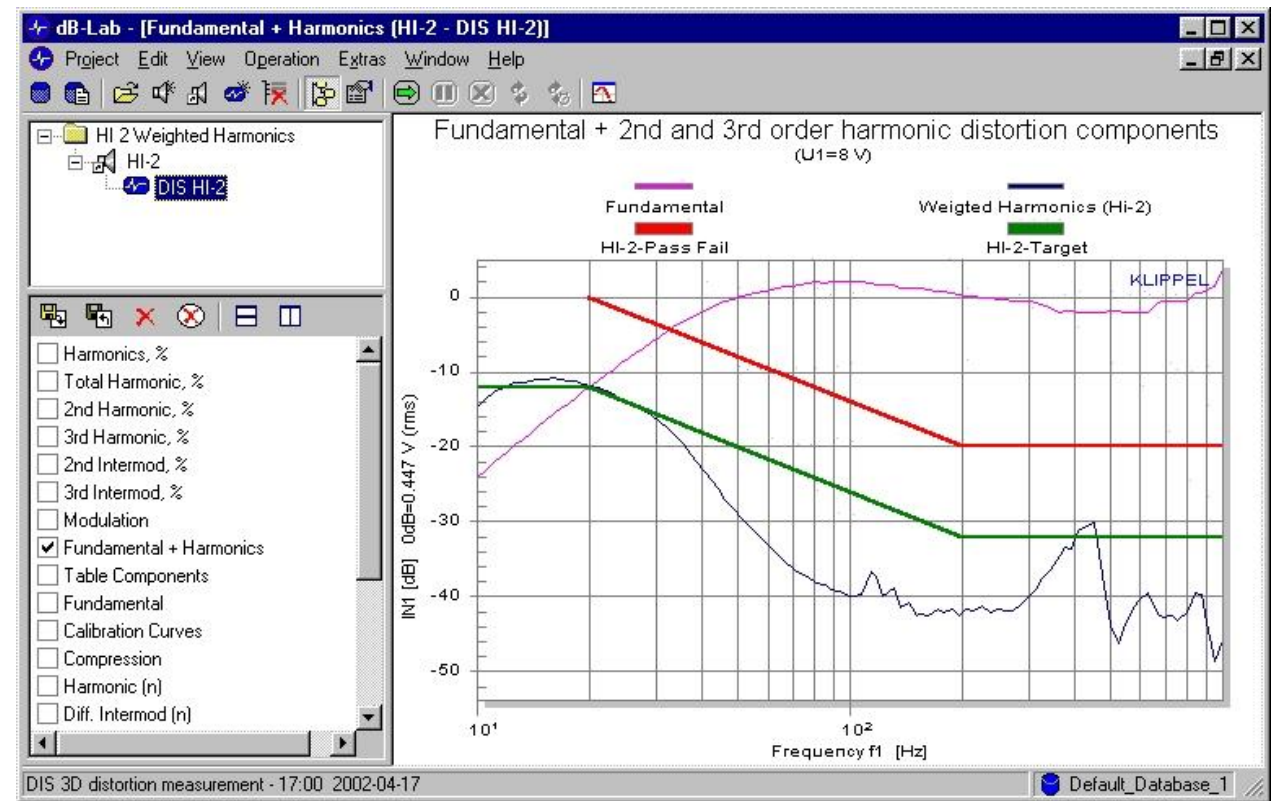


Measurement of weighted harmonic distortion HI-2 AN 7

Software of the KLIPPEL R&D and QC SYSTEM (Document Revision 1.0)

DESCRIPTION

The weighted harmonic distortion HI-2 is measured by using the DIS-Pro module of the KLIPPEL R&D SYSTEM. The HI-2 Weighted Harmonic Distortion is the ratio of the weighted rms sum of all harmonics and the level of the mean level of the fundamental in the pass band of the driver, expressed in dB. 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	<p>Measure and record the fundamental and the first through tenth harmonics $P(k*f)$ with $0 < k < 11$. Weight the harmonics by 12 dB per octave rising with frequency relative to the level of the fourth harmonic by using the weighting function</p> $w(k) = S^{1g2\left(\frac{k}{R}\right)}$ <p>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</p> $L_{HI-2} = 10 \lg \left(\frac{\sum_{k=2}^K (w(k)P(kf))^2}{P_{ref}^2} \right)$ <p>The reference amplitude P_{ref} is equal to the mean amplitude of the fundamental component in the pass band of the driver.</p>
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 3 rd -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. "

2 Using the DIS-Pro module

Requirements	The following hardware and software is required for assessing HI-2 distortion: <ul style="list-style-type: none"> - Distortion Analyzer + PC - Software module DIS-Pro + dB-Lab - Microphone
Setup 	<p>Connect the microphone to the input IN1 at the rear side of the Distortion Analyzer.</p> <p>Set the speaker in the approved environment and connect the terminals with SPEAKER 1.</p> <p>Switch the power amplifier between OUT1 and connector AMPLIFIER.</p>
Preparation	Create a new object based on the object template <i>Hi-2 Dist. Automotive AN 7</i> .
Measurement	1) Start the operation DIS HI-2 1 st measurement.

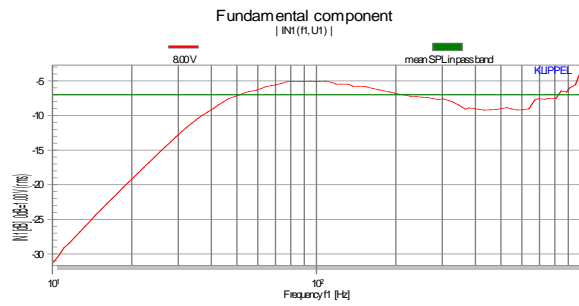
	<ol style="list-style-type: none"> 2) Open the window Fundamental and estimate the mean SPL level L_{mean} of the fundamental in the pass-band of the driver. 3) Click at the operation DIS Hi-2 2nd measurement. Open property page Input and enter $1V = -L_{\text{mean}}$ in the channel 1 Calibration group. 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.
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3 Setup Parameter for DIS Module

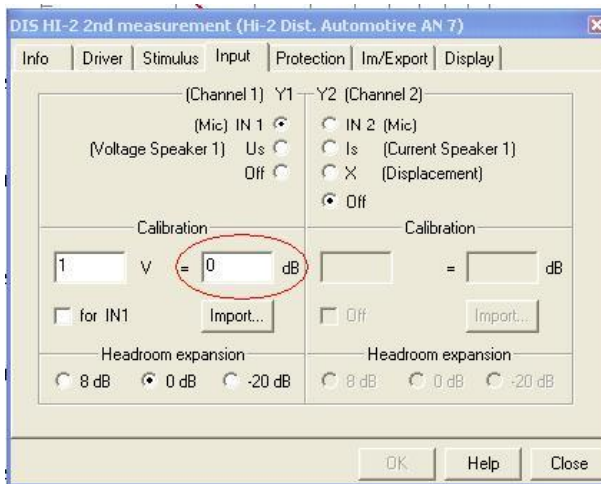
Template	Create a new Object, using the object template Hi-2 Dist. Automotive AN 7 in dB-Lab. If this database is not available, you may generate HI-2 measurements based on the general DIS module. You may also modify the setup parameters according to your needs.
DIS Hi-2 1st measurement	<ol style="list-style-type: none"> 1) Create a new DIS operation based on the Default template. Name the operation DIS Hi-2 1st measurement. 2) Open property page Stimulus. Select mode Harmonics. Switch off Voltage Sweep. Set Uend to 8 V rms at Speaker 1 terminals. Make sure the signal level is appropriate for loudspeaker. Switch on the Frequency Sweep with 200 points spaced logarithmically between 10 Hz and 1000 Hz. Disable additional excitation time. Set maximal order of distortion analysis to 10. 3) Open property page Input. Select (Mic) IN 1 for the first channel and Off for the second channel. Enter $1V = 0\text{dB}$ in the first channel Calibration group. 4) Open property page Protection. Disable temperature measurement and any protection. 5) Open PP Display. Select 2D plot, versus f1 and Signal at IN1 as State signal.
DIS Hi-2 2nd measurement	<ol style="list-style-type: none"> 1) Duplicate the operation DIS Hi-2 1st measurement and rename the operation DIS Hi-2 2nd measurement. 2) Open the Im/Export page in the operation DIS Hi-2 1st measurement and click at the Export to Clipboard button. 3) Open the Im/Export page in the operation DIS Hi-2 2nd measurement and click at the Import from Clipboard button.

4 Example

Fundamental



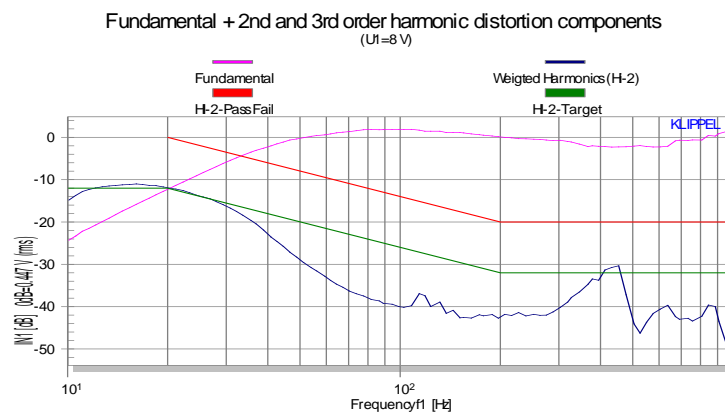
After performing the measurement *DIS Hi-2 1st measurement* open the result window **Fundamental** and determine the mean SPL value L_{mean} of the fundamental in the pass-band of the driver visually (-7 dB in this example). Please note that the green line was manually added to the graph to illustrate 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 $1V = +7\text{ dB}$ 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.

5 More Information

Paper	David Clark, "Blat Distortion in Loudspeakers," DLC Design Note 950189.
Related Specification	"DIS", S4
Software	User Manual of Klippel R&D System.

Find explanations for symbols at:

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

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