# Evaluating Suspension Asymmetry TN1

Technical Note for the KLIPPEL R&D and QC SYSTEM (Document Revision 1.1)

### $K_{MS}$ SYMMETRY POINT VS. STIFFNESS ASYMMETRY $A_K$

## 1 Background

The nonlinear characteristic of the mechanical suspension versus displacement Kms(x) is one of the major characteristics of the electrodynamic transducer defining the performance at large signal operation. The limiting effect of the stiffness at high excursions causes amplitude compression resulting in harmonic distortion. A symmetric characteristic produces mainly odd order distortion.

An asymmetric Kms(x) characteristic additionally generates even order harmonic distortion. Furthermore, the asymmetry rectifies the signal resulting in a dynamical DC component shifting the coil systematically towards the softer side of the suspension and away from the intended working point the magnetic field. The shifted Bl(x) curve generates broad-band intermodulation distortion impairing the speaker performance significantly. In contrast to other nonlinearities like Bl(x), the nonlinear characteristic of Kms(x) is only of interest at large amplitudes where symmetrical or asymmetrical limiting or a DC shift is caused. The symmetry at small signals is not relevant.

## 2 Kms(x) Asymmetry Measures

There are different measures to evaluate the asymmetry of the suspension. The ***Kms Symmetry Point*** is defined by the centre point between two points of the Kms(x) having the same stiffness value. The symmetry point in the stiffness curve shall be only considered at high signal amplitudes where the mechanical forces are high and a significant DC component is generated. Values close to zero are desirable.

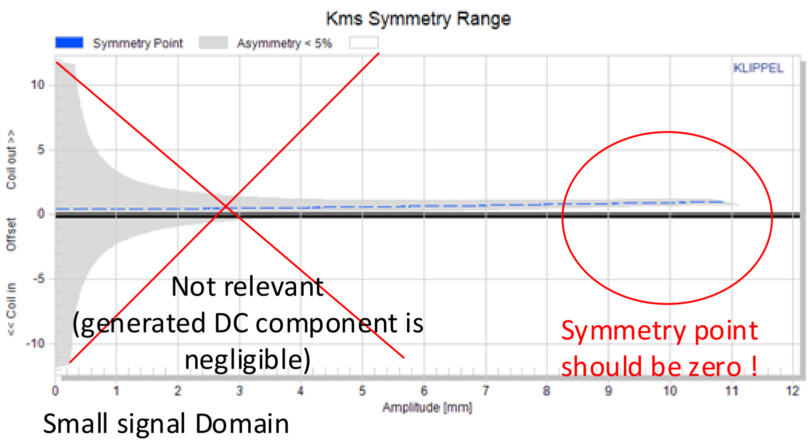
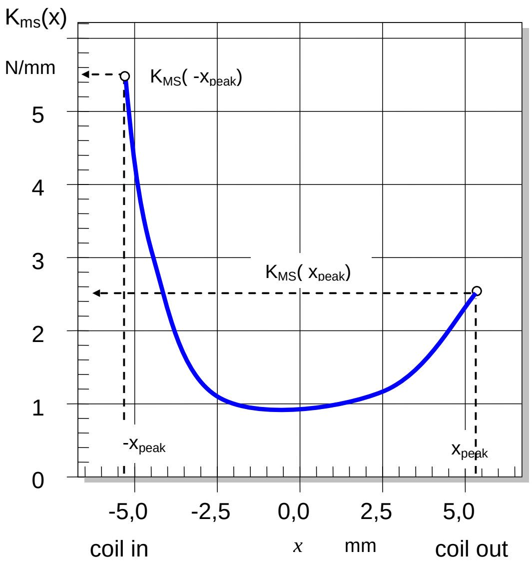



**Figure 1 Kms Symmetry Range result window of the Klippel LSI module.**

Although the concept of symmetry point is important for adjusting the rest position of the coil in loudspeakers with low coil overhang (or underhang) generating peaky Bl(x) curves, this concept is less powerful for evaluating suspension asymmetry. The symmetry point calculated from the Kms(x) curve gives usually no clear diagnostic information for improving the suspension. Only if the surround limits the excursion on one side it may be used to shift the surround relatively to the spider.




IEC standard 62458 suggests a much more powerful characteristic to evaluate suspension asymmetry at high amplitudes with respect to the difference of stiffness. The ***stiffness asymmetry Ak*** is a relative single value in percent relating the stiffness at both peak and bottom excursion to its sum

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

This value indicates the difference of the mechanical forces at high values Xpeak of negative and positive displacement which generate DC displacement. The sign of the $A_k$ indicates the harder and softer side of the suspension and the direction of the DC displacement generated by the asymmetry.

For Ak < 0 the suspension is softer for negative displacement generating a negative DC displacement.

For Ak> 0 the suspension is softer for positive displacement generating a positive DC displacement.

The stiffness asymmetry is a valuable measure to quickly evaluate the large signal performance of the transducer with respect to the suspension. Therefore, it is a suitable measure for both R&D and end-of-line testing. Both the Klippel R&D LSI and the QC MSC provide this characteristic.

| Name | Value | Min Limit | Max Limit | Unit | Description |
|---|---|---|---|---|---|
| Coil Offset | 0.732 | 0.588 | 0.859 | mm | recommended shift to |
| XBl | 1.095 | - | - | mm | force factor limiting di |
| XC | 1.135 | 1.019 | - | mm | compliance limiting dis |
| Stiffness Asymmetry | 59.8 | -20.0 | 20.0 | % | stiffness asymmetry |

Figure 2 Nonlinear parameter result table of the QC MSC

## 3 References

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|---|---|
| Specifications | • S1 LSI – Large Signal Identification<br>• S13 QC MSC – Motor + Suspension Check |
| Application Notes | • AN 02 Separating spider and surround<br>• AN 03 Adjusting Mechanical Suspension<br>• AN 13 DC Part In Displacement<br>• AN 14 Motor Stability<br>• AN 15 Asymmetry of Compliance<br>• AN 26 Suspension Part Measurement |
| Papers | W. Klippel, “Loudspeaker Nonlinearities – Causes, Parameters, Symptoms”; J. Audio Eg. Soc., Vol. 54, No. 10, 2006 |
| Standards | IEC 62458 – Measurement of Large Signal Parameters |

Find explanations for symbols at:

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

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