more easily. Thus, an asymmetric limiting of the surround can be balanced with the spider characteristic. To assess the asymmetry quantitatively and to find the optimal diaphragm shift value use the result windows ***K_{ms}(x)*** and ***K_{ms} Symmetry Range***. Note: The window compliance $C_{MS}(x)$ gives basically the same diagnostic information but the inverse display enhances nonlinear stiffness variation at small amplitudes $x \ll x_{peak}$ which is less important than the variation at higher amplitudes. The nonlinear stiffness curve $K_{ms}(x)$ leads intuitively to the right interpretation of the nonlinearity because the nonlinear variations correspond to the nonlinear restoring force.

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<td>Stiffness Asymmetry</td>
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The Stiffness Asymmetry A_K defined according IEC standard 62458 as

$$A_K(x_{peak}) = \frac{2\left(K_{MS}(-x_{peak}) - K_{MS}(x_{peak})\right)}{K_{MS}(-x_{peak}) + K_{MS}(x_{peak})} 100\%,$$

refers the difference between the stiffness values at the maximum negative and positive peak displacement $-x_{peak}$ and x_{peak}, respectively to the mean stiffness value at those two points. The sign of the stiffness asymmetry indicates the softer side of the stiffness curve which corresponds with the direction of the DC displacement generated by the asymmetry. For example, the stiffness curve shown on the right diagram has an asymmetry A_k=75% where the positive sign indicates a positive DC displacement moving the coil to the softer side of the suspension in coil out direction.

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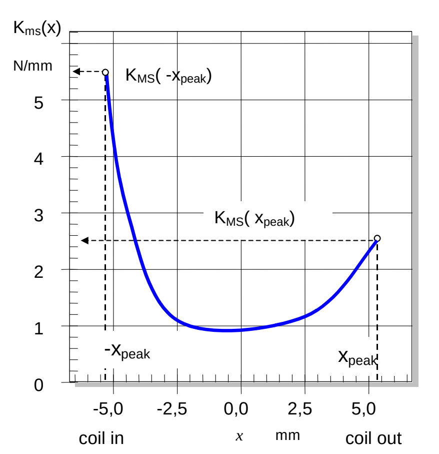

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3 Examples

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<td>Surround limiting</td>
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In this example, the stiffness of the surround has been separated from the spider. The procedure for doing this can be found in Application Note 2: Separating Spider and Surround. The spider stiffness characteristic, with the surround partially removed, is almost symmetrical but the stiffness increases for positive displacement. This may be caused by the asymmetrical shape of the surround geometry which limits the excursion at positive displacement. At negative displacements the surround moves freely and the stiffness is almost constant. The asymmetry in the working range of the mechanical suspension can be improved by shifting the diaphragm (with surround attached) 3 mm along the voice coil former in the negative direction (inwards towards the coil) to generate the lowest value of the stiffness asymmetry A_k.

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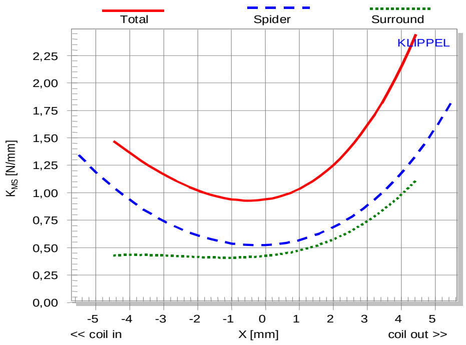

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<td>Balancing Spider and Surround</td>
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This example illustrates an asymmetrical total stiffness characteristic shown as red line in the right figure. The spider and surround have a similar asymmetrical shape of the nonlinear stiffness characteristic K(x).

These properties can be used to balance the total stiffness asymmetry by two ways:

1) If the spider has a flat geometry (not a cup spider) it may be considered to assemble the driver with the spider in upside-down orientation while keeping the original surround position.

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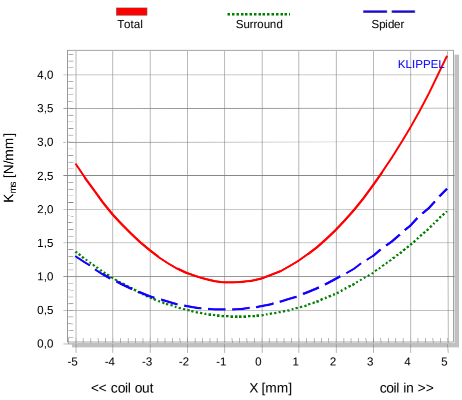

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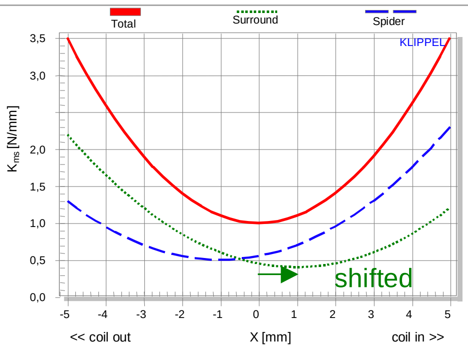
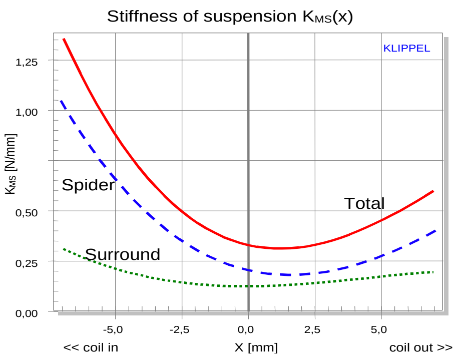
	2) Alternatively, the balancing can be achieved by shifting the surround 1.5 mm in the positive direction (outwards away from the coil) adding more stiffness at negative displacements which results in more symmetry in the total stiffness curve.	
Balancing not possible	If the surround or the spider dominates the total stiffness, balancing is not possible. In this example, the surround has no influence on the total stiffness asymmetry. Therefore, the spider has to be replaced or the geometry has to be corrected.	

4 More Information

Papers	W. Klippel, "Diagnosis and Remedy of Nonlinearities in Electro-dynamical Transducers," presented at the 109th Convention of the Audio Engineering Society, Los Angeles, September 22-25, 2000, preprint 5261.
Application Notes	AN2: "Separating Spider and Surround"

Find explanations for symbols at:

http://www.klippel.de/know-how/literature.html

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