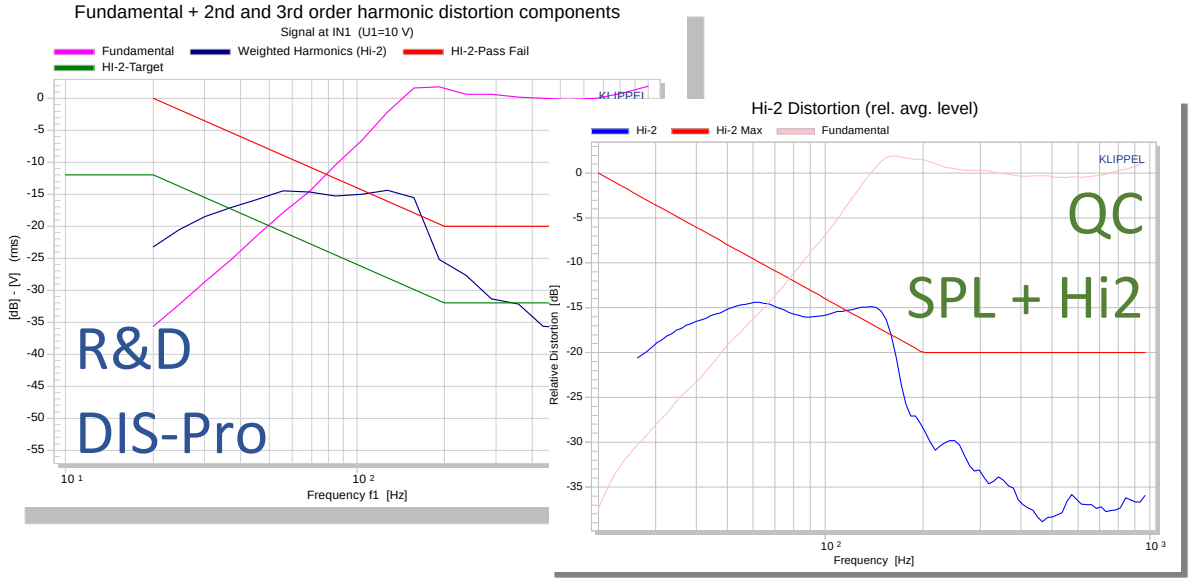
Measurement of Weighted Harmonic Distortion HI-2

AN 7

Application Note for the KLIPPEL R&D and QC SYSTEM (Document Revision 1.2)

DESCRIPTION

The weighted harmonic distortion HI-2 can be measured by using the DIS-Pro module of the KLIPPEL R&D SYSTEM or the SPL task with the HI-2 add-on in the QC system. The HI-2 Weighted Harmonic Distortion is an especially weighted sum of harmonics related to the mean level of the fundamental in the pass band of the driver. The measurement of HI-2 distortion enables the detection of unacceptable distortion, sounding like a “blat” on bass signals.



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1 Method of Measurements

Excitation Signal	A sinusoidal tone is swept from starting frequency f_{start}= 10 Hz to 1 kHz at 8.0 V rms with a minimum resolution of 40 points per decade.
Loudspeaker Setup	The loudspeaker shall be operated under free-field or half-space free-field condition. The measurement is to be taken 1 meter from the speaker (on axis).
HI-2 Weighted Harmonic Distortion	Measure and record the fundamental and the second through tenth harmonics P(k*f) with 2 <= k <= 10. Weight the harmonics by 12 dB per octave rising with frequency relative to the level of the fourth harmonic by using the weighting function $w(k) = S^{\log 2\left(\frac{k}{R}\right)}$ depending on the order k, using the slope parameter S=4 (12 dB/octave) and the referenced harmonic R=4. The HI-2 distortion is the RMS sum of the weighted harmonic $L_{HI-2} = 10\lg\left(\frac{\sum_{k=2}^{K}(w(k)P(kf))^2}{P_{ref}{}^2}\right)$ The reference amplitude P_{ref} is equal to the mean amplitude of the fundamental component in the pass band of the driver.
Why do we measure HI-2 distortion?	The limited height of voice coil, magnetic field, excursion capability of the mechanical suspension, varying voice coil inductance and nonlinear radiation (Doppler) are the dominant nonlinearities in loudspeaker systems. For loudspeakers without additional defects the amplitude of the harmonic and intermodulation components generated by the dominant nonlinearities decrease rapidly with the order of the distortion. Although, the second and 3rd-order components contribute mostly to the total distortion and these components are perceived as benign distortion. When the voice coil hits the back plate or the loudspeaker has defects such as an axial misalignment of coil and gap or buzzing leads this may cause extreme distortion that produce higher-order components. D. Clark defined an intermediate type of distortion (called blat distortion) between the benign and extreme type "Blat is a result of an intermediate stiffness change which produces amplitudes of fourth and tenth harmonic which are too high to be masked by the fundamental and the benign second and third harmonics. Blat results from a design characteristic rather than a rub, buzz or tick type of unit defect. "
Differences to Higher order distortion (Rub&Buzz)	HI-2 distortion are relatively low frequent but audible. They are calculated from pure harmonics not considering any energy between harmonics. Traditional analysis for speaker defects is based on higher order distortion analysis (n>=10) and usually includes non-harmonic signals. HI-2 distortion can be considered as a special defect symptom of subwoofers / woofers. It is recommended to check for HI-2 distortion in addition to the standard higher order distortion analysis (Rub&Buzz) using TRF or QC module.

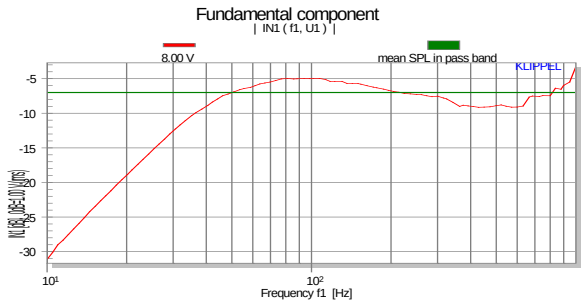
2 Using the DIS-Pro Module

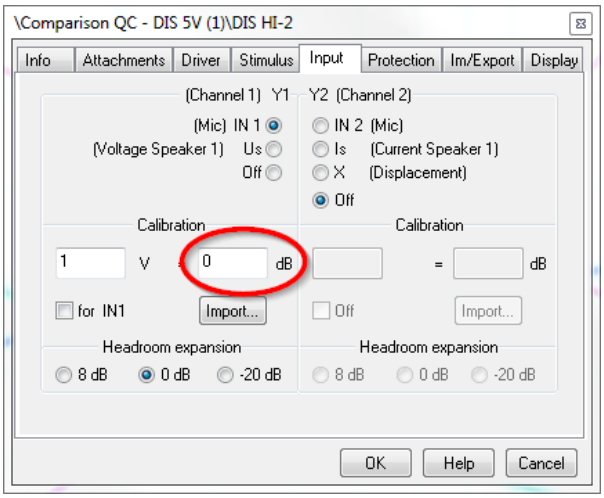
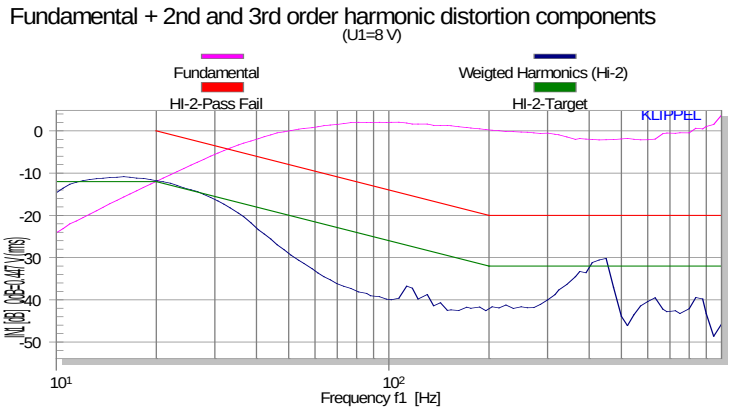
Requirements	The following hardware and software is required for assessing HI-2 distortion: - Klippel Analyzer (KA3 or DA2) + PC - Software module DIS-Pro + dB-Lab (210 or higher*) - Microphone
Setup	Connect the microphone to the Klippel Analyzer and select the corresponding input in the software. Set the speaker in the approved environment and connect the terminals with SPEAKER 1.

	Switch the power amplifier between OUT1 and connector AMPLIFIER.
Preparation	Create a new object based on the object template *Hi-2 Dist. Automotive - AN 7* in dB-Lab.
Measurement	1) Start the operation DIS HI-2 1st measurement. 2) Open the properties of the second operation **2 PPP Calc Mean SPL** and enter the frequency borders of the pass-band of the driver. Run this operation. Copy the value **Mean SPL** L_{mean} from the window **Result Table**. 3) Click at the operation DIS Hi-2 2nd measurement. Open property page **Input** and subtract L_{mean} from the dB value in the channel 1 **Calibration** group (see example below). 4) Start operation DIS Hi-2 2nd measurement. Open result window **Fundamental + Harmonics** to see the weighted harmonic distortion in decibel. Print the results or create a report. 5) Limits proposed by the referenced Design Note are added in this chart. Compare the measured results with the HI-2 target and Hi-2 Pass Fail limit.

* There is an older version of this Application Note for use with older versions of dB-Lab. Please ask support@klippel.de

2.1 Measurements and Results

Fundamental		After performing the measurement *DIS Hi-2 1st measurement* run the operation **2 PPP Calc Mean SPL.** This operation automatically imports the **Fundamental** curve from the 1st DIS operation and determines the mean SPL value L_{mean} of the fundamental in the pass-band of the driver (-7 dB in this example). Please note that the green line was manually added to the graph to illustrate the mean SPL value.

		Open the property page **Input** of operation *DIS Hi-2 2nd measurement* and enter the negated L_{mean} value in the channel 1 **Calibration** group (insert *1V = +7 dB* in the example). All curves of the DIS module will be referred to this value.
HI-2 Distortion	Start operation *DIS Hi-2 2nd measurement*. The result window **Fundamental + Harmonics** shows the amplitude response of fundamental and the weighted harmonic distortion components versus frequency.  The target values and the thresholds for the Pass/Fail decision are included as passive curves. These values may be modified by using the clipboard editor of dB-Lab.	

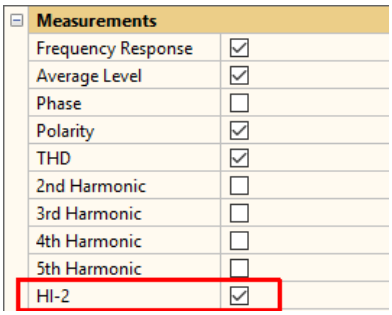
3 Using the QC Module

Requirements	The following hardware and software is required for assessing HI-2 distortion: - Klippel Analyzer or 3rd party soundcard + PC - QC6 Software Installation or higher or dB-Lab 210.500 or higher - SPL Task (included in QC Installations, special license required if used in R&D setup) - HI-2 Feature for SPL Task (License required) - Microphone
Setup	The standard QC setup can be used, check the QC User manual for details. Connect the microphone to Mic1, use Speaker 1 channel. Calibrate microphone and amplifier.
Preparation	Create a new QC Operation based on the template *QC SPL + HI-2*.

Measurement

1) Start the QC Operation (Login).

2) Make sure the HI-2 license is properly installed. On Property Page Tasks in section Measurements the measure HI-2 shall be visible and enabled.



3) The calculation mode for harmonics shall be set to *relative to level*. The calculation of the average level can be restricted to the passband. Adjust the *Average Level - Frequencies*.

4) Adjust the test level (The design note recommends $8V_{rms}$).

5) Select Property Page *Limits* and activate limit mode. The limit calculation mode for HI-2 shall be set to *HI-2 Standard*. Exit the limit mode, limits will be calculated automatically and displayed in chart *Distortion*.

6) Run the test (Start button) and check Chart Distortion.

3.1 Measurements and Results

Average Level in Pass Band

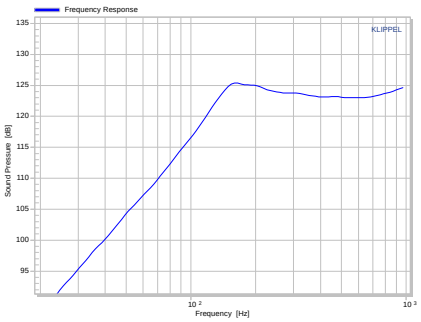
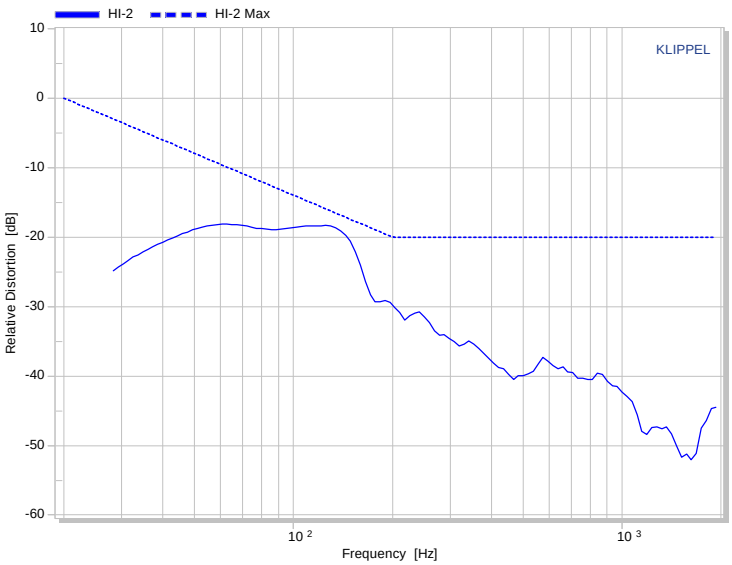


Chart *Frequency Response* shows the fundamental component of the measured microphone signal. The average level of the pass band is shown in result window *Summary*:

Name	Value	Min Limit	Max Limit	Unit
Average Level	122.5	119.6	125.6	dB

HI-2 Distortion

The result chart **Fundamental + Harmonics** shows the amplitude response of weighted harmonic distortion components versus frequency (HI-2).



The limit for the Pass/Fail decision is pre-defined as long as the limit calculation mode is set to HI-2 Standard. They may be user defined as well.

4 More Information

Paper	David Clark, "Blat Distortion in Loudspeakers," DLC Design Note 950189.
Related Specification	DIS Module, S4 (Dis-Pro) QC Module, C3 (available from QC6)
Software	User Manual of Klippel R&D and QC System.

Find explanations for symbols at:

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

Last updated: 31.08.2018