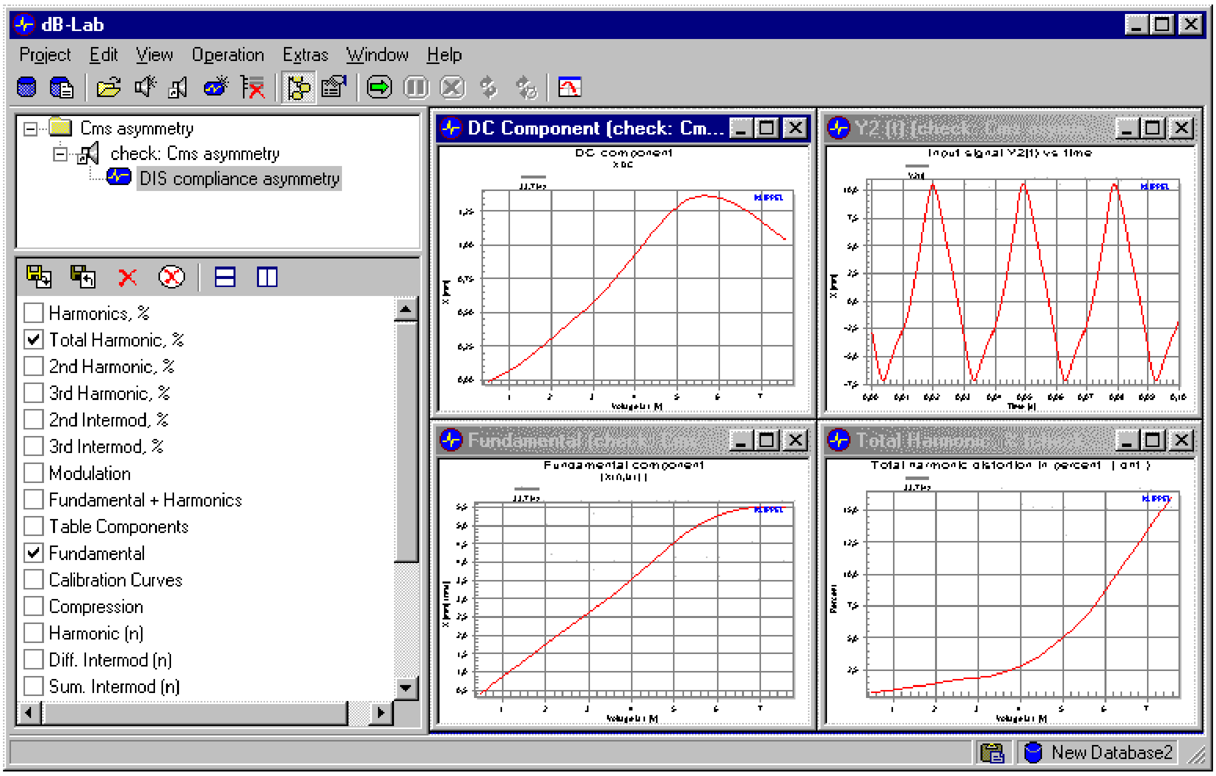
Checking for Compliance Asymmetry **AN 15**

Application Note to the KLIPPEL R&D SYSTEM

A mechanical suspension having an asymmetrical compliance characteristic $C_{ms}(x)$ will partly rectify the signal and will produce a DC component in voice coil displacement. This DC part may move the coil away from the optimal rest position of the coil in the magnetic field and deteriorate the performance of the speaker. Using the 3D Distortion Measurement (DIS) of the Klippel R&D System a simple test can be performed for checking the asymmetry of the suspension. Different ways for improving the suspension are discussed.



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Compliance Asymmetry

Effect	Any asymmetry in the nonlinear characteristic of the electrical and mechanical parameters produces a high magnitude of second-order distortion and a DC component of the displacement. The DC component produced by the nonlinear compliance of the suspension will always move the coil into a direction where the total effective compliance is maximal (softest point). If the driver has a symmetrical $C_{ms}(x)$ characteristic it has a stabilizing effect for the driver keeping the coil at the rest position. However, if the maximum of the $C_{ms}(x)$ curve is not at the rest position of the coil or if the curve is asymmetrical at higher values of *x* a DC component is generated. This deteriorates the performance of a good motor having a symmetrical *Bl(x)*-characteristic and the maximum of *Bl(x)* at the optimal rest position.
Critical Frequency	A critical excitation tone for a driver with asymmetries in the compliance is the resonance frequency. Here the AC part of the displacement is high and the rectification of the displacement produces high values of second-order harmonics and of the DC component. Fortunately, the input current *i* is minimal at the resonance. Thus the other nonlinearities such as inductance *L(x)* and force factor *Bl(x)* cannot produce a significant DC component. That's why the measurement of the DC component by a tone with constant frequency at f_s and variable amplitude U_1 is a good check for the symmetry of the suspension.
Critical Ratio	The ratio between DC displacement and magnitude of the fundamental displacement $$I_{DC} = \frac{X_{DC}(U_1, f_1)}{X_{fund}(U_1, f_1)} \times 100\ \%$$ is a critical measure for the stability of the driver. If the value of $I_{DC} < 10\ \%$ the driver is sufficient stable. Please note that in the DIS module X_{fund} is presented in mm rms and X_{DC} in mm peak.
Remedy	There are several ways to improve the symmetry of the compliance • The measurement of the large signal parameters (LSI) in connection with a FEM program for modeling mechanical structures reveals the constructional cause of the asymmetry. • The surround may be partly removed and a second measurement with the LSI or with the method presented here may be performed. Comparing the results of the measurements with complete and partly removed surround shows the defective part which should be replaced and optimized (see Application Note 2).

Method of Measurement

Loudspeaker Setup	Mount the driver in the stand and adjust the laser sensor to the diaphragm. A dot of white ink may be used to improve reflection and thus increase the signal to noise ratio of the measured displacement signal.
Resonance frequency	If the resonance frequency f_s of the driver is not known from the module Linear Parameter Measurement (LPM) than the fundamental response of the current vs. frequency is to be measured by using the 3D Distortion Measurement (DIS). The minimum of the current response shows the resonance frequency of the driver.
Measurement	At the resonance frequency f_s a series of measurement with varied amplitude is performed and the DC-component and the fundamental component of the displacement is measured.

Using the 3D Distortion Measurement (DIS)

Requirements

The following hardware and software is required for assessing the DC component:

- Distortion Analyzer + PC
- Software module 3D Distortion Measurement (DIS) + dB-Lab
- Laser sensor head and laser controller

Setup

Connect the laser controller to the input X at the rear side of the DA. Connect the terminals with SPEAKER 1. Switch the power amplifier between OUT1 and connector AMPLIFIER.

Preparation

- Open the database within dB-Lab
- Create a new object DRIVER and assign a new DIS operation based on the operation template "DIS Compliance Asymmetry AN 15" .

Measurement

1. Start the measurement "DIS Compliance Asymmetry AN 15"
2. If the measurement is paused and the warning “excessive distortion in the displacement signal” is shown, stop the measurement and reduce the voltage U_{end} of the excitation tone at the property page **Stimulus** and restart the measurement.
3. Open the window *Total harmonics, %*. If the total harmonic distortion in displacement is less than 10 % then you may increase the voltage U_{end} and restart the measurement. Make sure that the displacement state is selected at the Property Page **Display**.
4. Open the window *Fundamental* and *DC displacement*. Calculate the critical ratio I_{DC}.
5. Print the *DC component* curve (context menu) or create a report.

Setup Parameters for the DIS Module

Template

Create a new Object, using the operation template **DIS Compliance Asymmetry AN 15** in dB-Lab. If this database is not available you may generate the operation **DIS Compliance Asymmetry AN 15** based on the general DIS module. You may also modify the setup parameters according to your needs.

Default Setting for compliance asymmetry

1. Open the Property Page **Stimulus**. Select mode **Harmonics**. Switch on Voltage U_1 Sweep. Set U_{start} to 1 V rms and U_{end} to 8 V rms measured in 20 points spaced **linearly**. Make sure the signal level is appropriate for loudspeaker. Switch off the Frequency sweep. Set the frequency f_1 equals to f_s. Set additional excitation time to 0.5 s. Set maximal order of distortion analysis to N = 14.

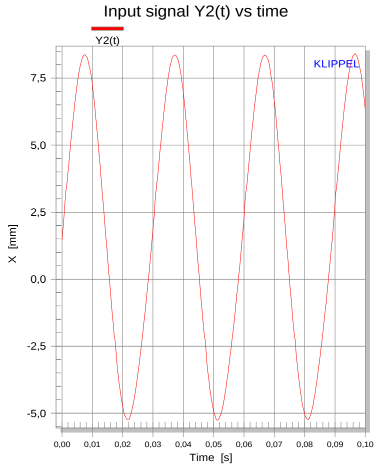
2. Open the Property Page **Protection**. Enable temperature measurement and set the maximal increase of voice coil temperature to 100 K. Enable interruption of measurement if total harmonic distortion of disaplacement X will exceed 10 %.

3. Open the Property Page **Input**. Select X (Displacement) at the second channel (Y2). Disable the first channel (Y1).

4. Open the Property Page **Display**. Select **Displacement X** as State signal. Set **Plot Style** to **2D Plot versus U1**.

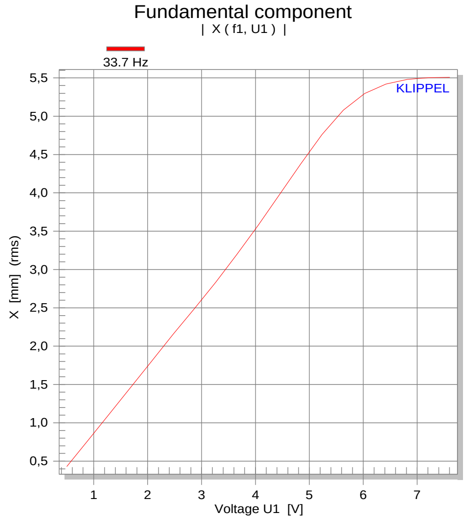
Example

Waveform



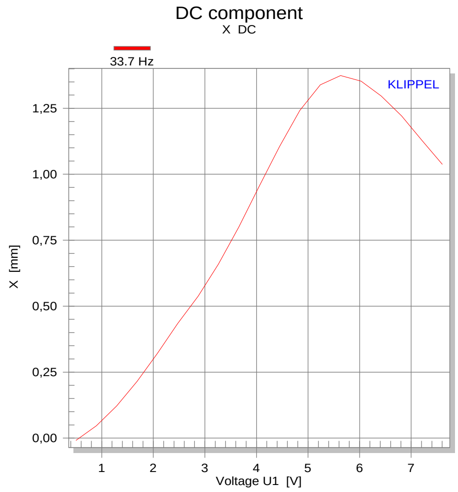
After pausing the measurement the result window Waveform Y2 shows the displacement versus time. A positive DC component is generated moving the coil about 1 mm to positive directions. This offset shifts the voice coil out of the symmetrical magnetic field and will produce the second-order intermodulation of any high-frequency tone in the pass band of the driver.

Fundamental Displacement



The result window **Fundamental** shows the displacement (rms) versus amplitude U_1. At lower amplitudes there is an almost linear relationship between input and output amplitude. At U_1 = 6 V rms the suspension limits the peak displacement to X = 5.5 mm.

DC component		The result window **DC Component** shows the DC Displacement generated dynamically versus voltage U_1 at f_1 = 34 Hz. At low amplitudes (U_1 < 5 V rms) the DC component grows linearly with input voltage moving the coil more and more to the compliance maximum. Here, the critical ratio I_D is about 20 % which is a critical value for compliance asymmetries. At high amplitudes where the suspension limits the positive and negative excursion symmetrically the DC displacement is reduced.



More Information

Related Application Notes	Separating Spider and Surround, Application Note AN 2, Klippel R&D System Dynamic Generation of DC Displacement, Application Note AN 13, Klippel R&D System Motor Stability, Application Note AN 14, Klippel R&D System
Related Specification	"DIS", S4
Software	User Manual for the KLIPPEL R&D SYSTEM or online help system

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