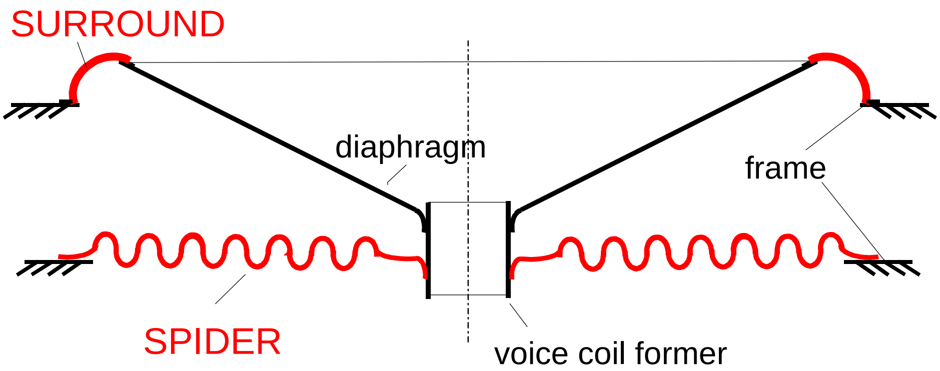
# Spider and Surround Separation AN 2

Application note to the KLIPPEL R&D SYSTEM (Document Revision 1.2)

## DESCRIPTION

Using the Large Signal Identification (LSI) module of the Klippel R&D System, the nonlinear characteristic of the mechanical stiffness $K_{ms}(x)$ or the reciprocal mechanical compliance $C_{ms}(x)$ can be measured. This measured parameter represents the total mechanical stiffness of the suspension system (spider and surround). In this application note, a procedure is described that shows how the total stiffness can be separated into its contributing parts, the spider stiffness and the surround stiffness. Although this procedure is destructive, the valuable information obtained allows the designer to improve the overall linearity of the suspension system by focusing on the stiffness properties of each part separately. Two examples are investigated that use the internal CAL module to calculate the surround characteristic. These examples represent typical cases for diagnosing and improving suspension designs.

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# 1 Measurement of the Nonlinear Suspension

**Requirements**

To measure the nonlinear characteristics of the suspension, the following hardware and software is required:

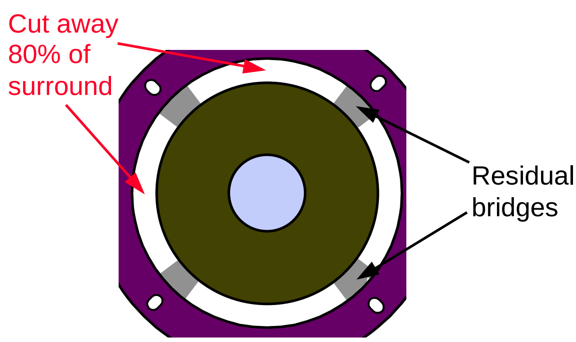
- Hardware platform Distortion Analyzer (DA)
- Software module LSI installed within dB-Lab on the PC (minimum version 202.52)
- A driver stand or similar clamping (recommended)

**Template**

Create a new measurement object *Driver* using the object template ***Separate Suspension AN2*** from the Klippel Templates Database.

**Procedure**


1) Operate the DUT in free air.
2) Select the measurement operation *1 LSI Woofer Total Suspension* and adjust the setup 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 $M_{MS}$ from a previous LPM or other measurement.
3) Ensure that the DUT polarity is correct.
4) Start the measurement.
5) After the measurement has finished, disconnect the DUT and carefully cut away 80 to 90% of the surround. It is sufficient to leave 4 residual bridges. The number of bridges and the width of each will depend on the suspensions ability to keep the diaphragm centered. This could be difficult if the surround is the dominant factor in the suspension’s total stiffness. Therefore, it is good practice to experiment with several stages of cutting. Start with about 50% and remove 10 to 15% incrementally, carefully checking for proper operation of the suspension at each step until 80 to 90% of the surround has been removed.




6) Select the measurement operation *2 LSI Woofer Spider Only* and adjust the setup parameters to match the parameters used in *1 LSI Woofer Total Suspension*.
7) Run the measurement and open the results window $\boldsymbol{K_{MS}(x)}$.
8) Right click on the $K_{MS}(x)$ curve $\boldsymbol{X_{prot}<X<X_{prot}}$. The curve will change color indicating that it has been selected correctly. Select ***copy curve***.
9) Display the corresponding $\boldsymbol{K_{MS}(x)}$ result window from *1 LSI Woofer Total Suspension*. Right click in this result window and select ***paste curve***. You should get a similar graph as shown below.

## 2 Post Processing and Interpretation

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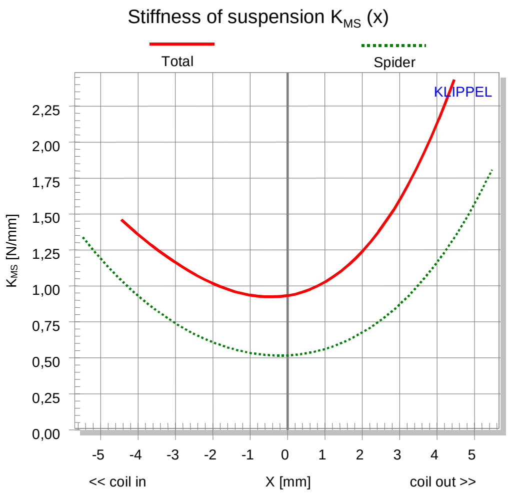
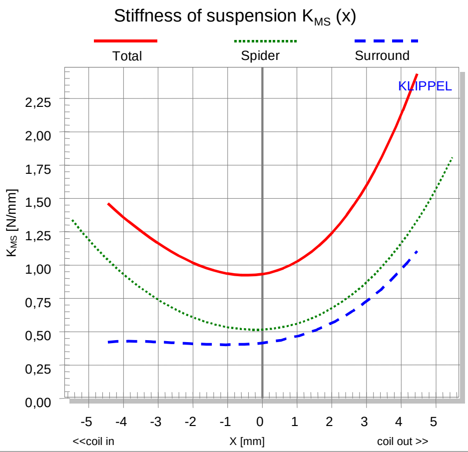
| **$K_{MS}$(x) of total suspension and spider only** |  |
| | The total stiffness will be decreased by the surround cutting process. If the spider stiffness characteristic and the total stiffness have very similar curves, then the spider dominates. This can be an acceptable design criteria provided the spider stiffness characteristic curve does not exhibit any asymmetries. In some cases, this observation is sufficient to determine if the spider is the root cause of problem. If so, the designer should improve the spider accordingly. However, as shown in this example, the curves are different at positive displacements, which indicates that both the spider and the surround contribute to the suspension problems. Therefore, the stiffness characteristic of the surround needs to be considered. |

### Stiffness of Surround (calculation)

The contribution from the surround may be determined by subtracting the spider stiffness from the total stiffness. Using the export interface of dB-Lab, the data can be easily exported and then manipulated by the internal MAT or CAL scripts or by an external program. To calculate the stiffness characteristic of the surround, perform the steps below:

1) Select the first LSI operation *1 LSI Woofer Total Suspension*. Select the Result window $K_{ms}(X)$ and copy the $X_{prot}<X<X_{prot}$ curve to the clipboard.
2) Select *3 CAL Spider*. On property page ***Input***, select the ***TotalStiffness*** item. Select ***Edit*** and then select ***From Clipboard*** in the ***Edit Parameters: TotalStiffness*** window.
3) Select the second LSI operation *2 LSI Woofer Spider Only*. Select the Result window $K_{ms}(X)$ and copy the $X_{prot}<X<X_{prot}$ curve to the clipboard.
4) Select *3 CAL Spider*. On property page ***Input***, select the ***MeasuredSpider*** item. Select ***Edit*** and then select ***From Clipboard*** in the ***Edit Parameters: MeasuredSpider*** window.
5) Determine the cut ratio, which is the geometrical ratio of surround removed to the total circumference, i.e. removing 80 % of the surround will correspond to a cut ratio of 0.8. On property page ***Input***, double click on the ***CutRatio*** item and enter this value.
6) On the dB Lab toolbar, select ***Run***. Open the result window ***Result Curve 1***.




The graph compares all three stiffness curves which allows a detailed investigation of the separated contributions towards the total stiffness. Note that the remaining surround material will partially influence the spider stiffness characteristic. However, in most cases, the surround is softer than the spider resulting in a minor influence. Further information on how to improve the suspension linearity may be obtained from the Application Note *AN3: Adjusting the Mechanical Suspension.*

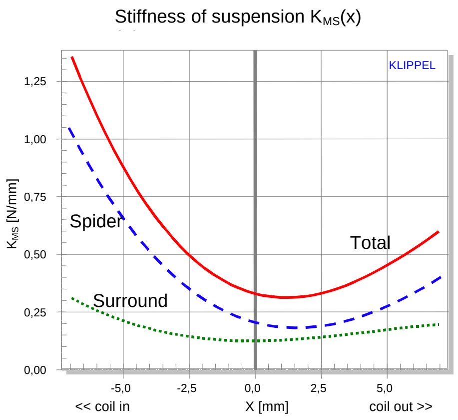
### Ensure correct rest position

Due to the cut away of the surround, the rest position of the voice coil may have changed. In some cases, this can occur when the surround stiffness is asymmetrical and it is a dominant factor in the suspension's total stiffness. To check for a change in the rest position, compare the $Bl(x)$ characteristic curve from both measurements and determine the displacement distance $\Delta x(Bl_{max})$ between the maximal Bl(x) values. This distance should be considered while calculating the surround stiffness using the external routines:

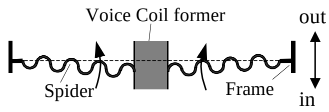
$K_{surround}(x) = K_{total}(x) - K_{spider}( x - \Delta x(Bl_{max}) )$.

## 3 Examples

**Spider causes Asymmetry**

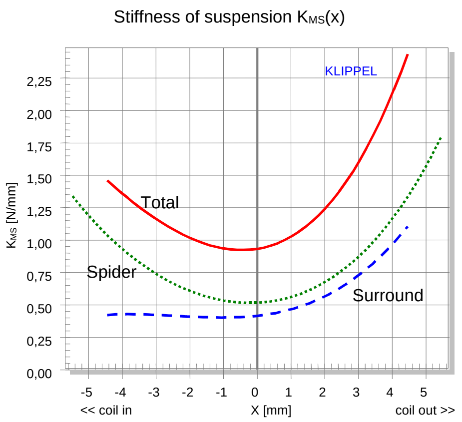



In this example, since the surround characteristic is very flat and much softer than the spider, the asymmetry in the spider clearly dominates the total stiffness. The surround has almost no influence on the asymmetry of the total stiffness. In the suspension's current rest position, shown at *x=0* in the graph, the spider material is stretched and it droops slightly inwards (towards the magnet.)




When the driver is operated in the large signal domain, the spider material will have its slackest (softest) point in the horizontal position, which is about 1 mm outwards from the current rest position. This behavior can be fixed by using a spider with a different form.

**Surround causes Asymmetry**




In this example, the asymmetry in the total stiffness is mainly caused by the mechanical limiting of the surround during outward displacements. The excessive stress on the surround at positive displacements may cause permanent damage to the surround material. This problem is fixable by adjusting the rest position of the surround with respect to the spider. This can be accomplished by moving the diaphragm further down the voice coil former towards the spider. For more information on how to improve the suspension linearity, see Application Note 3: *Adjusting the Mechanical Suspension*.

## 4 More Information

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| **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** | AN 3 "Adjusting the Mechanical Suspension" |

Find explanations for symbols at:
http://www.klippel.de/fileadmin/klippel/Files/Know_How/Literature/Papers/symbols.pdf

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