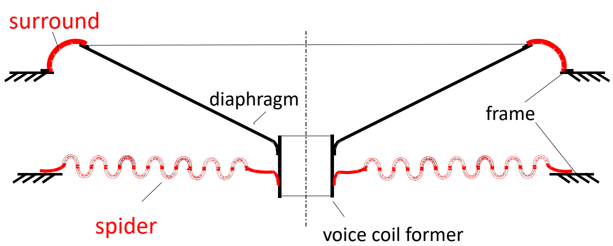
# Adjusting the mechanical suspension AN3

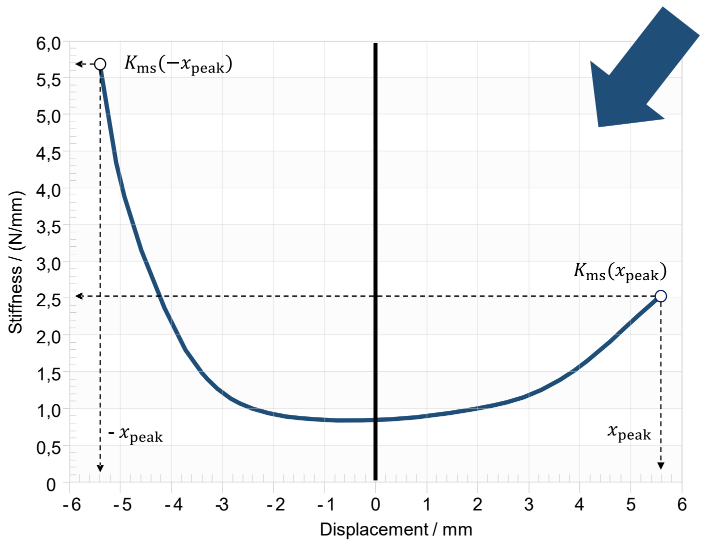
Application Note for the KLIPPEL ANALYZER SYSTEM

Document Revision 1.1

## DESCRIPTION

The suspension system in most electrodynamic transducers consists of a surround and a spider. Both components contribute to the overall stiffness and define the rest position of the voice coil. Separating spider and surround can help to pinpoint the contribution from each part towards the suspension's mechanical limiting. Furthermore, the symmetry of the transducer plays a crucial role in determining driver performance. Symmetrical compliance prevents the dynamic generation of DC displacement, which could otherwise shift the voice coil away from its optimal rest position and potentially cause instability. In addition, symmetrical compliance reduces distortion and improves resistance to excessive material strain, thereby promoting a longer operational lifespan of the suspension. This application note discusses the importance of transducer symmetry for driver performance and outlines several techniques for optimizing suspension symmetry.




## CONTENT

# 1 Measurement

## 1.1 Requirements

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| Klippel Analyzer (KA3) | Hardware platform for the measurement modules performing the signal generation, acquisition and digital signal processing |
| Laser displacement Sensor | High resolution laser sensor with low noise floor for reliable results also at higher frequencies with low displacement |
| Amplifier | External amplifier with a flat frequency response over the desired measurement bandwidth or internal AMP-Card of KA3 |
| dB-Lab | Frame software of the Klippel Analyzer system |
| Large Signal Identification (FLSI or LSI3) | Module for measurement of large signal parameters including nonlinearities of loudspeakers |

## 1.2 Hardware Setup

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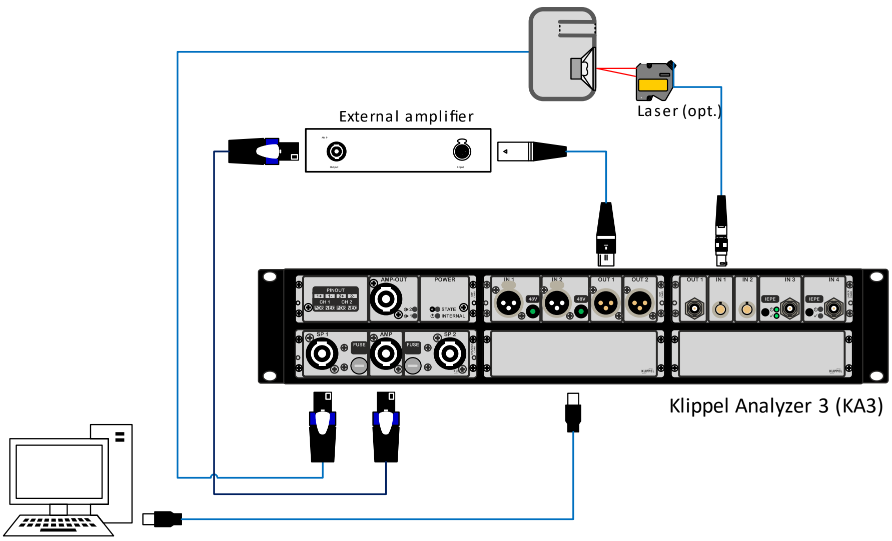
| Connect hardware | • Connect external power amplifier or use internal AMP-Card of KA3<br>• Mount DUT and connect KA3 with speaker terminals<br>• Connect laser to KA3 and adjust laser head to the diaphragm of DUT<br> |



## 1.3 Measurement

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| Measurement | • Open dB-Lab and select large signal identification operation (FLSI or LSI3)<br>• Adjust the setup parameters according to the requirements of your selected DUT (more information in FLSI manual or LSI3 manual).<br>• Start operation<br>• After measurement open result windows “Km(x) Stiffness of Suspension” |

# 2 Results

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<tr>
<td>Stiffness<br>$K_{m}(x)$</td>
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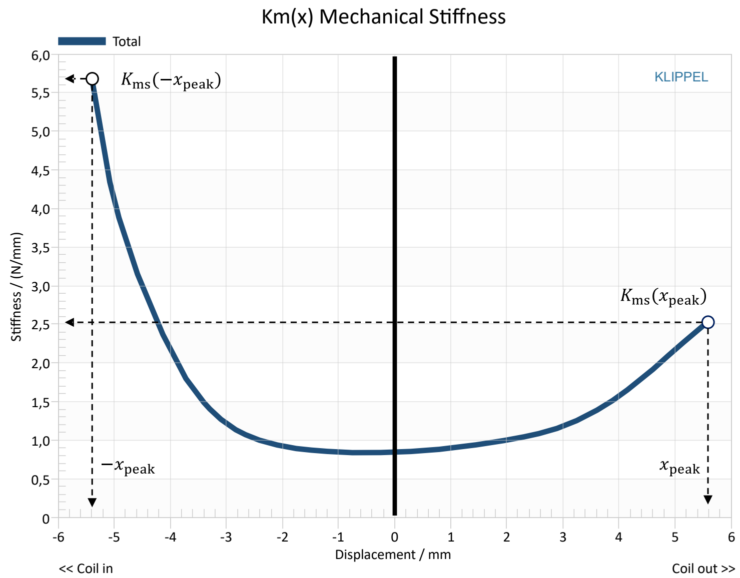
The nonlinear behaviour of the suspension system is defined by the stiffness $K_{ms}(x)$, defined as the inverse of the compliance $C_{ms}(x)$. Contrary to linear modeling assumptions, both parameters vary with voice coil displacement. The suspension stiffness typically increases at large positive and negative displacements. The asymmetries of the stiffness can be investigated by measuring the contributions of the spider and surround separately. Based on these measurements, individual components may be redesigned or replaced to achieve improved mechanical symmetry. Although effective, this procedure is often time-consuming. In later development stages, when mechanical components can no longer be modified, asymmetries may instead be compensated by reorienting or repositioning existing parts. While flipping the surround or spider is often impractical, adjusting the diaphragm position on the voice coil former is usually feasible. In this way, an asymmetric limitation introduced by the surround can be balanced against the spider stiffness characteristic. Quantitative assessment of suspension asymmetry and determination of the optimal diaphragm shift can be performed using the $K_{ms}(x)$ and Kms Symmetry Range result windows.




Note: The compliance curve $C_{ms}(x)$ provides essentially the same diagnostic information. However, displaying its inverse $K_{ms}(x)$ emphasizes nonlinear stiffness variations at larger displacements, which are more relevant than small-signal deviations. The nonlinear stiffness curve directly reflects the nonlinear restoring force and therefore enables a more intuitive interpretation of suspension nonlinearity.
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<td>Stiffness asymmetry</td>
<td>
The stiffness asymmetry $A_{K}$, defined according to IEC 62458, quantifies the relative difference between the suspension stiffness at the maximum negative and positive peak displacements $\pm x_{peak}$, referenced to the mean stiffness at these two operating points.

$$A_{\mathrm{K}}(x_{\mathrm{peak}}) = 2 \cdot \frac{\left(K_{\mathrm{ms}}(-x_{\mathrm{peak}}) - K_{\mathrm{ms}}(x_{\mathrm{peak}})\right)}{K_{\mathrm{ms}}(-x_{\mathrm{peak}}) + K_{\mathrm{ms}}(x_{\mathrm{peak}})} \cdot 100\%$$

The sign of the stiffness asymmetry indicates the softer side of the stiffness characteristic and therefore predicts the direction of the DC displacement generated by the asymmetry. A positive value corresponds to a softer suspension behavior in the positive displacement direction, resulting in a DC shift toward this side. For example, the stiffness curve shown above exhibits an asymmetry of $A_{K}$=75%. The positive sign indicates a positive DC displacement, meaning that the voice coil moves toward the softer region of the suspension in the coil-out direction.
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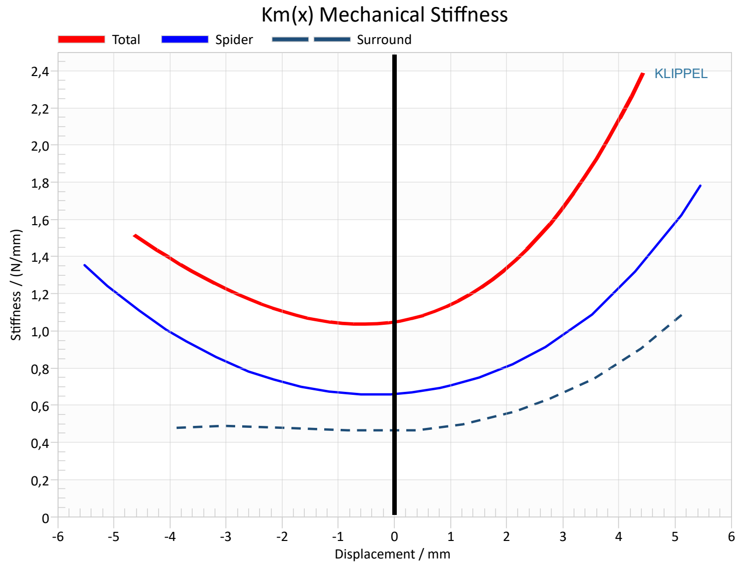
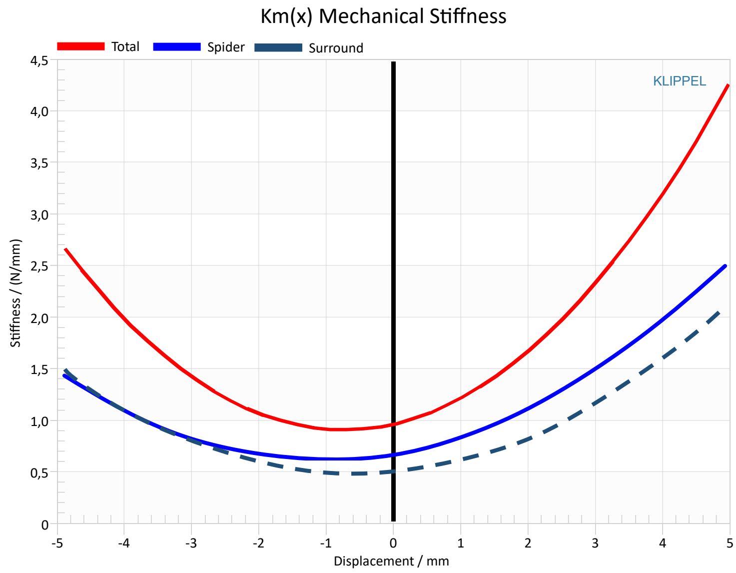
# 3 Examples

<table>
<tr><td>Surround limiting</td><td>In this example, the stiffness of the surround has been isolated from that of the spider. The procedure for this is described in AN2 Spider and Surround Separation. With the surround partially removed, the spider stiffness characteristic is nearly symmetrical, although the stiffness increases at positive displacement. This behavior may result from the asymmetrical geometry of the surround, which limits displacement in the positive direction. At negative displacements, the surround moves more freely and the stiffness remains almost constant. Asymmetry within the operating range of the mechanical suspension could be reduced by shifting the diaphragm (with surround attached) 3 mm in the negative direction along the voice coil former (toward the coil). This adjustment would produce the lowest value of stiffness asymmetry $A_k$.<br><br></td></tr>
<tr><td>Balancing spider and surround</td><td>This example illustrates an asymmetrical total stiffness of the suspension system (red curve). Both the spider and the surround exhibit a similar asymmetrical shape in their nonlinear stiffness $K_{ms}(x)$. The properties of the individual components can be used to compensate for the total stiffness asymmetry:<br>1. If the spider has a flat geometry (rather than a cup-shaped design), the driver may be assembled with the spider mounted in an inverted orientation, while keeping the surround in its original position<br><br></td></tr>
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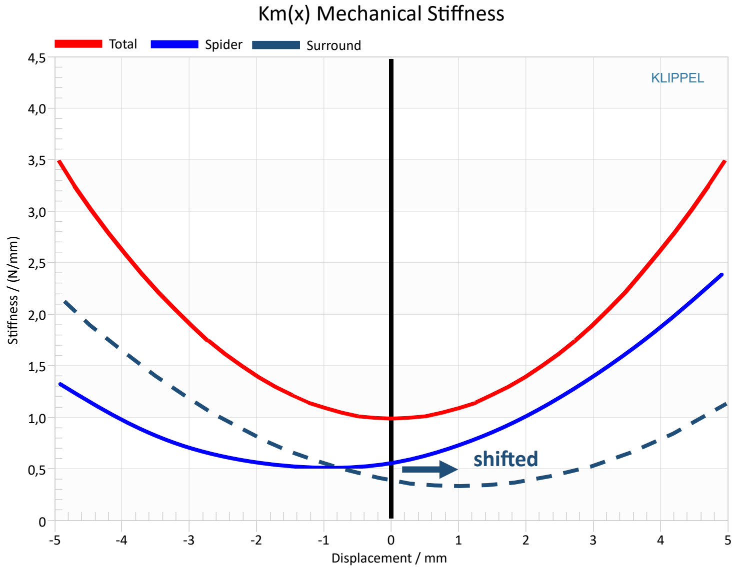
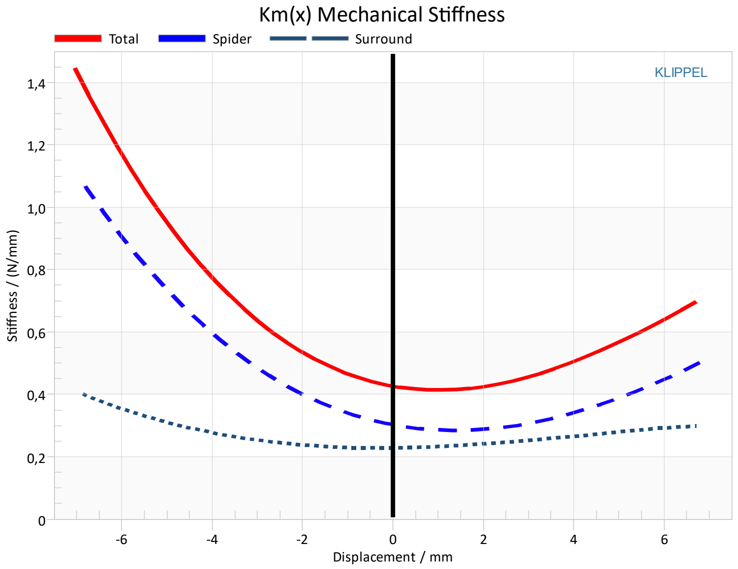
| | 2. Alternatively, the asymmetry can be compensated by shifting the surround 1.5 mm in the positive direction (outwards, away from the coil). This increases the stiffness at negative displacements and results in a more symmetrical overall stiffness characteristic.   |
| Balancing not possible | If 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.   |

# 5 More Information

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| Application Notes | Separating Spider and Surround, Application Note AN2 |
| Related Specification | Fast Large Signal Identification (FLSI), Specification FLSI<br>Linear Parameter Measurement, Specification LPM<br>Large Signal Identification (LSI3), Specification LSI3<br>Klippel Analyzer 3 (KA3), Specification H3<br>Laser displacement sensor, Specification A2 |
| Manuals | User Manual Fast Large Signal Identification<br>User Manual Large Signal Identification<br>User Manual Linear Parameter Measurement |
| Paper | Klippel, Wolfgang. "Diagnosis and remedy of nonlinearities in electrodynamical transducers." *Audio Engineering Society Convention 109*. Audio Engineering Society, 2000. |

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html
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