

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 $K_{ms}(x)$ 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 $K_{ms}(x)$ 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 $K_{ms}(x)$ 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 $K_{ms}(x)$ Asymmetry Measures

There are different measures to evaluate the asymmetry of the suspension. The *K_{ms} Symmetry Point* is defined by the centre point between two points of the $K_{ms}(x)$ 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.

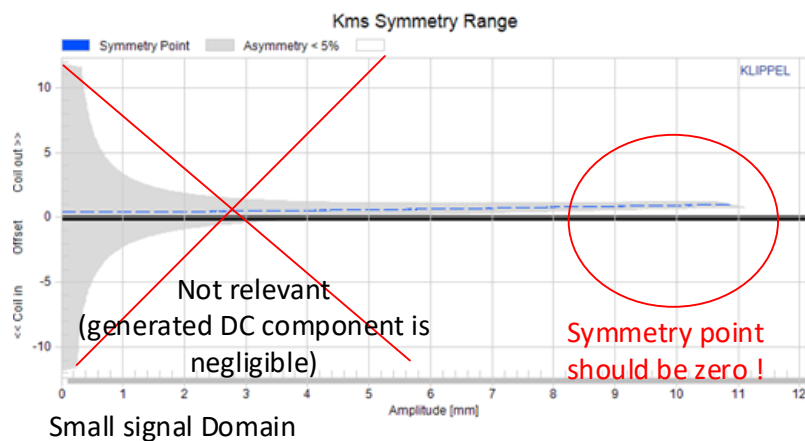
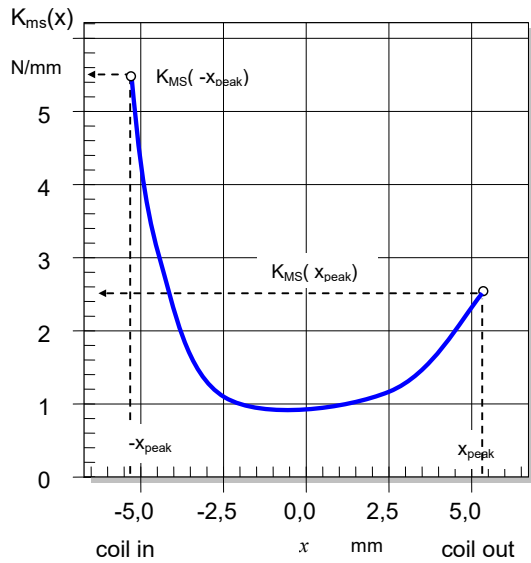


Figure 1 *K_{ms} Symmetry Range* result window of the Klippel LSI module.

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 $K_{ms}(x)$ 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

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

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 Ak 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
XBI	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

Specifications	<ul style="list-style-type: none"> S1 LSI – Large Signal Identification S13 QC MSC – Motor + Suspension Check
Application Notes	<ul style="list-style-type: none"> AN 02 Separating spider and surround AN 03 Adjusting Mechanical Suspension AN 13 DC Part In Displacement AN 14 Motor Stability AN 15 Asymmetry of Compliance AN 26 Suspension Part Measurement
Papers	W. Klippel, "Loudspeaker Nonlinearities – Causes, Parameters, Symptoms"; J. Audio Eng. 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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